8-2017

Essays on transportation cost, social security retirement income and housing market

Naqun HUANG
Singapore Management University, naqun.huang.2012@phdecons.smu.edu.sg

ESSAYS ON TRANSPORTATION COST, SOCIAL SECURITY RETIREMENT INCOME AND HOUSING MARKET

Naqun Huang

A DISSERTATION

in

ECONOMICS

Presented to the Singapore Management University in Partial Fulfilment

of the Requirements for the Degree of PhD in Economics

2017

____

Supervisor of Dissertation

____

PhD in Economics, Programme Director

ESSAYS ON TRANSPORTATION COST, SOCIAL SECURITY RETIREMENT INCOME, AND HOUSING MARKET

by

Naqun Huang

Submitted to School of Economics in partial fulfillment of the
requirements for the Degree of Doctor of Philosophy in Economics

Dissertation Committee:

Jing Li (Chair/advisor)
Assistant Professor of Economics
Singapore Management University

Jun Yu
Professor of Economics and Finance
Singapore Management University

Sock Yong Phang
Professor of Economics
Singapore Management University

Amanda Ross
Assistant Professor of Economics
University of Alabama

Singapore Management University
2017

Abstract

This dissertation comprises three papers that study how transportation cost affect price distribution across a city, how home equity affects the timing of pension withdrawal, and potential implications of macroprudential policies on the price informativeness. Specifically, the first paper examines how a change in the cost of car ownership affects housing price gradient with respect to distance from the central business district (CBD) in Singapore. The second paper investigates how household home equity affect the timing of claiming Social Security Retirement Income (SSRI) in the United States. The third paper explores how countercyclical policies in Singapore real estate market affect price informativeness.

Chapter 2 studies one important factor that helps to explain the price distribution of housing throughout a city. It is the acquisition cost of transportation. One key finding is obtained. When the cost of owning a car increases, the price of housing closer to the city center increases relative to housing farther away from the CBD, suggesting that increases in the price of a car cause individuals to increase their willingness to pay to locate closer to the CBD. This is consistent with the predictions from the monocentric city model that allows for two modes of transportation.

Chapter 3 examines the question that help to explain the timing when elderly individuals decide to receive SSRI benefits. The question investigates the trade-off between Social Security Retirement Income (SSRI) and home equity, two largest components among the various sources of financial assets of the elderly. Three key findings are obtained. An increase in the value of a home causes elderly individuals to delay SSRI claiming once they are eligible during the housing boom period, but we do not find a statistically significant impact on the claim decision during the bust period. Second, higher housing values have a positive effect on the likelihood of retirement in both the boom and bust period. Third, pension eligibility plays a role on the impact of home equity on retirement.

Chapter 4 address one question that helps us to understand the consequences of macroprudential policies. It asks how the countercyclical policies that are designed to deter speculators by increasing transaction cost affect price informativenss in real estate market. Two key findings are obtained. First, speculative trade decreases after dramatic increase in the transaction cost. Second, price trend along sales sequence shows significant increasing pattern. It suggests that price might not accurately reflect the true value of houses without market players who play a role in promoting informational efficiency.

Table of Contents

List of Tables

List of Figures

Acknowledgements

I would like to express my deepest gratefulness to my supervisor Jing Li for her incredible support and guidance. It would never have been possible for me to take this work to completion without her help and inspiration. I am deeply indebted to Jun Yu and Anthony Tay for their strong support and care. My sincere thanks also goes to Sock Yong Phang, Amanda Ross, Peter C.B. Phillips, Liangjun Su, Seonghoon Kim, Fali Huang, Zhenlin Yang as well as many visiting professors for their helpful advice. I am grateful for the suggestions from Yanying Chen and Yijin Tan.

I would also want to send my appreciation to Qiu Ling Thor and Yong Fong Koh for their administrative support and my Ph.D. program mates who are very helpful and bring so much joy. I am also grateful for comments and advice received from participants at the Asian Real Estate Society (AsRES) annual conference in July, 2016. Last but not the least, I would like to thank my parents, my sister who encourages me constantly and friends in Singapore for their guidance and support during this journey.

Chapter 1 Introduction

The price distribution of housing throughout a city has been of interest to urban economists since the advent of the monocentric city model (Alonso, 1964; Muth, 1969; Mills, 1967; Wheaton, 1974; Brueckner, 1987). While transportation costs include acquisition costs, operating costs and time costs (Coulson and Engle, 1987), previous literature have mainly focused on the operating cost and time costs, probably because the car ownership rate in the U.S. is high and usage costs are generally larger than the acquisition costs (Ferdous et al, 2010). In contrast, in jurisdictions where the government institutes traffic control policies, such as Shanghai and Singapore, the per-capita car ownership rate is low and the cost of acquiring a car is substantially larger than the usage costs (Chu, 2014; 2015). This implies that the acquisition cost of car ownership may affect the housing price gradient through its impact on the demand for a car versus other types of transportation. A better understanding of this question would be important for policy makers as well as academics.

Another important question in the real estate economics is related to the aging population. Many countries are moving into aging societies (e.g. the United States, China). For instance, the proportion of individuals over the age of 65 in the U.S. rose from 8% in 1950 to 13% in 2010 and is expected to rise to over 20% by 2030 (Lee, 2014). The rapid increase in the share of the elderly population raises concerns regarding the financial readiness of the retirement system for a dramatic increase in individuals filing for Social Security. Among the various sources of financial assets of the elderly, Social Security Retirement Income (SSRI) and home equity are the two largest components of an elderly household's balance sheet. Elderly individuals who need additional wealth and are at the eligible age to receive Social Security can choose to start receiving SSRI. However, if these individuals start receiving SSRI as soon as they become eligible, the monthly benefit is lower than if the individual delayed a few years Therefore, it would important to see if elderly individuals are more likely to start receiving SSRI later when house prices increase.

The third important question in the real estate economics concerns the impact of macroprudential polices on the market efficiency. The idea of market efficiency has been applied extensively to theoretical models and empirical studies of financial securities prices since Samuelson (1965), Fama (1965; 1970) and Ross (1976), but it has been less explored in the real estate market. While macroprudential policies are widely used globally after the recent housing and financial crisis (Ceruttia, Claessens and Laeven, 2017), our knowledge of the unintended consequences are still limited (Claessens 2015; Crowe, Dell'Ariccia, Igan and Rabanal, 2013; Hanson, Kashyap and Stein, 2011). Possible findings might have important policy implications.

This dissertation first helps to explain the price distribution of housing throughout a city by utilizing a unique traffic control policy in Singapore, then addresses the trade-off between SSRI and home equity for the elderly in the U.S., followed by the potential impact of countercyclical policies on price informativeness in Singapore real estate market.

Chapter 2 examines an important prediction from the monocentric city model by utilizing a unique institutional feature in Singapore of the car registration process. As one of the most classic models in urban economics, monocentric city model states that transportation cost is one relevant factor that affects the price distribution of housing throughout a city (Alonso, 1964; Muth, 1969; Mills, 1967; Wheaton, 1974; Brueckner, 1987). While most papers have focused on the usage cost of transportation, we focus on the acquisition cost. The identification is achieved by using the vehicle quota allocated by the government as the instrument variable for the cost of car ownership.

We find, as expected, that as the acquisition cost of car ownership increases, the price of housing closer to the city center increases relative to the housing farther away from the city center, consistent with the predictions from the monocentric city model with both public transportation and private transportation. Policy makers need to be cognizant of the unintended consequences that traffic control policies, such as restricting the number of car registrations, have on residential house prices.

Chapter 3 investigates the extent to which elderly households make decisions on financing retirement using SSRI and housing equity. The majority of the existing literature has focused primarily on the relationship between local labor market shocks and the decision to withdraw SSRI, with any discussion of home equity being a secondary consideration (Coile and Levine, 2007, 2011a, 2011b; Goda, Shoven and Slavov, 2011). Another strand of literature focusing on the role of home equity has examined how changes in house prices affect the decision to retire and leave the labor market (Disney, Ratcliffe, and Smith, 2015; Farnham and Sevak, 2007; Ondrich and Falevich, 2016; Zhao and Burge, 2017a; Zhao and Burge, 2017b). We expand upon this literature by directly drawing a link between how elderly individuals make the decision to start receiving SSRI benefits versus using their home equity to finance expenditures. The identification is achieved by drawing upon geographic variation in the land supply elasticity of an MSA, developed by Saiz (2010), as the topological characteristics of an area are not likely to be correlated with local demand shocks to the economy. We interact this supply elasticity measure with the change in the national house price index and use this interaction term as an instrument for the change in local house prices.

We find that larger increases in house prices are associated with delayed SSRI claiming during the boom period from 2002-2006. During the bust period from 2007-2009, we do not find a statistically significant effect on SSRI claiming. Furthermore, we see that when house values increase, individuals are more likely to retire, and that SSRI eligibility also play a role when considering the impact of home equity on the retirement decision. Our findings suggest that the elderly seems to treat home equity and SSRI as substitutes when financing retirement. It appears that most of this trade-off is during boom periods, but not when house prices decline, consistent with cashing-out home equity as a viable option only when house price appreciates. Our findings are important for policy makers in designing relevant policies after having a better understanding of the substitutability between these two assets.

Chapter 4 explores the potential impact of unexpected macroprudential policies that are designed to deter speculators on the price informativeness in Singapore real estate market. The idea of market efficiency has been applied extensively to theoretical models and empirical studies of financial securities prices since Samuelson (1965), Fama (1965; 1970) and Ross (1976). There have been debates on whether speculator contribute to the market efficiency. Market could be inefficient with short-term speculation (Brunnermeier, 2005; Froot, Scharfstein and Stein, 1992), or speculative trade is conducive to market efficiency (Brown and Yang, 2016; Chang, Luo, and Ren, 2014; Cornell and Dietrich, 1978; Jaffe and Winkler, 1976), or the effect of speculators on the market efficiency depends on traders' characteristics (Figlewski, 1978; Tirole, 1982).

While macroprudential policies are more widely used globally after the recent housing and financial crisis (Ceruttia, Claessens and Laeven, 2017), our knowledge of the unintended consequences are still limited (Claessens 2015; Crowe, Dell'Ariccia, Igan and Rabanal, 2013; Hanson, Kashyap and Stein, 2011). This chapter utilizes a unique feature of Singapore housing market that most transactions happen before the consumption feature is ready and the uncompleted property market attracts investors (Fu and Qian, 2014; Fu, Qian, and Yeung 2015). Another feature of Singapore housing market is that all units within each residential project in Singapore are very homogeneous before households move in (Baltagi and Li, 2015). This means that, after adjusting for observed characteristics, we have essentially identical units transacted at near time. We are interested in how short-term investment behavior in this segment of market affects the price informativeness.

This is achieved by examining the housing price of very similar units over sales sequence using unexpected macroprudential policies as transaction cost shocks to short term speculators. We find that short-term speculative transactions decreased dramatically after policies and the price over sales sequence shows significant upward trend after dramatic increase in transaction cost for short term traders. Our results suggest that transaction tax can deter speculators, and price might not accurately reflect the true value of houses without market players who play a role in promoting informational efficiency.

Chapter 2 The Impact of the Cost of Car Ownership on the Housing Price Gradient in Singapore

(Coauthored with Jing Li and Amanda Ross)

2.1 Introduction

The price distribution of housing throughout a city has been of interest to urban economists since the advent of the monocentric city model (Alonso, 1964; Muth, 1969; Mills, 1967; Wheaton, 1974; Brueckner, 1987). The monocentric city model argues that there are different factors that affect the price of housing relative to distance from the city center. For example, as transportation costs increase, individuals will be willing to pay more to locate closer to the central business district (CBD) so that they do not have to travel as far to work.[1] However, estimating the effect of transportation costs on the urban price gradient is problematic, as the costs are likely correlated with various unobserved factors that contribute to the house price gradient. To address endogeneity concerns, we examine the urban house price gradient in Singapore, as the unique nature of the car registration process allows us to obtain supply-driven, exogenous variation in the price of car ownership to identify a causal relationship.

The city-country of Singapore offers a unique opportunity to study the urban price gradient due to a key feature of its transportation policy aimed at reducing road congestion. To own a car in Singapore, like most countries, you must obtain a registration, known as a Certificate of Entitlement (COE).[2] However, unlike most countries, the government restricts the number of COEs available to curb growth of the number of cars and hence to reduce traffic. To distribute the limited number of COEs, the government allocates the registrations through a competitive on-line bidding process.[3] Therefore, the price of a COE, which is a significant portion of the price of acquiring a car in Singapore,

[1] Glaeser, Kahn, and Rappaport (2008) found that the poor tend to live in cities due to reliance on public transportation, consistent with predictions from this model.
[2] Singapore also engages in congestion pricing practices. However, since we are not studying congestion specifically in this paper, we do not discuss the details of this policy. For more information on congestion pricing, see Verhoef (2002), Saleh (2007), Larsen, Pilegaard, and Van Ommeren (2008), Eliasson et al. (2009), and De Lara et al. (2013).
[3] We discuss the auction process in detail later in the paper.

varies over time based on the number of registrations available each auction. The high cost of obtaining a COE is one of the primary reasons that car ownership rates are so low in Singapore (Chu, 2014; 2015).

We estimate the extent to which house prices throughout Singapore vary with respect to distance from the CBD as transportation costs, specifically the price of a car, change.[4] To obtain causal estimates, we use the number of COEs released by the Land Transport Authority as an exogenous, supply-driven instrument for the price of a car. The number of COEs released each auction is based on the government's desire to reduce congestion and is unlikely to be affected by the future change in house prices throughout the city. Therefore, we use the number of COEs released each quarter as an instrument for the price of a COE and hence the price of a car. Our first stage regressions support the use of the number of COEs as an instrument for the price of a COE.

Using the number of COEs allocated in a given quarter as our instrument, we examine how the price of housing varies with respect to distance from the city center as the price of a COE, and hence the price of a car, changes. To do so, we obtained proprietary information on residential property sales in Singapore from 2002Q2 to 2015Q4. To control for house-specific characteristics other than distance to the city center, we exploit a homogeneity feature of Singapore's private residential market to include "unit" specific fixed effects. This is a viable option because all units within each residential project are homogenous, with the same interior design, the same furnishings, the same major electrics, and the same outdoor facilities. In this context we have high-frequency transaction records for almost identical units in the property sales market (Baltagi and Li, 2015). This feature of the Singaporean private housing market enables us to frequently trace the change in house prices at various distances from the CBD while including "unit" (project) fixed effects.

[4] Glaeser and Kahn (2004) argue that the declining cost of a car in the U.S. is one of the main reasons why American cities have become so sprawled. This suggests that the price of a car is important when considering transportation costs.

We find that higher COE premiums are associated with higher house prices for units that are closer to the CBD. Specifically, we find that if the COE premium increases from $10,000 to $40,000, which is how much the premium increased between 2009 and 2010, the price of centrally located housing increases by approximately 8.37%. At the same time, we find that this increase in house prices declines with distance from the CBD. For those units that are 10 kilometers away from the city center, the same increase in the COE premium is associated with only a 2.19% increase in house prices. In other words, the percent increase in the price of housing for units 10 kilometers from the CBD is approximately four times less than the price increase of centrally located housing units. This result supports the predictions of the monocentric city model, allowing for alternative modes of transportation (i.e. private or public transportation). Our findings are consistent across various specifications, such as using different time trends as controls, using different definitions of the CBD, restricting the sample to only those units that are sufficiently far from a subway stop that residents are more likely to rely on cars for transportation, and to including different types of COE registrations.

Our results are consistent with the literature on the "negative rent gradient," which has been discussed extensively in the urban economics literature.[5] To estimate the effect of transportation costs on house prices at various distances from the CBD, prior studies have mainly considered time costs and gasoline prices. For instance, Coulson and Engle (1987) and Blake (2016) found that increases in gas prices increased the price of centrally located houses. Anas and Chu (1984) reported that the probability of living in a given neighborhood is decreasing in average travel time and travel cost to the city center. Cortright (2008) showed that house prices fell more in ZIP codes with longer commutes after an increase in gas prices. Molloy and Shan (2010) found that an increase in gasoline prices led to a decrease in new home construction in locations with longer commutes, but found no significant effect on existing house prices. Accounting for both monetary and time costs, Tse and Chan (2003) found

[5] Arnott and MacKinnon (1978) also examined these price gradients, allowing for congestion.

evidence of a negative rent gradient using data from Hong Kong, versus the other studies mentioned which focused on the U.S.

We contribute to this literature by examining the effect of a change in the acquisition costs of car ownership on the house price gradient. In the U.S., the car ownership rate is high and usage costs, both monetary and non-monetary, are generally larger than the acquisition costs (Ferdous et al, 2010). However, in jurisdictions where the government institutes traffic control policies, such as Shanghai and Singapore, the per-capita car ownership rate is low (12 cars per 100 people in Singapore) and the cost of acquiring a car is substantially larger than the usage costs (Chu, 2014; 2015). This implies that the acquisition cost of car ownership may affect the housing price gradient through its impact on the demand for a car versus other types of transportation. We expand upon the literature by examining how changes in the acquisition costs of a car affect the price of housing at various locations throughout the city using a model with two modes of transportation. Furthermore, our identification strategy is novel within the urban price gradient literature as we use an exogenous change in the supply of car registrations, which is unlikely to be correlated with other demand factors influencing the house price gradient, as an instrument for the price of a car. While the use of such supply side instruments is becoming increasingly popular in the economics literature, we are the first to utilize this type of instrumental variables approach to estimate the urban price gradient.[6]

The rest of the paper will proceed as follows. Section 2 discusses the institutional details of vehicle ownership and the housing market in Singapore. Our theoretical model is presented in Section 3. Section 4 outlines our identification strategy and we discuss our data in Section 5. Section 6 describes our main results and we show a series of robustness checks in Section 7. We conclude in Section 8.

[6] These supply-side instruments have become increasing popular since Saiz (2010) created estimates of the elasticity of supply for MSAs in the U.S. These elasticity estimates have been used in the literature to address demand-related endogeneity issues, including Mian and Sufi (2011, 2013) and Cvijanović (2014) who use this measure to explain variation in house price appreciation across MSAs.

2.2 Vehicle Ownership and Residential Property Market in Singapore

2.2.1 Vehicle Ownership in Singapore

According to the Economist Intelligence Unit (EIU)'s report in 2016, Singapore retained the title of the most expensive city in the world for the third consecutive year, and the price of owning a car is one of the factors that make the city-country so expensive. The Singaporean government has implemented several policies to reduce traffic and congestion, specifically congestion pricing[7] and vehicle ownership restraint. As a result of these policies, the costs of owning a vehicle in Singapore are extremely high and subsequently the car ownership rate is low (Chu, 2014; 2015).

To curb the growth of the vehicular population, a vehicle quota system was introduced by the Singaporean government in May 1990 via the Certificate of Entitlement (COE) scheme. Vehicle owners must obtain a COE to purchase a car, but there are a limited number of these registrations available. Therefore, obtaining a COE is conditional on making a successful bid when buying a car. A COE is valid for ten years and individuals have the option to renew at the end of the term but will have to pay a significantly higher road tax premium and obtain a new COE at the current market price.[8] COEs are distributed via five categories of vehicles, and households primarily obtain COEs for their personal cars from categories A and B, but sometimes through category E as this is an open category.[9]

The number of COEs available, known as the COE quota, is determined by the Singaporean government based on three components: the number of vehicles de-registered, the allowable growth rate

---

[7] While congestion pricing is in effect in Singapore, we do not discuss it in detail as it is not the focus of our analysis. For more information, see Agarwal, Koo, and Sing (2015) and http://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/managing-traffic-and-congestion/electronic-road-pricing-erp.html.

[8] When the COE for a vehicle is about to expire, the owner can renew it by paying a Prevailing Quota Premium (PQP). There are two options for COE Renewal: (1) revalidate the COE for another 10-year period by paying the PQP; (2) revalidate their COE for another 5-year period by paying half the PQP. For motorcycles and cars, there is no limit to how many times you can renew the COE so long as the COE is renewed for 10 years. However, there will be road tax surcharge applied for vehicles over 10 years old. Details can be found at https://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/owning-a-vehicle/costs-of-owning-a-vehicle/tax-structure-for-cars.html.

[9] Category A refers to cars up to 1,600cc and maximum power output not exceeding 97kW, Category B refers to cars above 1,600cc or maximum power output above 97kW, Category C refers to goods vehicles and buses, Category D refers to motorcycles, and Category E can be used for any type of vehicle.

as determined by the government, and adjustments to account for changes in the vehicle population.[10] The auction for a COE is held through an online, open-bid process and has been conducted over a three day period, twice a month since April 2002. The number of successful bidders is limited by the number of COEs available in each category in that auction. The price of the COE is increased over the bidding period until the number of bids is less than or equal to the quota for that auction. All successful bidders in the vehicle category pay the same premium, the minimum amount needed to have a successful bid in that auction, regardless of the bid made.[11]

Kochhan et al. (2014) estimate that the total cost, net of the resale value, of a new mid-range car over a seven-year operation period in Singapore is 150,001 Singapore Dollars (SGD) (see Table A2 for the details of this example), with an acquisition cost of 122,144 SGD, an operating costs of 61,530 SGD, and a resale value of 33,673 SGD.[12] In the case that Kochhan et al. (2014) discuss, the COE premium was 63,630 SGD, which was the average 2012 COE bidding results, and accounted for 52.1% of the acquisition cost and 34.6% of the combined acquisition and operating costs. Note that the total operating costs over a seven-year period for a mid-range car is estimated to be less than the price of a COE. This further highlights the importance of considering the impact of the acquisition costs of a personal vehicle in jurisdictions where the government institutes traffic control policies.

2.2.2 Residential Property Market in Singapore

Residential properties in Singapore are grouped into three categories: private non-landed properties (including private apartments and condominiums), private landed properties, and public housing, locally known as Housing and Development Board (HDB) flats. Private landed properties are

---

[10] For specific details on the allowable growth rate set, see https://www.mot.gov.sg/About-MOT/Land-Transport/Motoring/Vehicle-Ownership/.

[11] For more information on the auction process, see http://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/owning-a-vehicle/vehicle-quota-system/certificate-of-entitlement-coe.html. For an example of the bid process, see Appendix Table A1.

[12] Acquisition costs include open market value (OMV), customs duty, goods and services tax, a registration fee, an additional registration fee (ARF), a carbon emission-based vehicle scheme (CEVS), the COE price, and the retailer margin.

those properties where the owner owns the title to the land. Private non-landed properties are leased from the government through either a 99-year lease or a 999-year lease. HDB flats are low-income properties that are heavily subsidized by the Singaporean government.

For our analysis, we restrict our sample to the private non-landed residential market. We make this restriction for several reasons. First, private residential housing is likely to be affected by any market force that impacts the price of housing, unlike HDB flats which are heavily subsidized by the government. While HDB flats make up the largest portion of the overall housing market in Singapore, approximately 85% of Singaporeans live in HDB flats according to the 2012/13 General Households Expenditure Survey (HES),[13] we exclude these units due to the high subsidy received when purchasing a HDB unit as well as other policies that restrict the demand and supply of these properties.[14]

In addition, compared to other market segments, private non-landed housing units are very homogenous within each residential project. This provides an opportunity to explore price variation of hedonically adjusted units that are essentially the "same." In Singapore, it is uncommon to find repeatedly transacted units that would allow us to explore price variation of the *same unit* over time (Jiang, Phillips, and Yu, 2015).[15] As such, it is important to match hedonic characteristics to track price changes of *matched units* over time. Private non-landed housing units within the same housing project are very homogenous in terms of the attributes of the units (Baltagi and Li, 2015).[16] This feature allows us to track the price change of almost identical units in the same project.

2.3 Theoretical Model

[13] The HES collects detailed information on the expenditures of households in Singapore. HES 2012/13 was the tenth in the series conducted by the Singapore Department of Statistics from October 2012 to September 2013.
[14] For more information on the policies and the nature of the subsidy for HDB housing flats in Singapore, see: https://lkyspp.nus.edu.sg/wp-content/uploads/2014/11/Public-Housing-in-Singapore.pdf
[15] This is especially true for landed private properties. These units make up a very small portion of the market, less than 5%, and are not frequently transacted. Given that we do not have many repeat sales of comparable properties for this segment of the market, we exclude the landed market from our analysis.
[16] Guntermann, Liu, and Nowak (2016) also argue that nearby properties are likely to have similar attributes in the U.S. and a nearest neighbor model can be used to increase the number of observations in a repeat sales model.

Consider first the standard downward sloping bid-rent function from the monocentric city model, as shown in Figure 2.1. Many factors may cause this bid-rent function to shift, including a change in the cost of purchasing a car. If the cost of acquiring a car changes, there will be a parallel shift in the bid-rent function due to the change in the fixed costs of car ownership. For example, suppose that the purchase price of a car decreases, then this would cause a parallel shift outwards as indicated by the arrow in Figure 2.1.

However, the model in Figure 2.1 assumes cars are the only means of transportation. In many cases, like in Singapore, alternative modes of transportation (i.e. the subway or bus) are popular options. Therefore, individuals who live the closest to the city center, where the subway system is the most extensive, do not need a car and will be willing to pay more for housing. Those individuals farther from the CBD, where public transportation is not as extensive and amenities are not as nearby, may not be willing to spend as much on housing because they are more likely to need to purchase a car for daily transportation.[17] Therefore, when there are two modes of transportation we will have two bid-rent functions, as shown in Figure 2.2, and the price of housing at various distances from the CBD will be determined by the outer envelope of the two bid-rents.

Now, suppose that we see the same decrease in the price of acquiring a car that shifts the bid-rent function for private transportation outwards. In this situation, we see that there will be a change in the portion of individuals who rely on public versus private transportation. Specifically, those individuals who live at a distance between X^1 and X^2 from the city center will switch from using public transportation to car ownership. Given this change in the mode of transportation used by some

[17] Independent of the intention to drive to work, which in the standard assumption of the monocentric city model, individuals may also use cars for other types of trips, such as shopping or taking the kids to school. This will also affect the willingness to pay for a car at various points in the city. As transportation is needed to access amenities, a car may make these other errands easier especially in more distant areas where amenities are more likely to be scattered.

residents, we have a new outer envelope of the bid-rent function and hence will observe a change in both the level and slope of the observed house prices throughout the city.

2.4 Identification Strategy

We estimate how changes in the price of a car, driven by variation in the cost of a COE, affect the price of housing. Furthermore, we consider how this effect varies based on the distance of the housing project from the CBD to estimate the house price gradient. To do so, we start with the following specification:

$$P_{i,t} = \beta_1 COEP_t + \beta_2 DD_i \times COEP_t + \beta_3 PPI_t + \gamma_i + u_{i,t} \tag{1}$$

where the dependent variable, $P_{i,t}$, is the median area-adjusted house price in housing project i in quarter t. $COEP_t$ is the average COE premium in quarter t. We focus on COEs in categories A and B to calculate $COEP_t$ based on the quarterly COE premium weighted by the quarterly COE quota in each category.[18] DD_i represents the distance (in kilometers) between project i and the city center, which we define as the Raffles Place MRT station.[19] We also include the price index for the national non-landed private housing market, PPI_t, to control for the national trend in house prices.[20] Individual project fixed effects, γ_i, are included to control for project-specific characteristics that could affect the price of housing, including the amenities in the unit as well as the distance to the city center. We include different time trend controls across specifications, such as a yearly time trend, year-by-quarter fixed effects, and a planning-area specific linear time trend.[21]

[18] Categories A and B are the primary categories for personal vehicles. As a robustness check, we include Category E which can be used for any type of vehicle.
[19] The Raffles Place MRT stop is considered the CBD in Singapore because it is directly beneath the center of the financial district . As a robustness check, we use the City Hall MRT stop as the city center, which is considered the closest to the political center of Singapore.
[20] For more information on the creation of house price indices, see Bailey, Muth, and Nourse (1963) and Case and Shiller (1987, 1988).
[21] There are 55 urban planning areas in Singapore, spanning five regions. Each planning area has a population of about 150,000 people and is served by a town center and several neighborhood commercial/shopping centers. More details can be found at http://www.ura.gov.sg/uramaps/?config=config_preopen.xml&preopen=Planning Boundaries&pbIndex=1.

If we estimate equation (1) using OLS, β_1 captures the overall price response of residential properties with respect to changes in the price of the COE (also known as the COE premium). β_2 captures the house price response with respect to changes in the COE premium relative to a given project's distance from the CBD. This coefficient is an estimate of the urban price gradient, where the effect of the COE premium on house prices varies based on how far the unit is from the CBD.

However, there may be reverse causality present which would cause OLS estimates to be biased. For example, it is likely that housing farther away from the CBD and cars are complementary goods, as individuals with farther commutes are more likely to rely on personal vehicles for transportation.[22] Therefore, if the price of housing farther from the CBD increases due to an unobserved local shock, then this would decrease the demand for personal vehicles and drive down COE premiums. Since both of these effects are expected to have a negative relationship, our estimated average effect will be somewhere in between these two slopes, which suggests that we could have an upward or downward bias, depending on which effect is stronger.[23]

To address this concern and obtain causal effects, we instrument for the COE premium using the number of COEs available (also known as the COE quota), announced by the Land Transport Authority. The COE quota measures the supply of COEs in a given quarter, which is likely to be correlated with the price of the COE. However, the COEs are allocated by the government based on concerns about

[22] Based on data released by the Department of Statistics in Singapore, the proportion of resident working persons aged 15 years and over using a car to commute to work is the lowest in CBD area. This proportion generally increases as the distance to CBD increases, except for three spikes in car usage rate in areas concentrated with high income residents living in private condos and landed properties. For more information, see https://www.singstat.gov.sg/docs/default-source/default-document-library/publications/publications_and_papers/cop2010/census_2010_release3/cop2010sr3.pdf

[23] Specifically, we argue that housing prices for units farther away from the CBD can be negatively explained by COE premiums, $P_{far} = -aCOEP + u_1$, where $a > 0$. However, due to potential reverse causality issues, the following causation may also exist: $COEP = -bP_{far} + u_2$, where $b > 0$. In identifying the first equation, we may suffer from an omitted variable bias where the sign of the bias depends on $COV(COEP, u_1)$. Note that $COEP = -b(-aCOEP + u_1) + u_2$. We have $COEP = \frac{b}{ab-1}u_1 + \frac{1}{1-ab}u_2$, where $COV(COEP, u_1) > 0$ if $a > \frac{1}{b}$ and $COV(COEP, u_1) < 0$ if $a < \frac{1}{b}$. That is, the estimated coefficient of -a will be biased upwards (less negative) if the slope of the key equation is steeper and is biased downwards (more negative) if the slope of the key equation is flatter.

congestion and traffic in Singapore from past statistics, not expected house price appreciation throughout the city-country.[24] Therefore, we believe that the COE quota is a valid instrument for the COE premium.

To show that the price of the COE and the COE quota are correlated, in Figure 2.3 we plot the relationship between the COE premium and quota for vehicles in categories A, B, and E. As we see in this figure, these variables are highly negatively correlated, suggesting that as the number of COEs available increases, the COE premium decreases. We therefore can use the COE quota ($COEQ_t$) as an instrument for the COE premium ($COEP_t$), where we will use $COEQ_t$ and $DD_i \times COEQ_t$ to instrument for $COEP_t$ and $DD_i \times COEP_t$ in equation (1).

2.5 Data

To conduct our analysis, we rely on three datasets. The first dataset is transaction-level price data for all private residential transactions in Singapore from the Real Estate Information System (REALIS) maintained by the Urban Redevelopment Authority of Singapore (URA).[25] The REALIS database provides proprietary information on the universe of all residential property sales since January 1, 1995.[26] The data contains information on the transaction date, transaction price, unit attributes (project identity, building block, floor level, and living area), and project attributes (project size, location by postal district, completion date, and land title).

[24] One possible concern may be that traffic is a disamentiy, and since traffic tends to be concentrated in the CBD in many cities there may be a problem with our instrument. However, unlike most American and European cities, the Singaporean government is cognizant of traffic related issues and has implemented various policies to curb traffic congestion. The COE quota system and congestion pricing have been especially effective in ensuring good traffic conditions in Singapore. For more information on what has been done by the government in Singapore to curb congestion, see https://www.lta.gov.sg/content/ltaweb/en/roads-and-motoring/managing-traffic-and-congestion.html.

[25] https://spring.ura.gov.sg/lad/ore/login/index.cfm

[26] Sales are logged with the Singapore Land Authority (SLA) by the purchasers' lawyers shortly after the property is sold.

We aggregate the house price data to the project-quarter level. To do so, we compute the median floor-area-adjusted transaction price for all the units transacted within the same project in that quarter.[27] As discussed above, there are not many repeated house sales in Singapore. Therefore, we rely on the area-adjusted median price within a project to determine the average sale price of a unit within the building, as the units within the same project are very homogenous. We exclude transactions that took place under an en bloc sales (collective sales) agreement as they are not conducted in a standard market and thus may bias our results.[28]

The second dataset we utilize contains the COE bidding results from April 2002 to December 2015, which is publicly available from the Land Transport Authority.[29] This data contains the COE quota each auction, the number of successful bids, the number of bids received, and the COE premium for each vehicle category in each auction. To calculate the quarterly COE premium, we weight the COE premium in categories A and B by the number of successful bids in each category in each auction. We then take the average of all auctions that happened in a quarter to obtain the quarterly COE premium. The quarterly COE quota is calculated in the same manner.

The third dataset we use is the distance from each property to the city center, obtained from MapInfo, a GIS software developer. We first match the postal code of each building in the REALIS dataset with the postal code in MapInfo, and from this we obtain the distance from each building to the 141 MRT stations in Singapore.[30] We calculate the distance from each project to the Raffles Place MRT

---

[27] To calculate the area-adjusted price, we first divide the transaction price by its corresponding floor area. We then take the median of the area-adjusted price among all the transactions within a quarter for a particular project. We only keep records of projects that have at least three transactions each quarter to reduce the amount of noise in our estimates.

[28] En bloc sales refer to the sale of all the units within a housing development to a single party or a consortium/joint venture. The price of housing bought through an en bloc sale is usually higher than the market price.

[29] https://www.lta.gov.sg/content/dam/ltaweb/corp/PublicationsResearch/files/FactsandFigures/COE_Result_2005_2009.pdf and http://www.lta.gov.sg/content/dam/ltaweb/corp/PublicationsResearch/files/FactsandFigures/COE_Result_2010_2013.pdf

[30] Since Singapore is a small city-country, each building has a unique postal code.

station to determine the distance from each building to the CBD.[31] If a project has multiple buildings, we use the average distance from each building within a project to the city center as the distance measure for that project.[32] We also gather information on the distance to the closest MRT station. In one of our robustness checks, we restrict the sample to those properties that are more than 1,000 meters away from the closest MRT station. To determine the closest MRT station, we base our calculations on all 2015 proposed and existing stations. We use both proposed and existing MRT stations as there may be anticipatory effects of future subway stops on house prices. We combine these three data sets to create a panel data set of 2,543 projects from 2002Q2 to 2015Q4.

Table 2.1 provides summary statistics for the area-adjusted median house price, the COE premium, the COE quota, and the distance to the city center for the 43,073 observations in our sample. The average COE premium over our sample period is 38,826 SGD, which is almost four times the average of the area-adjusted median house price of 10,677 SGD. We see in Table 2.1 that there is a large amount of variation in the COE premiums during our sample period, ranging from 3,590 SGD to 83,425 SGD. The quarterly COE quota ranges from 3,894 to 24,503, with an average of 12,525 registrations. The average distance to the city center is approximately 7,000 meters if we use Raffles Place MRT station as the city center and is 6,470 meters if we use the City Hall MRT stop as the city center. Some properties are only 380 meters from the CBD, while the farthest units are 18,580 meters away.

2.6 Main Results

We begin our analysis by estimating equation (1), which gives us the effect of the COE price on the housing price gradient using a simple OLS regression. Results are presented in Table 2.2. Column (1) provides our baseline specification, which includes project fixed effects. In column (2) we include

[31] As a robustness check, we use the City Hall MRT station as the city center, using the same type of distance calculation.
[32] The buildings within a project are relatively close to one another, so distance does not vary much from building to building.

the property index for the private non-landed housing market to capture the market trend in house prices. In column (3) we add an annual time trend. Column (4) includes year-quarter fixed effects, and column (5) adds a planning area[33] specific linear time trend. T-statistics are reported in parentheses below each coefficient, which are calculated using standard errors clustered at the project level.

Looking at Table 2.2, we see that a higher COE premium is associated with a higher median price in a given private residential project. We also see that as the distance from the CBD increases, a higher COE premium is associated with a lower private non-landed housing price. This is consistent with results in the literature regarding the urban price gradient – that as the price of transportation (i.e. a car) increases, individuals will pay more for housing closer to the CBD (Coulson and Engle, 1987; Anas and Chu, 1984; Cortright, 2008; Molloy and Shan, 2010; Bradley, 2016).

However, as discussed above, there may be a reverse causality issue that would cause OLS estimates to be biased. To address this endogeneity issue and obtain unbiased coefficient estimates, we instrument for the COE premium with the COE quota released each quarter. Our first stage IV results are presented in Table 2.3a. As we see in this table, the signs are as expected and are highly significant, indicating that we have a valid instrument.

Table 2.3b presents the second stage coefficients from our IV regression. Across all specifications, we find consistent evidence of an urban price gradient. Note that these coefficients are larger than the OLS estimates produced in Table 2.2, indicating that the OLS coefficients have an upward bias. Based on the coefficient estimates in column (3) and the mean of the area-adjusted median house price, we find that if the COE premium increases by 30,000 SGD, which is how much the premium increased between 2009 and 2010, then the price of centrally located private non-landed housing increases by approximately 8.37%. However, for units that are 10 kilometers from the city center, the same increase in the COE premium is associated with only a 2.19% increase in house prices.

[33] There are 30 planning areas are in our sample, out of the 55 in Singapore.

In other words, the percent increase in the price of units 10 kilometers from the CBD is approximately four times less than the price increase of centrally located housing. The impact on the housing price gradient is consistent even after we adopt the richest controls in column (5), although in this case the fixed effects make us unable to identify the relationship between COE premium and house prices independent of distance.

2.7 Robustness Checks

To show that the results presented above are robust, we perform three additional tests.[34] First, in Table 2.4 we restrict our sample to projects that are more than 1,000 meters from the closest MRT station,[35] as these are the areas where individuals are the most likely to use a car for transportation. As we see in Table 2.4, when we restrict our sample to these units, we continue to find that as the price of a COE increases, individuals are willing to pay more for housing that is located closer to the city center.

In Table 2.5 we use an alternative definition of the CBD. In our initial regressions, we used the distance to the Raffles Place MRT station to calculate the distance between a housing project and the CBD because Raffles Place is the subway stop that is directly beneath the financial center of Singapore. To show that our results are not driven by our definition of the CBD, in Table 2.5 we use the City Hall MRT station as the city center to calculate our distance measures. The City Hall MRT stop is located close to Parliament and the Supreme Court and is considered to be the center of political activity in Singapore. As we see in Table 2.5, our results are robust to this alternative definition of the CBD.

Finally, in Table 2.6 we include vehicle categories A, B, and E to calculate the COE premium and quota. The majority of private vehicles use a COE from category A or B, as these categories are for personal vehicles. However, category E may be used for any type of vehicle, so it is possible that the

[34] Our sample changes slightly with each robustness check. We show in Appendix Tables A3, A4, and A5 the first stage results for each model. In all three models, our instrument continues to be strong.
[35] More than a 1,000 meter walking distance is often considered far and inconvenient to access public transportation hubs given the hot and humid weather conditions of Singapore.

price of a COE from category E is relevant. As we see in Table 2.6, our results are consistent when we include this category of COEs. Overall, our results are consistent across various specifications, suggesting that as the price of a COE increases, residents living in the non-landed, private property housing market in Singapore are willing to pay more to live closer to the CBD.

2.8 Conclusions

We estimate the house price gradient with regards to changes in the price of transportation, specifically the price of registering a car, in Singapore. Simply estimating the effect of the price of a car on house prices may suffer from a reverse causality issue, specifically if car ownership and housing farther from the city center are complementary goods. To address this concern, we focus on Singapore, which has a unique feature to its car registration process that allows us to obtain causal estimates. The Singaporean government, in an effort to curb traffic and congestion, requires all cars to have a Certificate of Entitlement (COE), which is a significant portion of the cost of acquiring a car and is one of the reasons the car ownership rate is low in Singapore. These COE registrations are rationed by the government based on growth and traffic concerns. Therefore, the COE quota is likely to be correlated with the COE price, and hence the price of a car, but uncorrelated with the price of housing, allowing us to use an instrumental variables strategy to obtain causal effects.

When we estimate the effect of the COE premium on house prices, we find that as the price of a COE increases, the price of housing farther from the CBD decreases. This is consistent with the predictions from the monocentric city model that allows for two modes of transportation. As the price of transportation increases, individuals will be willing to pay more to locate closer to the CBD, hence increasing house prices closer to the city center. We find that if the price of a COE increases by 30,000 SGD, then the percent increase in the price of housing for units 10 kilometers from the CBD is approximately four times less than the price increase of centrally located housing units. Overall, our findings suggest that the urban house price gradient responses to changes in the price of purchasing a car in Singapore. Policy makers need to be cognizant of the unintended consequences that traffic control policies, such as restricting the number of car registrations, have on residential house prices.

References

Agarwal, S., Koo, K.M. and Sing, T.F., 2015. Impact of electronic road pricing on real estate prices in Singapore. *Journal of Urban Economics*, 90, pp.50-59.

Alonso, William. 1964. Location and land use. Harvard University Press.

Anas, A. and Chu, C., 1984. Discrete choice models and the housing price and travel to work elasticities of location demand. *Journal of Urban Economics*, 15(1), pp.107-123.

Arnott, R., MacKinnon, J.G., 1978. Market and shadow land rents with congestion. *American Economic Review* 68, 588 – 600.

Bailey, M.J., Muth, R.F. and Nourse, H.O., 1963. A regression method for real estate price index construction. *Journal of the American Statistical Association*, 58(304), pp.933-942.

Baltagi, B.H. and Li, J., 2015. Cointegration of matched home purchase and rental price indexes – Evidence from Singapore. *Regional Science and Urban Economics*, 55, pp. 80-88.

Blake, T.B. 2016. Commuting costs and geographic sorting in the housing market. *Real Estate Economics*.

Brueckner, Jan K. 1987. The structure of urban equilibria: a unified treatment of the Muth-Mills model. In Handbook of Regional and Urban Economics. Vol II ed E.S. Mills. North-Holland.

Case, K.E. and Shiller, R.J., 1987. Prices of single family homes since 1970: New indexes for four cities (No. w2393). National Bureau of Economic Research.

Case, K.E. and Shiller, R.J., 1988. The efficiency of the market for single-family homes (No. w2506). National Bureau of Economic Research.

Coulson, N.E. and Engle, R.F., 1987. Transportation costs and the rent gradient. *Journal of Urban Economics*, 21(3), pp.287-297.

Chu, S., 2014. Mitigating supply and price volatilities in Singapore's vehicle quota system. *Transportation* 41 (5), 1119 – 1134.

Chu, S., 2015. Car restraint policies and mileage in Singapore. *Transportation Research Part A: Policy and Practice*, 77, pp.404-412.

Cortright, J. 2008. Driven to the Brink: How the Gas Price Spike Popped the Housing Bubble and Devalued the Suburbs. CEOs for Cities White Paper.

Cvijanović, D., 2014. Real Estate Prices and Firm Capital Structure. *Review of Financial Studies* 27, 2690-2735

De Lara, M.D., Palma, A.D., Kilani, M., Piperno, S., 2013. Congestion pricing and long term urban form: application to Paris region. *Regional Science and Urban Economics* 43, 282 – 295.

Eliasson, J., Hultkrantz, L., Rosqvist, L.S., 2009. Editorial. *Transportation Research Part A: Policy and Practice*, 43 (3), 237 – 239.

Ferdous, N., Pinjari, A. R., Bhat, C. R., & Pendyala, R. M., 2010. A comprehensive analysis of household transportation expenditures relative to other goods and services: an application to United States consumer expenditure data. *Transportation*, 37(3), 363-390.

Glaeser, E. and Kahn, M. (2004) "Sprawl and Urban Growth," in J. Vernon Henderson and Jacques-Fran cois Thisse (eds.), *Handbook of Urban and Regional Economics, Vol. IV*. New York: North-Holland, pp. 2481–2527.

Glaeser, E.L., Kahn, M.E. and Rappaport, J., 2008. Why do the poor live in cities? The role of public transportation. *Journal of Urban Economics*, 63(1), pp.1-24.

Guntermann, K.L., Liu, C., and Nowak, A.D., 2016. Price Indexes for Short Horizons, Thin Markets or Smaller Cities. *Journal of Real Estate Research* 38(1), pp. 93-127.

Larsen, M.M., Pilegaard, N. and Van Ommeren, J., 2008. Congestion and residential moving behaviour. *Regional Science and Urban Economics* 38(4), pp.378-387.

Jiang, L., Phillips, P.C.B., Yu, J., 2015. New methodology for constructing real estate price indices applied to the Singapore residential market. Journal of Banking & Finance 61, Supplement 2, S121-S131

Kochhan, R., Lim, J., Knackfuß, S., Gleyzes, D. and Lienkamp, M., 2014. Total Cost of Ownership and Willingness-to-Pay for Private Mobility in Singapore. In Sustainable Automotive Technologies 2013 (pp. 251-261). Springer International Publishing.

Mian, A., Sufi, A., 2011. House Prices, Home Equity-Based Borrowing, and the US Household Leverage Crisis. *American Economic Review* 101, 2132-56

Mian, A., Rao, K., Sufi, A., 2013. Household Balance Sheets, Consumption, and the Economic Slump. *The Quarterly Journal of Economics*, 1687-1726

Mills, Edwin S. 1967. An aggregative model of resource allocation in a Metropolitan area. *American Economic Review* 57: 197-210.

Molloy, R. and Shan, H., 2013. The Effect of Gasoline Prices on Household Location. *Review of Economics and Statistics*, 95(4), pp.1212-1221.

Muth, Richiard F. 1969. Cities and housing. University of Chicago Press.

Saleh, W., 2007. Success and failure of travel demand management: is congestion charging the way forward? *Transportation Research Part A: Policy and Practice*, 41 (7), 611 – 614.

Saiz, A., 2010. The geographic determinants of housing supply. *Quarterly Journal of Economics* 125(3), 1253-1296.

Small, K.A., Verhoef, E.T., 2007. The economics of urban transportation Routledge, London and New York.

Tse, C.Y, Chan, A.W.H. 2003. Estimating the community cost and commuting time property price gradients. *Regional Science and Urban Economics*, 33(6), 745-767.

Verhoef, E.T., 2002. Second-best congestion pricing in general static transportation networks with elastic demand. *Regional Science and Urban Economics* 32, 281 – 310.

Wheaton, William C. 1974. A comparative static analysis of urban spatial structure. *Journal of Economic Theory* 9: 223-237.

Figure 2.1: Bid Rent Function with One Mode of Transportation

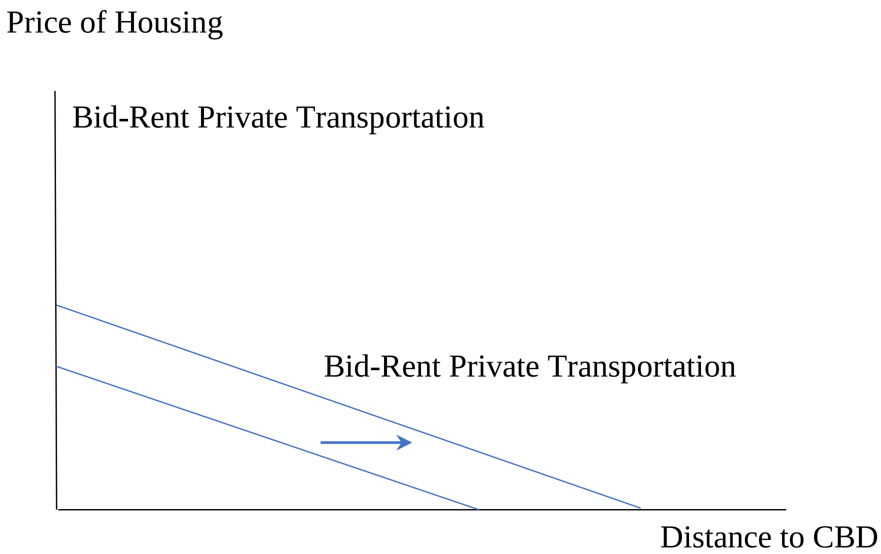


Figure 2.2: Bid Rent Function with Two Modes of Transportation

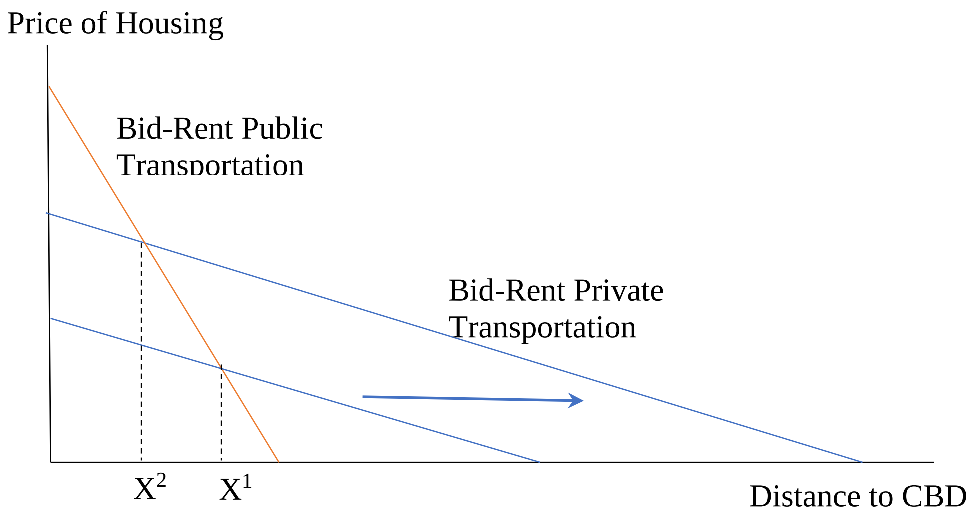
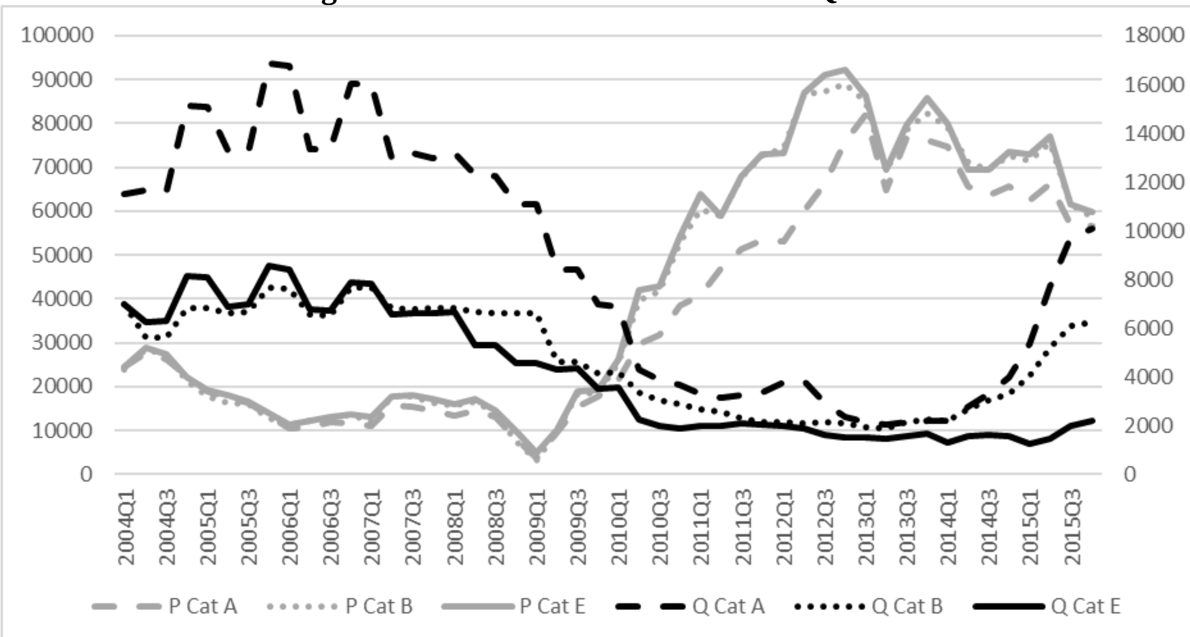


Figure 2.3: COE Premiums and COE Quotas



Notes: This figure presents COE premiums trends and COE quotas from 2004 quarter 1 in Singapore. The data is from http://coe.sgcharts.com/ based on Results of Bidding Exercises for Certificates of Entitlement from Land Transport Authority.

Table 2.1: Summary Statistics

	Observations	Mean	Std. Dev.	Min	Max
Area-adjusted Median Transaction Price[1]	43,073	10,677.39	5,742.30	1,150	73,629
COE Premium	43,073	38,826.45	24,786.63	3,589.50	83,425.49
COE Quota	43,073	12,524.66	66,77.38	3,894.00	24,503.00
Distance to Downtown Raffles Place MRT[2]	43,073	7.00	3.93	0.38	18.58
Distance to Downtown City Hall MRT[2]	43,073	6.47	3.88	0.10	17.64
Housing Price Index	43,073	118.77	24.71	79.60	148.90

[1] Area adjustment is achieved by dividing the unit transaction price by the corresponding floor area.
[2] Distance is measured in kilometers.

Table 2.2: OLS Regressions
Dependent Variable: Area-adjusted Median Transaction Price
(t statistics are reported in parentheses using clustered standard errors at the project level)

	(1)	(2)	(3)	(4)	(5)
COE Premium	0.0947***	0.0309***	0.0298***	-	-
	(53.77)	(17.57)	(17.40)	-	-
COE Premium × Distance to Downtown	-0.0018***	-0.0021***	-0.0022***	-0.0022***	-0.0029***
	(-10.82)	(-13.60)	(-13.64)	(-13.91)	(-10.25)
Housing Price Index	-	92.6842***	85.5108***	-	-
	-	(52.38)	(40.56)	-	-
Year Trend	NO	NO	YES	NO	NO
Year × Quarter Fixed Effects	NO	NO	NO	YES	YES
Year Trend × Planning Area	NO	NO	NO	NO	YES
Project Fixed Effects	YES	YES	YES	YES	YES
Observations	43,073	43,073	43,073	43,073	43,073
R-squared	0.450	0.699	0.700	0.712	0.789

Table 2.3a: IV Regressions – First Stage
(t statistics are reported in parentheses using clustered standard errors at the project level)

	(1)		(2)		(3)		(4)	(5)
	COE Premium	COE Premium × Distance to DT	COE Premium	COE Premium × Distance to DT	COE Premium	COE Premium × Distance to DT	COE Premium × Distance to DT	COE Premium × Distance to DT
COE Quota	-2.8581***	0.5720***	-2.0146***	6.6435***	-2.1075***	5.9628***	-	-
	(-163.36)	(4.84)	(-114.17)	(36.64)	(-134.24)	(36.88)	-	-
COE Quota × Distance to DT	-0.0095***	-3.0277***	-0.0051**	-2.9956***	-0.0039**	-2.9873***	-2.9591***	-2.3285***
	(-4.93)	(-148.27)	(-2.56)	(-148.68)	(-2.22)	(-161.57)	(-248.18)	(-82.77)
Housing Price Index	-	-	350.1318***	2,520.4106***	-56.2757***	-457.9634***	-	-
	-	-	(79.44)	(48.11)	(-9.93)	(-10.08)	-	-
Year Trend	NO	NO	NO	NO	YES	YES	NO	NO
Year × Quarter Fixed Effects	NO	NO	NO	NO	NO	NO	YES	YES
Year Trend × Planning Area	NO	NO	NO	NO	NO	NO	NO	YES
Project Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	43,073	43,073	43,073	43,073	43,073	43,073	43,073	43,073
R-squared	0.640	0.648	0.698	0.693	0.732	0.720	0.916	0.986

Table 2.3b: IV Regressions – Second Stage
Dependent Variable: Area-adjusted Median Transaction Price
(t statistics are reported in parentheses using clustered standard errors at the project level)

	(1)	(2)	(3)	(4)	(5)
COE Premium	0.1196***	0.0447***	0.0454***	-	-
	(54.17)	(21.37)	(21.55)	-	-
COE Premium × Distance to Downtown	-0.0032***	-0.0034***	-0.0034***	-0.0034***	-0.0037***
	(-15.20)	(-17.68)	(-17.73)	(-17.98)	(-10.07)
Housing Price Index	-	88.9396***	82.3325***	-	-
	-	(47.47)	(38.26)	-	-
Year Trend	NO	NO	YES	NO	NO
Year × Quarter Fixed Effects	NO	NO	NO	YES	YES
Year Trend × Planning Area	NO	NO	NO	NO	YES
Project Fixed Effects	YES	YES	YES	YES	YES
Observations	43,073	43,073	43,073	43,073	43,073

Table 2.4: IV Regressions Second Stage – Projects Beyond 1,000 Meters of the Closest MRT Station
Dependent Variable: Area-adjusted Median Transaction Price
(t statistics are reported in parentheses using clustered standard errors at the project level)

	(1)	(2)	(3)	(4)	(5)
COE Premium	0.1283***	0.0604***	0.0612***	-	-
	(26.75)	(15.52)	(15.44)	-	-
COE Premium × Distance to Downtown	-0.0041***	-0.0040***	-0.0041***	-0.0040***	-0.0035***
	(-9.90)	(-11.54)	(-11.56)	(-11.65)	(-6.03)
Housing Price Index	-	78.0234***	71.3582***	-	-
	-	(25.51)	(19.64)	-	-
Year Trend	NO	NO	YES	NO	NO
Year × Quarter Fixed Effects	NO	NO	NO	YES	YES
Year Trend × Planning Area	NO	NO	NO	NO	YES
Project Fixed Effects	YES	YES	YES	YES	YES
Observations	12,099	12,099	12,099	12,099	12,099

Table 2.5: IV Regressions Second Stage – City Hall MRT Station as the City Center
Dependent Variable: Area-adjusted Median Transaction Price
(t statistics are reported in parentheses using clustered standard errors at the project level)

	(1)	(2)	(3)	(4)	(5)
COE Premium	0.1177***	0.0427***	0.0434***	-	-
	(55.46)	(20.96)	(21.16)	-	-
COE Premium × Distance to Downtown	-0.0032***	-0.0033***	-0.0033***	-0.0034***	-0.0036***
	(-14.83)	(-17.18)	(-17.23)	(-17.48)	(-9.75)
Housing Price Index	-	88.9397***	82.3076***	-	-
	-	(47.44)	(38.28)	-	-
Year Trend	NO	NO	YES	NO	NO
Year × Quarter Fixed Effects	NO	NO	NO	YES	YES
Year Trend × Planning Area	NO	NO	NO	NO	YES
Project Fixed Effects	YES	YES	YES	YES	YES
Observations	43,073	43,073	43,073	43,073	43,073

Table 2.6: IV Regressions Second Stage – Vehicle Categories A, B, and E
Dependent Variable: Area-adjusted Median Transaction Price
(t statistics are reported in parentheses using clustered standard errors at the project level)

	(1)	(2)	(3)	(4)	(5)
COE Premium	0.1199***	0.0448***	0.0449***	-	-
	(53.82)	(21.79)	(21.74)	-	-
COE Premium × Distance to Downtown	-0.0032***	-0.0035***	-0.0035***	-0.0035***	-0.0036***
	(-15.25)	(-18.16)	(-18.21)	(-18.47)	(-9.92)
Housing Price Index	-	88.7099***	81.7859***	-	-
	-	(46.98)	(37.18)	-	-
Year Trend	NO	NO	YES	NO	NO
Year × Quarter Fixed Effects	NO	NO	NO	YES	YES
Year Trend × Planning Area	NO	NO	NO	NO	YES
Project Fixed Effects	YES	YES	YES	YES	YES
Observations	43,073	43,073	43,073	43,073	43,073

Appendix A

Table A1: Calculation of COE Quota Premium[1]

Reserve Price	Bid Status	Remarks
S$100	Successful	Only the first 2 bids will be successful. The COE Price (or Quota Premium) will be S$71. The 3rd and 4th bids (both with reserve price of S$70) are not accepted as then the number of successful bids would exceed the COE Quota of 3. The remaining 1 unallocated COE Quota will be carried forward to the next corresponding COE bidding exercise in the following month (i.e. 2nd COE Open Bidding Exercise in month (N+1).
$88	Successful	
$70	Unsuccessful	
$70	Unsuccessful	
$41	Unsuccessful	

[1] An example: COE Quota for Category A = 3. Number of bidders = 5 with reserve prices of S$100, S$88, S$70, S$70 and S$41. Source of the example: Land Transport Authority of Singapore.

Table A2: Cost of a New Mid range – Car with 7-year Usage in Singapore

Main Components		Singapore Dollars
	OMV (open market value)	16,000
	Customs duty	3,200
	Goods and services tax	1,344
	ARF (additional registration fee)	16,000
	Registration fee	170
	CEVS (carbon emission-based vehicle scheme)	5,000
	COE[1]	63,630
	Retailer margin	16,800
Acquisition costs	Total	122,144
Total operating costs		61,530
Resale value incl. tax refund		-33,673
Total cost		150,001
Total cost/km		1.13

Source: Kochhan, R., Lim, J., Knackfuß, S., Gleyzes, D. and Lienkamp, M., 2014. Total Cost of Ownership and Willingness-to-Pay for Private Mobility in Singapore. In Sustainable Automotive Technologies 2013 (pp. 251-261). Springer International Publishing.
[1]This is based on the average 2012 COE bidding results.

Table A3: IV Regressions First Stage – Projects Beyond 1,000 Meters of MRT Station
(t statistics are reported in parentheses using clustered standard errors at the project level)

	(1)		(2)		(3)		(4)	(5)
	COE Premium	COE Premium × Distance to DT	COE Premium	COE Premium × Distance to DT	COE Premium	COE Premium × Distance to DT	COE Premium × Distance to DT	COE Premium × Distance to DT
COE Quota	-2.8279***	0.8060***	-1.9946***	8.3297***	-2.1041***	7.3331***	-	-
	(-70.22)	(2.73)	(-49.17)	(21.54)	(-58.91)	(21.48)	-	-
COE Quota × Distance to DT	-0.0117***	-3.0412***	-0.0086**	-3.0131***	-0.0059*	-2.9884***	-2.9375***	-2.4691***
	(-3.06)	(-80.71)	(-2.21)	(-80.02)	(-1.70)	(-87.90)	(-138.20)	(-51.86)
Housing Price Index	-	-	338.5273***	3,056.3486***	-65.1444***	-616.4223***	-	-
	-	-	(46.42)	(33.31)	(-6.51)	(-6.43)	-	-
Year Trend	NO	NO	NO	NO	YES	YES	NO	NO
Year × Quarter Fixed Effects	NO	NO	NO	NO	NO	NO	YES	YES
Year Trend × Planning Area	NO	NO	NO	NO	NO	NO	NO	YES
Project Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	12,099	12,099	12,099	12,099	12,099	12,099	12,099	12,099
R-squared	0.648	0.654	0.704	0.702	0.737	0.731	0.949	0.991

Table A4: IV Regressions First Stage – City Hall MRT Station as the City Center
(t statistics are reported in parentheses using clustered standard errors at the project level)

	(1)		(2)		(3)		(4)	(5)
	COE Premium	COE Premium × Distance to DT	COE Premium	COE Premium × Distance to DT	COE Premium	COE Premium × Distance to DT	COE Premium × Distance to DT	COE Premium × Distance to DT
COE Quota	-2.8573***	0.5204***	-2.0136***	6.1534***	-2.1072***	5.5148***	-	-
	(-170.22)	(5.14)	(-118.62)	(36.78)	(-139.09)	(36.99)	-	-
COE Quota × Distance to DT	-0.0104***	-3.0295***	-0.0056***	-2.9977***	-0.0043**	-2.9885***	-2.9600***	-2.3329***
	(-5.34)	(-156.25)	(-2.81)	(-155.85)	(-2.38)	(-168.72)	(-253.64)	(-82.66)
Housing Price Index	-	-	350.1057***	2,337.4053***	-56.2764***	-433.1928***	-	-
	-	-	(79.42)	(46.20)	(-9.93)	(-10.17)	-	-
Year Trend	NO	NO	NO	NO	YES	YES	NO	NO
Year × Quarter Fixed Effects	NO	NO	NO	NO	NO	NO	YES	YES
Year Trend × Planning Area	NO	NO	NO	NO	NO	NO	NO	YES
Project Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	43,073	43,073	43,073	43,073	43,073	43,073	43,073	43,073
R-squared	0.640	0.649	0.698	0.692	0.732	0.719	0.908	0.985

Table A5: IV Regressions First Stage – Vehicle Categories A, B, and E
(t statistics are reported in parentheses using clustered standard errors at the project level)

	(1)		(2)		(3)		(4)	(5)
	COE Premium	COE Premium × Distance to DT	COE Premium	COE Premium × Distance to DT	COE Premium	COE Premium × Distance to DT	COE Premium × Distance to DT	COE Premium × Distance to DT
COE Quota	-2.2869***	0.4787***	-1.7299***	4.4214***	-1.7400***	4.3473***	-	-
	(-166.39)	(5.41)	(-122.94)	(33.76)	(-130.62)	(34.60)	-	-
COE Quota × Distance to DT	-0.0077***	-2.4267***	-0.0042***	-2.4018***	-0.0030*	-2.3931***	-2.3713***	-1.8776***
	(-5.22)	(-161.48)	(-2.60)	(-153.83)	(-1.95)	(-157.73)	(-264.00)	(-83.79)
Housing Price Index	-	-	288.0990***	2,039.1012***	-5.4179	-97.1091**	-	-
	-	-	(67.20)	(47.35)	(-0.95)	(-2.27)	-	-
Year Trend	NO	NO	NO	NO	YES	YES	NO	NO
Year × Quarter Fixed Effects	NO	NO	NO	NO	NO	NO	YES	YES
Year Trend × Planning Area	NO	NO	NO	NO	NO	NO	NO	YES
Project Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Observations	43,073	43,073	43,073	43,073	43,073	43,073	43,073	43,073
R-squared	0.682	0.693	0.714	0.717	0.733	0.731	0.927	0.987

Chapter 3 Home Equity and the Timing of Claiming Social Security Retirement Income

(Coauthored with Jing Li and Amanda Ross)

3.1 Introduction

It is widely recognized that the United States, like many other countries, is moving into an aging society. The proportion of individuals over the age of 65 in the U.S. rose from 8% in 1950 to 13% in 2010 and is expected to rise to over 20% by 2030 as the Baby Boomer generation continues to age (Lee, 2014). The rapid increase in the share of the elderly population is something policy makers are cognizant of, as it raises concerns regarding the financial readiness of the retirement system for a dramatic increase in individuals filing for Social Security. Among the various sources of financial assets of the elderly, Social Security Retirement Income (SSRI) and home equity are the two largest components of an elderly household's balance sheet.[36] Therefore, a better understanding of how elderly households utilize these assets has become increasingly important when designing policy.

This paper studies the extent to which elderly households make decisions on financing retirement using SSRI and housing equity. Elderly individuals who need additional wealth and are at the eligible age to receive Social Security can choose to start receiving SSRI. However, if these individuals start receiving SSRI as soon as they become eligible, the monthly benefit is lower than if the individual delayed a few years.[37] We examine if elderly individuals are more likely to start receiving SSRI later when house prices increase. In other words, our research examines the trade-off between these two assets, as elderly individuals may choose to draw upon

[36] Retirement support includes pensions, housing equity, financial equity, and other savings. Social security retirement income and home equity are the two largest components of household balance sheet, especially for the bottom two-thirds of the wealth distribution for households aged 65-69 (Poterba 2014).

[37] Sixty two is the age when individuals become eligible to receive SSRI. Sixty five is generally considered as the full retirement age (varies slightly across cohorts). If individuals delay receiving SSRI from 62 to 65, for example, the benefit level as a percent of the primary insurance amount would rise from 80% to 100% accordingly. We will describe the specifics of the program and how the benefits vary based on the age individuals start to claim SSRI later in the paper.

their home equity and delay receiving SSRI benefits when the value of their house increases. Studying this issue will allow us to gain a better understanding of the substitutability of these two assets as a source of income for the aged population. The implications of our research are important for policy makers, as our findings will aid in designing suitable policies to help the rising number of senior citizens adjust to fluctuations in the price of housing.

We focus on the role of home equity to finance retirement life due to the rising importance of home equity in the investment portfolio of the elderly. Based on the Survey of Income and Program Participation (SIPP), the average ratio of home equity to total household net worth was 36.07% in 2005 for individuals under the age of 35 and this ratio increased to more than 45% as individuals reach 65 years old (shown in Figure 1). Due to the fact that the elderly had a larger amount of home equity prior to the Great Recession, they suffered a more substantial decrease in total assets after the decline in real estate prices in 2007 (also shown in Figure 1). The deterioration in home equity likely impacts elderly individuals directly through the wealth effect and indirectly through the home equity-based borrowing channel (Mian, Rao, and Sufi, 2013). The latter implies that a decline in house values reduces the ability and amount that the elderly can receive through home equity loans to finance their retirement expenses.

For senior citizens, one way to supplement income if there is a decline in house value is to adjust when they start receiving SSRI. Individuals are eligible to receive SSRI at the early retirement age of 62. However, they may choose to delay the withdrawal decision to the full retirement age[38] since delaying the receipt of benefits will increase the amount received in each pay check. Research has shown that there are peaks in Social Security benefits claiming at the

[38] Full retirement age varies between 65 and 66, depending on when the individual was born. But social health insurance, Medicare, which provides benefits for Americans aged 65 and older, may also be a factor that affects the decision to retire at age 65 (Madrian, Burtless, and Gruber, 1994; Rust and Phelan, 1997; Blau and Gilleskie, 2006 and 2008; French and Jones, 2011).

beginning of the eligibility age and the full retirement age (Behaghel and Blau, 2012). During the housing boom period from 2000 to 2006, the take-up rate[39] at the age 62 declined from 45% to 38%. The early take-up rate rose again to 42% in 2009 during the housing bust period (Coe and Rutledge, 2012). These statistics suggest that elderly individuals are more likely to delay receiving Social Security when housing appreciates in value and may start to withdraw early when experiencing housing market downturns.

However, there are likely to be endogeneity issues present when considering interactions between housing wealth and SSRI withdrawal decisions. Specifically, there may be unobserved local demand shocks that are correlated with changes in house prices that also affect when an elderly individual decides to start receiving SSRI. For example, when house prices decline in an area, it is likely that the local economy is experiencing a negative demand shock in both the labor market and housing market. Therefore, this shock may affect the labor market opportunities and the income of elderly households, which will affect the likelihood of claiming SSRI, while simultaneously affecting local house prices.

To address this endogeneity problem, we utilize an instrumental variables strategy. We draw upon geographic variation in the land supply elasticity of an MSA, developed by Saiz (2010), as the topological characteristics of an area are not likely to be correlated with local demand shocks to the economy. We interact this supply elasticity measure with the change in the national house price index and use this interaction term as an instrument for the change in local house prices. Our identifying assumption is that the cross-sectional variation in local house

[39] The ratio of new claimants at the end of the year to the eligible individuals who had not claimed at the beginning of the year.

prices from the national average is driven by differences in local land supply elasticities, which is not correlated with time-varying local economic activity.[40]

We find that larger increases in house prices are associated with delayed SSRI claiming during the boom period from 2002-2006. During the bust period from 2007-2009, we do not find a statistically significant effect on SSRI claiming, which is consistent with the idea that the cashing-out of home equity is only a viable channel to finance retirement when house prices appreciate. Specifically, we find that if the housing value increases by 10% in the previous two years leading to the eligibility year, the probability of claiming SSRI within one year once they become eligible reduced by 0.05, and the probability of claiming SSRI within two years reduced by 0.06. Our findings are consistent across various specifications. Overall, our results suggest that when house prices increase, and thus home equity, elderly individuals delay receipt of SSBI.

We have further extended our work to look into the impact of home equity on retirement decisions.[41] We find that larger increases in house prices are associated with earlier retirement during the boom period. Similarly, we find that when house prices depreciate during the bust period, individuals retire later but the effect is of a smaller magnitude. These results are consistent with retirement decisions cycling with market fluctuations potentially due to wealth effects. However, during the market boom period, given the additional channel to cash-out home equity, senior citizens tend to be more responsive to the accumulated home equity and are more likely to retire early. We also show that pension eligibility plays a role in the impact of house price appreciation on retirement decisions.

---

[40] This instrument has been used previously in the literature by Mian and Sufi (2011), Chaney, Sraer, and Thesmar (2012), Mian, Rao, and Sufi (2013), and Cvijanović (2014).

[41] Recent research has studied the relationship between housing wealth and the retirement and/or labor supply decision (Ondrich and Falevich, 2016; Zhao and Burge, 2017a; Zhao and Burge, 2017b). These papers utilize other identification strategies, which we will discuss in detail later in the paper.

Our research contributes to the existing literature by highlighting the trade-off that elderly households make when deciding whether to draw upon housing equity in retirement or to start receiving Social Security benefits. The majority of the existing literature has focused primarily on the relationship between local labor market shocks and the decision to withdraw SSRI, with any discussion of home equity being a secondary consideration (Coile and Levine, 2007, 2011a, 2011b; Goda, Shoven and Slavov, 2011). Another strand of literature focusing on the role of home equity has examined how changes in house prices affects the decision to retire and leave the labor market (Disney, Ratcliffe, and Smith, 2015; Farnham and Sevak, 2007; Ondrich and Falevich, 2016; Zhao and Burge, 2017a; Zhao and Burge, 2017b). We expand upon this literature by directly drawing a link between how elderly individuals make the decision to start receiving SSRI benefits versus using their home equity to finance expenditures. Previous literature has found little evidence that elderly households draw down their housing equity to finance their expenses (Venti and Wise 1989, 1991, and 2004; Sheiner and Weil, 1993; Hurd, 2002). However, our research conducts analysis separately for boom and bust period and uses a more robust identification strategy through an instrumental variables approach to obtain causal estimates of the effect of house price fluctuations on the decision to receive SSRI.

The rest of the paper will proceed as follows. Section 2 discusses the institutional details of Social Security Retirement Income in the United States, as well as literature related to SSRI claiming, retirement, and home equity of the elderly. We discuss our data in Section 3 and our identification strategy is outlined in Section 4. Section 5 describes our main results and we show a series of robustness checks in Section 6. Section 7 concludes.

3.2 Social Security Retirement Income in the United States

Individuals are eligible to receive SSRI if they have been working for at least ten years and are at least 62 years old.[42] The amount of Social Security benefits received is based on the worker's average indexed earnings over the highest amount he or she earned over 35 years. However, the benefit amount is then adjusted based on when the individual starts receiving SSRI, penalizing individuals for claiming before the full retirement age (FRA) of 65. Furthermore, workers can receive additional benefits if they delay receiving OASI payments beyond age 65, increasing benefits each year with a cap at 70 years old (Song and Manchester, 2007).[43]

The Social Security Advisory Board summarizes the decision an elderly individual has to make by stating that: "If you withdraw early, you may not have enough income to enjoy the years ahead of you. Likewise, if you withdraw late, you'll have a larger income, but fewer years to enjoy it. Everyone needs to find the right balance based on his or her own circumstances" (Social Security Advisory Board 2009). The AARP website begins its advice about when to claim Social Security benefits with the statement: "If you're healthy and can afford it, you should consider waiting until you reach your full retirement age."[44]

Several changes were made to the program in 2000. First, the retirement earnings test, which penalized individuals for working while receiving Social Security through lower benefits, was removed for individuals who did not receive benefits until after the full retirement age. The second change was that the FRA was increased, based on the year of birth of the individual. However, the earliest age at which an individual could receive Social Security remained at 62. In this paper, we focus on the decision to withdraw SSRI within one or two years once individuals reach 62 years old.

[42] Originally, workers could not claim SS benefits until the age of 65. However, in 1962 the program was adopted to allow workers to retire at age 62 at a reduced benefit.
[43] There is an ongoing debate regarding whether the penalties for early take-up are actuarially fair. For more information on this literature and debate, see Myers and Schobel (1990) and Goda, Shoven, and Slavov (2012).
[44] http://www.aarp.org/work/social-security/info-12-2010/top-25-social-security-questions.5.html.

In addition to receiving SSRI, individuals may have pension accounts and other retirement benefits through their employers.

3.3 Theoretical Background

As Social Security has become an increasingly important policy in the U.S., there has been a growing literature examining what affects an individual's decision to start receiving SSRI, given that delaying results in higher benefits. Crawford and Lilien (1981) have argued that the main reason individuals start receiving SSRI is a liquidity constraint, where low-income workers do not save enough while working and therefore claim earlier to finance consumption during retirement. Individuals with longer life expectancy also tend to delay claiming SSRI (Munnell and Soto, 2005). Hurd, Smith, and Zissimopoulos (2004) show that subjective assessments of mortality risk are associated with early retirement and early claiming. Behavioral economists argue that the decision is affected by the institutional details of Social Security system. Brown, Kapteyn, and Mitchell (2011) show that when an individual self-reports that he/she will start claiming SSRI depends on the way in which the decision is framed. Other explanations include reference dependence with loss aversion, where individuals have a frame regarding when they will retire and chose to start claiming at that age, regardless of what may be the optimal strategy to maximize lifetime utility (Behaghel and Blau, 2012). Publically provided health insurance, specifically Medicare, may also affect the timing of retirement. Most workers lose employer-provided health insurance upon retiring. Therefore, workers may delay retirement until age 65 not because of the SSRI benefits, but to ongoing health insurance coverage (Madrian, Burtless, and Gruber, 1994; Rust and Phelan, 1997; Blau and Gilleskie, 2006 and 2008; French and Jones, 2011).

However, there is little evidence on the effect of wealth, specifically unexpected shocks to wealth, on claiming SSRI. Previous literature examining the impact of wealth shock on elderly individuals has mainly focused the decision to retire. Imbens, Rubin, and Sacerdote (2001) find significant labor supply effects of winning the lottery, particularly among individuals aged 55 to 65. Sevaj (2002) exploits the bull market of the 1990s to study the effect of unexpected capital gains on retirement timing. He shows that increases in wealth led to increases in the probability of retirement among individuals ages 55 to 60.

The decision to retire and the timing of receiving SSRI are intertwined. Hurd and Boskin (1981) find that the Social Security benefit increases from 1969 to 1972 can explain a large amount of the acceleration of the number of people retiring in that period. Chan and Stevens (2008) find that individuals' retirement ages respond to pension incentives. The Social Security's Delayed Retirement Credit raised employment rates among workers over age 65 and the Social Security reform in 1983 that increased the Normal Retirement Age (NRA) tended to increase the retirement age (Pingle 2006, Mastrobuoni 2009). Coile and Levine (2007) show that retirements increase in response to an increase in the unemployment rate, only when workers hit age 62, suggesting that access to SSRI benefits may allow older workers to weather the financial shock associated with job loss by retiring.

A significant segment of the population appears to be income-poor and house-rich (Mayer and Simons, 1994; Merrill, Finkel, and Kutty, 1994), so drawing upon housing equity is a potentially important source of wealth for the elderly. Older households have a larger fraction of housing equity that they can use to fund home equity loans and obtain reverse mortgages (Sinai 2007). There is an extensive literature examining the relationship between housing wealth and consumption and savings decisions (Engelhardt, 1996; Case, Quigley, and Schiller, 2005;

Jiang, Sun, and Webb, 2011). A number of more recent papers have examined the effect of changes in housing wealth on retirement, but have found mixed results. Disney, Ratcliffe, and Smith (2015) uses data from the United Kingdom to look at cyclical fluctuations in asset prices and the labor market on retirements but they find little evidence of any positive wealth effects. However, the authors do not address the endogeneity between housing price and retirement decision, possibly causing their estimates to be biased. Goda, Shoven and Slavov (2011) find no effect of housing wealth on the retirement decision during the Great Recession. However, Farnham and Sevak (2007) find that increase in housing wealth is associated with a reduction in expected retirement age.

In this paper, we expand upon the existing literature by using a robust instrument to explore the direct substitutability between cashing-out home equity and receiving SSRI benefits with extensions to concurrent implications on retirement.

3.4 Empirical Strategy

We are interested in determining the degree to which changes in the value of a home affects the decision of an elderly individual to begin to receive SSRI. Recently, the U.S. experienced an extreme increase in house price, followed by a dramatic decrease that had never been seen before in the country. We look how the boom period (2002 to 2006), when house prices were increasing, affected the timing of beginning to receive SSRI for elderly individuals and the timing of retirement. Then, we look at if there were different effects on these decisions during the bust period (2007 to 2009), when house prices dropped dramatically.

Specifically, we consider the impact of a percentage change in housing values on SSRI claiming once individuals are eligible. To do so, we estimate the following Probit regressions:

$$claim_t^{i,m} = \Phi\left(\beta_1 \Delta\% HNW_t^{i,m} + \gamma_1 X_t^{i,m} + \gamma_s + \delta_t + \varepsilon_t^{i,m}\right) \quad (1)$$

Where Φ is the standard normal cumulative distribution, $claim_t^{i,m}$ in specification (1) is an indicator variable equal to one if individual *i*, living in MSA *m*, began receiving Social Security benefits within one or two years of reaching age 62 in year *t*. $\Delta\%HNW_t^{i,m}$ is the percentage change in house value in the previous two years for individual *i*, living in MSA *m* in year *t*. We use the two-year change in house prices due to the fact that our data, the Health and Retirement Survey, is a biannual survey. We also include controls for individual attributes, $X_t^{i,m}$, such as gender, race, marital status, tenure in the last job, education, and total non-housing wealth, to control for individual heterogeneity. We use state fixed effect γ_s to control for unobservable state specific attributes and year fixed effects δ_t to capture unobservable variables that are specific to a given year.

However, there are likely to be endogeneity issues present in the simple Probit model. Specifically, there are likely to be unobserved local demand shocks that are correlated with housing price changes and other sources of income such as waged salaries and the value of other, non-housing assets. For example, if an area is experiencing a recession, this is likely to impact both the price of housing and employment opportunities. Therefore, we believe that a simple probit or OLS model will produce biased estimates, as there are likely to be omitted variables in the error term.

To address this endogeneity issue, we employ an instrumental variables strategy. For our instrument, we use the land topology-based measure of housing supply elasticity introduced by Saiz (2010) interacted with the change in the national housing price index. For a given shift in housing demand, an MSA with a more inelastic housing supply (i.e. an area with more mountains or near water such as New York City, NY or San Francisco, CA) should experience large house price changes than the national change in house prices, while MSAs with a more elastic housing supply (i.e. flat areas such as Houston, TX) should experience a more modest change. This measure of the supply elasticity is likely to be exogenous to local demand shocks, as this is a supply-side measure versus a demand-side measure. In addition, national house prices are likely to be correlated with local house prices, but not necessarily other local demand factors such as the local labor market. This interaction term has been used previously in the literature by Mian and Sufi (2011, 2013, 2014), Chaney, Sraer, and Thesmar (2012) and Cvijanovi (2014) as an instrument for changes in local house prices.

Therefore, we use the following specification for our first stage regression:

$$\Delta\%HNW_t^{i,m} = \rho_1 \Delta\%P_t^{US} \times Elasticity^m + \rho_2 X_t^{i,m} + \gamma_s + \delta_t + \nu_t^{i,m} \qquad (2)$$

where $\Delta\%P_t^{US}$ is the percentage change in the national housing price index in the previous two years, $Elasticity^m$ is the Saiz (2010) estimate of the housing supply elasticity in MSA m, γ_s is a state fixed effect and δ_t represents time fixed effects. ν_t captures omitted variables in household housing wealth change.

3.5 Data and Summary Statistics

This study uses restricted access data from the Health and Retirement Study (HRS) from 1992 to 2012. Given that the instrumental variable we employ is at the MSA level, we need to use the restricted data to have the necessary geographic detail to conduct our analysis. The HRS is a longitudinal household data set of more than 26,000 Americans over the age of 50 every two years. The sample we use in our analysis includes a total of 19,787 individuals after preliminary screening.[45]

[45] We start with a sample of 37,319 elderly individuals. We exclude 4,969 individuals who report receiving Social Security benefits before 62 years old. We also exclude the 706 respondents who report ever receiving disability retirement benefits. Further, we include only individuals whom we observe before they turn 60 (two years before the eligibility age for pension withdrawal), which causes us to lose another 11,857 respondents.

The HRS data is an extraordinarily rich data set on the retirement decisions and health status of the elderly in the United States. We draw upon a few key variables for our analysis. Table 3.1 presents summary statistics of these variables. Looking at this table, we see that over 54% of people claim SSRI benefits within one year of becoming eligible and 64% claim SSRI within two years of becoming eligible. In a given year, 38% of the sample had retired and left the labor force. The average percentage change in housing value over two years is 10%. However, we see in Table 3.1 that there is a large amount of variation in percentage change in housing values, ranging from -65% to 216%. About 54% respondents are female, 86% are white, and 83% are married. Older workers with more than ten years of service at in their last job accounts for 35% of our sample. Approximately 56% of the sample has completed high school and 26% have a college degree.

Controlling for the potential endogeneity of local real estate prices in an SSRI claiming decision is important for any researcher interested in causal effects. Following Mian and Sufi (2011, 2014), Chaney, Sraer, and Thesmar (2012), Mian, Rao, and Sufi (2013), and Cvijanović (2014), we instrument for local real estate prices using the interaction between the change in the national house price index and the local housing supply elasticity. Local housing supply elasticities are provided by Saiz (2010) and are available for 269 MSAs. Saiz (2010) estimates land supply elasticities by processing satellite-generated data on elevation and the presence of bodies of water.

To obtain the national house price index, we use the quarterly index created by the Federal Housing Finance Agency.[46] We use national house price index rather than MSA house price since the latter is likely to be correlated with factors associated with local demand conditions, and hence would not be a valid instrument. The identifying assumption of using the

[46] http://www.fhfa.gov/DataTools/Downloads/Pages/House-Price-Index-Datasets.aspx#qat.

interaction between the MSA supply elasticity and the change in the national house price index is that any deviation from the national trend in house prices is due to differences in the supply elasticity of the area, which is not correlated with local demand shocks. For example, San Francisco, CA will experience a more dramatic fall in prices than Houston, TX when national house prices fall, not because of local demand factors but because of the ability to supply additional housing more easily in Houston than in San Francisco.

We then the match MSA and county using the Geographic Correspondence Engine.[47] Given that we use the MSA-level housing supply elasticity as our instrument, we must limit our sample to those counties located within an MSA covered by the Saiz (2010) topography-based elasticity measure. We also drop households that experienced a percent change in housing prices above the 99th percentile and below the 1st percentile, as well as individuals who didn't move in the previous two years to ensure the full exposure to the change in home equity due to price appreciation/depreciation. This reduces the sample to 5,526 individuals within 1,235 counties in 215 MSAs.

3.6 Effect of House Price Changes on SSRI Withdrawal

We begin our analysis by estimating equation (1) using a simple Probit regression. Results are presented in Table 3.2. The estimation is conducted separately for the housing boom period and the bust period. Column (1) focuses on whether the individuals claim SSRI within one year after they turn 62 during the housing boom period (2002 to 2006) while including state fixed effects. In column (2), we add year fixed effects to the model. Columns (3) and (4) look at whether an individual claims SSBI within two years after turning 62, with column (3) including only state fixed effects and column (4) adding year fixed effects. Columns (5) to (8) follow the same structure as columns (1) to (4) but cover the bust period (2007 to 2009). We report

[47] http://mcdc2.missouri.edu/websas/geocorr2k.html.

estimated coefficient from the Probit model in Panel A and the corresponding marginal effects in Panel B. T-statistics are reported in parentheses and are calculated using standard errors clustered at the MSA level. Estimates presented in Table 3.2 suggest negative but insignificant effect of changes in house value on Social Security benefit claiming during the boom period. However, we see in column (5) to (8) that during the bust period, a decline in house price seems to decrease the probability of early pension withdrawal.

As mentioned above, OLS estimation may suffer from endogeneity issues, as unobserved local demand shocks will likely create correlation between house price changes and other local labor market conditions. For example, a negative local demand shock may affect housing market outcomes and at the same time cause individuals to delay retirement due to lower wages, which may also delay SSRI benefit claiming, suggesting there the Probit model coefficient estimates may have an upward bias. To address this issue, we use an instrumental variables approach and instrument for house price changes using the interaction between the MSA supply elasticity and the change in the national house price index. Results from the IV regression are presented in Table 3.3, where the columns follow the same structure as in Table 3.2. The first stage regression results are presented in Panel B and suggest that our instrument is valid. The Wald test of exogeneity rejects the null hypothesis that the change in housing value is an exogenous variable in equation (1).

Panel A of Table 3.3 presents the second stage coefficients from our IV regression. We find a significantly negative effect of a change in house price on the likelihood of claiming SSRI benefits earlier during the boom period. This suggests that when house prices increase, elderly individuals may delay receiving Social Security benefits, as they may cash out housing equity to cover expenses. Our results indicate that when housing value increases by 10%, the probability of claiming SSRI within one year reduced 0.05 once they become eligible and the probability of claiming SSRI within two years reduced 0.06. In contrast, we do not find a statistically significant effect during the housing bust period. Estimates reported in column (5) – (8) show negative but insignificant effects. This seems to be consistent with cashing-out home equity during the boom period as home equity may be a viable substitute for pension withdrawals when housing assets appreciate. This channel, however, shuts down when house price declines.

3.7 Effect of SSRI on Retirement Decision

We also extend our analysis to examine the effect of a change in house price on the decision to retire. We begin by estimating the effect of changes in house prices on the decision to retirement using a Probit model. These results are presented in Table 3.4. Column (1) and (2) focus on the effect of a change in housing value on retirement decisions during the housing boom period (2002 to 2006), and column (3) to (4) show the effect during the bust period (2007 to 2009). The Probit estimates in Table 3.4 column (1) and (3) are not statistically significant and are likely to be biased due to the endogeneity issue mentioned above. It is likely that SSRI eligibility will also play a role when considering the impact of home equity on the retirement decision. In this regard, we further interact the percent change in house value with a dummy indicating whether the respondent meets the eligibility criteria to receive SSRI. We pick up stronger signal in this specification, especially for the interaction term.

To address potential endogeneity concerns, we conduct similar IV estimation and present our results in Table 3.5. We find consistent evidence that higher housing values have a positive effect on the likelihood of retirement in both the boom and bust period. The coefficients estimated for the boom period tend to be of higher magnitude than that of the bust period. When housing value increases 10% (percent), the probability of retirement increases 0.04 during 2002 to 2006. The probability of retirement decreases 0.02, when housing value decreases 10% during 2007 to 2009. We think this is consistent with retirement decisions cycling with housing market fluctuations. Due to additional channel to cash out home equity during the housing boom period, the effect becomes stronger when price appreciates.

The coefficients associated with the interaction term between house price appreciation and eligibility for pension withdrawal suggest that the impact on retirement mainly comes from after the eligibility year during the housing boom period (Table 3.5 Column (2)). Before turning 62, elderly individuals tend not to respond significantly to home equity accumulation in their retirement decisions. However, once they become eligible for receiving SSRI, the elderly may decide to retire once they have experience sufficient house price appreciations. During the housing boom period, pension eligibility seems to serve as a safety net in cancelling the negative impact of housing price depreciations on early retirement. If house price decreases by 10%, for example, the likelihood of retirement for individuals below 62 years old increases 0.04. This effect, however, becomes almost zero once they turn 62.

3.8 Conclusion

We estimate the impact of changes in housing value on the SSRI claiming and retirement decisions. Simple OLS methods are likely to suffer from omitted variables bias, as changes in the price of housing and the decision to withdraw SSRI are likely to be correlated with local unobserved demand shocks. To address this concern, we use the interaction of changes in the national house price index and land supply elasticity at the MSA level as an instrument for the change in the value of a house. This instrument has been used previously in the literature, allowing us to obtain causal effects.

When we estimate the effect of changes in housing value on the likelihood an individual begins receiving SSRI with our instrumental variables approach, we find that as the housing price increases by 10% during the boom period, the probability an individual begins to receive benefits within one year decreases by 0.05 once they are eligible and the probability of individuals claiming SSRI within two years decreases by 0.06. Meanwhile, we find the probability of retirement decrease by 0.04 as housing prices increase 10%. While the housing price decreases 10% during the bust period, the probability of retirement decrease 0.02. Pension eligibility also plays a role on the impact of home equity on retirement.

Overall, our findings suggest that the elderly seems to treat home equity and SSRI as substitutes when financing retirement. It appears that most of this trade-off is during boom periods, but not when house prices decline. This is consistent with cashing-out home equity as a viable option only when house price appreciates. Furthermore, we see that when house values increase, individuals are more likely to retire, possibly because the increase in this asset allows them to finance retirement more. Our findings are important for policy makers in designing relevant policies after having a better understanding of the substitutability between these two assets.

References

Behaghel, L. and Blau, D.M., 2012. Framing social security reform: Behavioral responses to changes in the full retirement age. *American Economic Journal: Economic Policy*, 4(4), 41-67.

Blau, D.M. and Gilleskie, D.B., 2006. Health insurance and retirement of married couples. *Journal of Applied Econometrics*, 21(7), 935-953.

Blau, D.M. and Goodstein, R.M., 2010. Can social security explain trends in labor force participation of older men in the United States?. *Journal of Human Resources*, 45(2), 328-363.

Brown, Jeffrey R., Arie Kapteyn, and Olivia S. Mitchell. 2011. Framing Effects and Expected Social Security Claiming Behavior, NBER Working Paper 17018.

Case, K.E., Quigley, J.M. and Shiller, R.J., 2005. Comparing wealth effects: the stock market versus the housing market. *Advances in Macroeconomics*,5(1).

Chan, S. and Stevens, A.H., 2008. What you don't know can't help you: Pension knowledge and retirement decision-making. *The Review of Economics and Statistics*, 90(2), 253-266.

Chaney, T., Sraer, D. and Thesmar, D., 2012. The collateral channel: How real estate shocks affect corporate investment. *The American Economic Review*, 102(6), 2381-2409.

Coile, C.C. and Levine, P.B., 2007. Labor market shocks and retirement: Do government programs matter?. *Journal of Public Economics*, 91(10), 1902-1919.

Coile, C. and P.B. Levine. 2011a. Recessions, Retirement and Social Security. *American Economic Review Papers and Proceedings* 101(3), 23-28.

Coile, C. and P.B. Levine. 2011b. The Market Crash and Mass Layoffs: How the Current Economic Crisis May Affect Retirement. The B.*E. Journal of Economic Analysis and Policy: Contributions,* 11(1).

Crawford, V.P. and Lilien, D.M., 1981. Social security and the retirement decision. *The Quarterly Journal of Economics*, 96(3), 505-529.

Cvijanović, D., 2014. Real estate prices and firm capital structure. *Review of Financial Studies*, 27(9), 2690-2735.

Disney, R., Ratcliffe, A. and Smith, S., 2015. Booms, busts and retirement timing. *Economica*, 82(327), 399-419.

Engelhardt, G.V., 1996. House prices and home owner saving behaviour. *Regional Science and Urban Economics*, 26(3), 313-336.

Farnham, M. and Sevak, P., 2007. Housing wealth and retirement timing. Michigan Retirement Research Center Research Paper No. UM WP, 172.

French, E. and Jones, J.B., 2011. The effects of health insurance and self-insurance on retirement behavior. *Econometrica*, 79(3), 693-732

Goda, G.S., Shoven, J.B. and Slavo, S.N., 2011. What explains changes in retirement plans during the Great Recession?. *The American Economic Review*, 101(3), 29-34.

Goda, G.S., Shoven, J.B. and Slavov, S.N., 2012. Does stock market performance influence retirement intentions?. *Journal of Human Resources,* 47(4), 1055-1081.

Gustman, A.L., and T.L. Steinmeier. 2005. The Social Security early retirement age in a structural model of retirement and wealth. *Journal of Public Economics*. 89(2-3), 441-463.

Hurd, M. 2002. Portfolio holdings of the elderly. In Household portfolios, ed. Luigi Guiso, Michael Haliassos, and Tullio Jappelli, 431-92. Cambridge, Mass.: MIT Press.

Hurd, M.D. and Boskin, M.J., 1984. The effect of social security on retirement in the early 1970s. *The Quarterly Journal of Economics*, 99(4), 767-790.

Hurd, M.D., Smith, J.P. and Zissimopoulos, J.M., 2004. The effects of subjective survival on retirement and social security claiming. *Journal of Applied Econometrics*, 19(6), 761-775.

Imbens, G.W., Rubin, D.B. and Sacerdote, B.I., 2001. Estimating the effect of unearned income on labor earnings, savings, and consumption: Evidence from a survey of lottery players. *American Economic Review*, 91(4), 778-794.

Jiang, S., Sun, W. and Webb, A., 2011. Did the Housing Boom Increase Household Spending? (No. ib2011-10).

Lee, R.D., 2014. Macroeconomic Consequences of Population Aging in the United States: Overview of a National Academy Report. *The American Economic Review* 104(5): 234-239.

Lovenheim, M.F., 2011. The effect of liquid housing wealth on college enrollment. *Journal of Labor Economics*, 29(4), 741-771.

Lovenheim, M.F. and Mumford, K.J., 2013. Do family wealth shocks affect fertility choices? Evidence from the housing market. *Review of Economics and Statistics*, 95(2), 464-475.

Lovenheim, M.F. and Reynolds, C.L., 2013. The effect of housing wealth on college choice: Evidence from the housing boom. *Journal of Human Resources*, 48(1), 1-35.

Madrian, B.C., Burtless, G. and Gruber, J., 1994. The effect of health insurance on retirement. *Brookings Papers on Economic Activity*, 1994(1), 181-252.

Mastrobuoni, G., 2009. Labor supply effects of the recent social security benefit cuts: Empirical estimates using cohort discontinuities. *Journal of Public Economics*, 93(11), 1224-1233.

Merrill, S.R., M. Finkel, and N. Kutty. 1994. Potential beneficiaries from reverse mortgage products for elderly homeowners: An analysis of AHS data. *Journal of the American Real Estate and Urban Economics Association* 22(2), 257-99.

Mian, A., K. Rao, and A. Sufi. 2013. Household Balance Sheets, Consumption, and the Economic Slump, *The Quarterly Journal of Economics*, 128, 1687-1726.

Mian, A., and A. Sufi, House Prices, Home Equity Based Borrowing, and the U.S. Household Leverage Crisis, *The American Economic Review*, 101 (2011), 2132-2156.

Mian, A., and A. Sufi. 2014. What Explains the 2007-2009 Drop in Employment? *Econometrica*, 82(6), 2197-2223.

Munnell, A.H., and M.S. Rutledge. 2013. The effects of the Great Recession on the retirement security of older workers. *The ANNALS of the American Academy of Political and Social Science* 650(1), 124-142.

Munnell, A.H. and Soto, M., 2005. What replacement rates do households actually experience in retirement?. Canadian Rights Reporter Paper, (2005-10).

Myers, R.J., and B.D. Schobel. 1990. Early-Retirement Reduction and Delayed-Retirement Increase Factors under U.S. Social Security Law. Transactions, XLII 295–320.

Ondrich, J. and A. Falevich, 2016. The Great Recession, housing wealth, and the retirement decisions of older workers. *Public Finance Review*, 44(1), 109-131.

Pingle, J.F., 2006. Social Security's delayed retirement credit and the labor supply of older men. FEDS Working Paper no. 2006-37

Rust, J. and Phelan, C., 1997. How Social Security and Medicare affect retirement behavior in a world of incomplete markets. *Econometrica*, 65(4), 781-831.

Saiz, A., 2010. The geographic determinants of housing supply. *Quarterly Journal of Economics*, 125(3), 1253-1296.

Sheiner, L., and D. Weil. 1993. The housing wealth of the aged. NBER Working Paper No. 4115.

Sinai, T. and N.S. Souleles. 2007. Net Worth and Housing Equity in Retirement. NBER Working Paper No. 13693.

Song, J.G. and Manchester, J., 2007. New evidence on earnings and benefit claims following changes in the retirement earnings test in 2000. *Journal of Public Economics*, 91(3), 669-700.

Venti, S.F., and D.A. Wise. 1989. Aging, moving, and housing wealth. In The economics of aging, ed. David A. Wise, 9-48. Chicago: University of Chicago Press.

Venti, S.F., and D.A. Wise. 1991. Aging and the income value of housing wealth. *Journal of Public Economics* 44, 371-97.

Venti, S.F., and D.A. Wise. 2004. Aging and housing equity: Another look, ed. David A. Wise. Chicago: University of Chicago Press.

Zhao, L. and G. Burge. Forthcoming. Retirement, unretirement, and housing wealth during the Great Recession. *Journal of Health Economics*.

Zhao, L. and G. Burge. Forthcoming. Housing wealth, property taxes, and labor supply among the elderly. *Journal of Labor Economics.*

Table 3.1: Summary Statistics

	Mean	Std. Dev.	Min	Max
Withdraw within 1 year	0.5432	0.4982	0	1
Withdraw within 2 years	0.6431	0.4791	0	1
Retired	0.3804	0.4855	0	1
Δ% in house value in previous 2 years	0.1005	0.3034	-0.6571	2.1634
Female	0.5390	0.4985	0	1
White	0.8557	0.3514	0	1
Married	0.8310	0.3748	0	1
Tenure one to five years	0.2147	0.4106	0	1
Tenure five to ten years	0.1138	0.3176	0	1
Tenure more than ten years	0.3472	0.4761	0	1
High school	0.5561	0.4969	0	1
College	0.2559	0.4364	0	1
Non-housing Wealth	361070	1430634	-814000	90100000
Self-assessed health status	2.4671	0.9930	1	5

Table 3.2: Probit Regressions - Pension Withdrawal within 1 or 2 years after Becoming Eligible[1]
(t statistics are reported in parentheses using clustered standard errors at the MSA level)

	2002 – 2006				2007- 2009			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dependent Variable	Withdraw within 1 Year		Withdraw within 2 Years		Withdraw within 1 Year		Withdraw within 2 Years	
Panel A: Probit Regression Coefficient								
Δ% in house value in previous 2 years	-0.1295	-0.1048	-0.1464*	-0.1143	0.5617**	0.7522**	0.5636*	0.8456**
	(-1.31)	(-1.06)	(-1.77)	(-1.39)	(1.99)	(2.35)	(1.85)	(2.35)
Panel B: Marginal Effect								
Δ% in house value in previous 2 years	-0.0441	-0.0357	-0.0485*	-0.0374	0.1846**	0.2455**	0.1863*	0.2775**
	(-1.31)	(-1.06)	(-1.77)	(-1.39)	(2.01)	(2.39)	(1.86)	(2.35)
State Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	NO	YES	NO	YES	NO	YES	NO	YES
Observations	1600	1600	1578	1578	653	653	640	640
Log Pseudolikelihood	-960.5648	-957.7640	-919.5976	-908.7914	-377.6022	-375.1797	-373.0571	-370.4327

[1] Other control variables include gender, race, marital status, tenure in the last job, education, total non-housing wealth, and self-assessed health.

Table 3.3: IV Probit Regressions - Pension Withdrawal within 1 or 2 Years after Becoming Eligible[1]
(t statistics are reported in parentheses using clustered standard errors at the MSA level)

	2002 – 2006				2007- 2009			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A: Second-Stage								
Dependent Variable	Withdraw within 1 Year		Withdraw within 2 Years		Withdraw within 1 Year		Withdraw within 2 Years	
	Probit Regression Coefficient							
Δ% in house value in previous 2 years	-1.0945**	-1.5391***	-1.4400***	-1.6462***	-0.1165	-0.2593	-0.3244	-0.3230
	(-2.14)	(-2.74)	(-2.82)	(-2.83)	(-0.19)	(-0.44)	(-0.56)	(-0.55)
	Marginal Effect							
Δ% in house value in previous 2 years	-0.3345**	-0.5111***	-0.5051***	-0.6254***	-0.0465	-0.1024	-0.1186	-0.1182
	(-2.14)	(-2.73)	(-2.79)	(-2.83)	(-0.19)	(-0.45)	(-0.56)	(-0.55)
Panel B: First-Stage								
Dependent Variable	Δ% in House Value in Previous 2 Years							
Δ% in U.S. HPI in previous 2 years	2.4312***	-	2.3837***	-	2.1927***	-	2.1712***	-
	(6.81)	-	(6.68)	-	(7.38)	-	(7.46)	-
Δ% in U.S. HPI in previous 2 years × MSA land supply elasticity	-0.5422***	-0.5118***	-0.5399***	-0.5218***	-0.4695***	-0.4651***	-0.4657***	-0.4659***
	(-5.05)	(-4.61)	(-4.91)	(-4.67)	(-3.57)	(-3.51)	(-3.64)	(-3.61)
State Fixed Effects	YES	YES	YES	YES	YES	YES	YES	YES
Year Fixed Effects	NO	YES	NO	YES	NO	YES	NO	YES
Wald Test of Exogeneity	3.67	4.89	5.56	4.83	3.52	4.32	6.73	6.74
Observations	1197	1197	1181	1181	486	486	477	477
Log Pseudolikelihood	-955.9601	-951.2390	-885.3643	-874.6170	-90.6797	-88.6880	-85.0922	-85.0911

[1] Other control variables include gender, race, marital status, tenure in the last job, education, total non-housing wealth, and self-assessed health status.

Table 3.4: Probit Regressions - Retirement Decision[1]
(t statistics are reported in parentheses using clustered standard errors at the MSA level)

	2002 – 2006		2007- 2009	
	(1)	(2)	(3)	(4)
Dependent Variable:	Retirement Status (1 – retired; 0 - otherwise)			
Panel A: Probit Regression Coefficient				
Δ% in house value in previous 2 years	0.0148	-0.5891***	0.0812	-0.0806
	(0.30)	(-5.87)	(0.82)	(-0.57)
Δ% in house value in previous 2 years × Eligible for Pension Withdrawal	-	0.8522***	-	0.2556*
	-	(8.19)	-	(1.86)
Panel B: Marginal Effect				
Δ% in house value in previous 2 years	0.0045	-0.1777***	0.02164	-0.0215
	(0.30)	(-5.97)	(0.82)	(-0.57)
Δ% in house value in previous 2 years × Eligible for Pension Withdrawal	-	0.2571***	-	0.0681*
	-	(8.50)	-	(1.87)
Year Fixed Effects	YES	YES	YES	YES
State Fixed Effects	YES	YES	YES	YES
Age Fixed Effects	YES	YES	YES	YES
Observations	9125	9125	4113	4113
Log Pseudolikelihood	-4920.2133	-4876.6623	-1954.3837	-1951.8035

[1] Other control variables include gender, race, marital status, tenure in the last job, education, total non-housing wealth, and self-assessed health status.

Table 3.5: IV Probit Regressions - Retirement Decision[1]
(t statistics are reported in parentheses using clustered standard errors at the MSA level)

	2002 – 2006			2007- 2009		
	(1)	(2)		(3)	(4)	
Panel A: Second-Stage						
Dependent Variable	Retirement Status (1 – retired; 0 - otherwise)					
	Probit Regression Coefficient					
Δ% in house value in previous 2 years	1.3950***	0.3128		0.6948***	1.5902***	
	(3.55)	(0.45)		(2.66)	(3.14)	
Δ% in house value in previous 2 years × Eligible for Pension Withdrawal	-	1.9046***		-	-1.4705**	
	-	(5.98)		-	(-2.13)	
	Marginal Effect					
Δ% in house value in previous 2 years	0.3895***	0.0847		0.1586***	0.4072***	
	(3.55)	(0.46)		(2.66)	(3.12)	
Δ% in house value in previous 2 years × Eligible for Pension Withdrawal	-	0.5157***		-	-0.3765***	
	-	(5.96)		-	(-2.13)	
Panel B: First-Stage						
Dependent Variable	Δ% in House Value in Previous 2 Years	Δ% in House Value in Previous 2 Years	Δ% in HV × Eligible for PW	Δ% in House Value in Previous 2 Years	Δ% in House Value in Previous 2 Years	Δ% in HV × Eligible for PW
Δ% in U.S. HPI in previous 2 years × MSA land supply elasticity	-0.2849**	-0.3369***	0.0271	-0.4085***	-0.3804***	0.0341
	(-2.33)	(-2.76)	(0.35)	(-3.97)	(-3.86)	(1.61)
Δ% in U.S. HPI in previous 2 years × Eligible for Pension Withdrawal	-	-0.1215*	1.7002***	-	0.1276	1.8525***
	-	(-1.70)	(10.51)	-	(0.69)	(6.02)
Δ% in U.S. HPI in previous 2 years × MSA land supply elasticity × Eligible for Pension Withdrawal	-	0.0907**	-0.3033***	-	-0.0493	-0.4444***
	-	(2.07)	(-4.26)	-	(-0.70)	(-3.53)
Wald Test of Exogeneity	9.32	64.13		5.80	8.43	
Observations	6844	6844		2963	2963	
Log Pseudolikelihood	-4654.1125	-494.5766		-951.2854	1417.4989	

[1] Other control variables include age, gender, race, marital status, tenure in the last job, education, total non-housing wealth, and self-assessed health status. All specifications also include year fixed effects, state fixed effects, and age fixed effects.

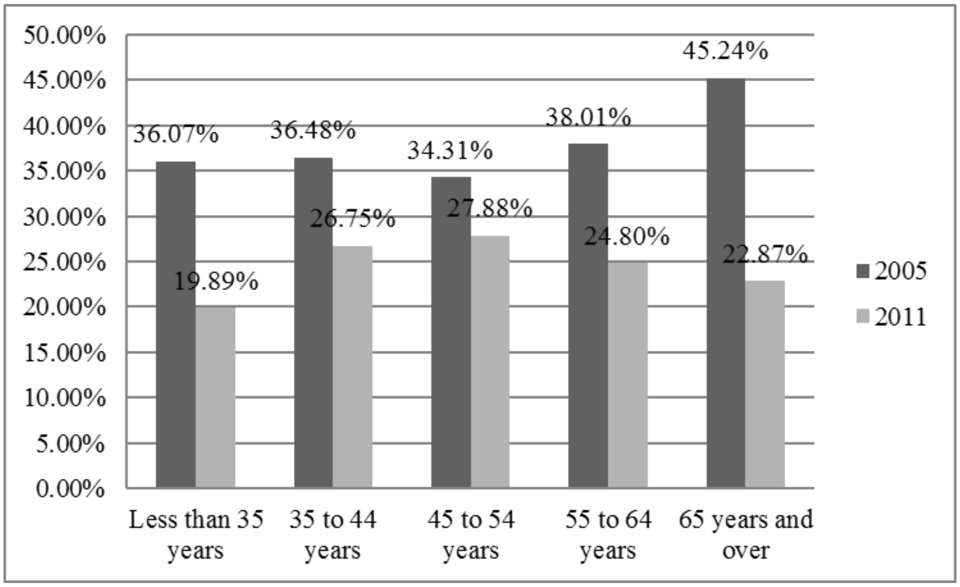


Figure 3.1: Ratio of Home Equity to Household Net Worth in 2005 and 2011

Chapter 4 The Role of Speculation on the Price informativeness: Evidence from Macroprudential Policies in Singapore Housing Market

(Coauthored with Jing Li)

4.1 Introduction

The recent housing and financial crisis has highlighted the need for macroprudential policies which aim to address the systematic risks. Based on the IMF Global Macroprudential Policy Instruments (GMPI) survey, countries generally use 2.5 times more macroprudential measures in 2013 than in 2000 (Ceruttia, Claessens and Laeven, 2017). Examples of the macroprudential tools employed are countercyclical capital requirements and time-varying loan-to-value (LTV). [48] While macroprudential approach is in principle to lower excessive procyclicality, the usage of macroprudential policies may generate unintended consequences (Claessens 2015; Crowe, Dell'Ariccia, Igan and Rabanal, 2013; Hanson, Kashyap and Stein, 2011). This paper explores the potential impact of unexpected transaction tax on price informativeness in Singapore real estate market.

One key feature of housing is that it has duel natures – consumption and investment. It is the investment component that plays a significant role in driving up the price and forming bubbles especially when market participants have excessive expectation of capital gains (Case and Shiller, 2003; Dusansky and Koç, 2007; Himmelberg, Mayer, and Sinai, 2005). However, it is typically hard to identify investment incentive from consumption purpose in home purchase. This paper utilizes a unique feature of Singapore housing market that most transactions happen before the consumption feature is ready and the uncompleted property market attracts investors

[48] For more examples of macroprudential policy tools, please refer to Akinci and Olmstead-Rumsey (2017) Ceruttia, Claessens and Laeven (2017), Galati (2013), etc.

(Fu and Qian, 2014; Fu, Qian, and Yeung 2015). We are interested in how short-term investment behavior in this segment of market affects the price informativeness.

To investigate whether the price reflect all the information, the ideal situation would be that we compare price of two similar goods transacted at the same time so that we can control for observed characteristics and time varying effect.[49] In practice, real estate is typically highly heterogeneous and thinly traded over long holding periods (Krainer,2001; Lin and Vandell, 2007). However, we could overcome the limitations to some extent. All units within each residential project in Singapore are very homogeneous before individual household move in, given that they will be all fully furnished by developers with the same interior design, the same type of furnishing, the same major electrics, and the same outdoor facilities (Baltagi and Li, 2015). On the other hand, 90% new houses are sold out within a few years during the construction. This means that, after adjusting for observed characteristics, we have essentially identical units transacted at near time.

We define transactions that are purchased and will be sold before the completion of property as speculative purchase. Figure 1a shows this measure at quarter level, and Figure 1b shows the ratio of quarterly speculative purchases over the total quarterly transactions of uncompleted housing units. The number of speculative purchases and the total transactions are moving towards the same direction until Q1 2011, when the sellers' stamp duty increases dramatically. The ratio jumps from 4.92% in Q4 2010 to 0.62% in Q1 2011, and subsequently goes to zero. The ratio also decreases after the two policies in December 2006 and October 2007 but the ratio becomes high at Q1 2009 when housing price index is historically low, which may

[49] The idea is similar to testing the law of one price, which states that identical goods must have identical prices in competitive markets with no transaction costs and no barriers to trade. The law of one price stems from pure theory of international economics and has been extensively studied in international trade (e.g. Ardeni, 1989; Baffes, 1991; Richardson, 1978) or financial market (e.g. Garleanu and Heje Pedersen, 2011; Roll, Schwartz, and Subrahmanyam, 2007).

suggest that speculators may have incentive to purchase units when market is in bust. It might also imply that two policies in 2006 and 2007 do not have long lasting effect.[50]

Using countercyclical polices that were announced with immediate effect as exogeneous transaction shock, we first estimate the possibility of speculative purchase and then study price pattern over sales sequence within the same real estate development. We find that speculative trade decreases by 10.35% after dramatic increase in transaction cost if one chose to speculate and price of similar houses increases more over sales sequence. Specifically, comparing a unit that was purchased immediately after the launch of sale and another housing unit that was purchased 12 months later, the difference of price per square meter increases 0.276 % after the dramatic increase in transaction cost. Our findings are consistent across various specifications, such as restricting sample to projects having only one construction phase, including units that have transactions before and after policy.

Our paper is closely related to the discussions on macroprudential policies. While macroprudential policies are widely used, our knowledge of macroprudential approach is still limited. Theoretically, macroprudential regulations could prevent boom and bust cycles (e.g. Bianchi and Mendoza (2012) for a DSGE model, Allen and Carletti (2013) for a model of real estate pricing). In practice, the effect depends on specific tools and market characteristics (Akinci and Olmstead-Rumsey, 2015; Ceruttia, Claessens and Laeven, 2017; Galati, 2013; Kannan, Rabanal, and Scott, 2012) and the usage of macroprudential policies may generates unintended consequences (Claessens 2015; Crowe, Dell'Ariccia, Igan and Rabanal, 2013;

[50] To have a comprehensive understanding of speculative trading, we construct another measure indicating the realization of arbitrage opportunities. Figure 2a shows the quarterly transactions that were purchased and are sold before the completion of property. Figure 2b shows the ratio of this number over total transactions of uncompleted properties at year-quarter level.

Hanson, Kashyap and Stein, 2011). This paper explores the potential consequences of countercyclical policy – transaction cost in Singapore real estate market on price discovery.

Our paper is also related to the literature on transaction tax. We demonstrate that number of transactions decreased after government imposed transaction cost on short-term speculators, which is consistent with previous papers that transaction cost could reduce trade volume and reduce liquidity (Kiefer, 1990; Constantinides, 1986; Wurgler, 2000).[51] Our more persistent price pattern along sales sequence after imposing transaction cost could imply that speculators do not respond to changes in expected returns by rebalancing their positions, as the gain from doing so might be less than the huge transaction cost (Constantinides, 1986). The pattern also suggests that information is not effectively reflected into price as trade process by informed traders could transmit information into market (Danthine, 1978; Easley, Kiefer, and O'Hara, 1997; Easley, O'hara, and Srinivas, 1998; Frino and West, 2003; Froot and Perold, 1995; Glosten and Milgrom, 1985; Grossman, 1976 and 1977; Grossman and Stiglitz, 1976 and 1980; and Kyle, 1985).

Another strand of literature our paper is related to is on the market efficiency. The idea of market efficiency has been applied extensively to theoretical models and empirical studies of financial securities prices since Samuelson (1965), Fama (1965; 1970) and Ross (1976). There have been debates on whether speculator contribute to the market efficiency. Market could be inefficient with short-term speculation (Brunnermeier, 2005; Froot, Scharfstein and Stein, 1992), or speculative trade is conducive to market efficiency (Brown and Yang, 2016; Chang, Luo, and Ren, 2014; Cornell and Dietrich, 1978; Jaffe and Winkler, 1976), or the effect of speculators on the market efficiency depends on traders' characteristics (Figlewski, 1978; Tirole, 1982). Our finding of more persistent price trend over sales sequence, might suggest that market is less informationally efficient without speculators, probably informed traders, consistent with the

[51] In our situation, the decline of speculative transactions implies the total transactions decrease.

finding in Fu, Qian, and Yeung (2015) who study the same policy in December 2006 and claim that the policy is likely to deter informed trader more than it does noise traders.

We also contribute to the literature on price of assets over sales sequence. Price pattern for similar assets sold sequentially could increase as early transactions provide additional information about the value of the good to later potential buyers (Milgrom and Weber, 1982), the declining of consumption risk (Sirmans, Turnbull, and Dombrow, 1997) or agglomeration economies (Rauch 1993). Also, price could decline as the sales sequence proceeds if choice units tend to sell first (Ashenfelter and Genesove, 1992; Beggs and Graddy, 1997; Burguet 2005) or risk-averse buyers who are willing to pay a higher price in the early periods to ensure the opportunity to purchase (Ashenfelter, 1989). We find that the evidence of the effect of transaction cost on the price over sales sequence.

The rest of the paper will proceed as follows. Section 2 discusses the Singapore housing market and the policies we use. Our data is outlined in Section 3 and we discuss our identification strategy in Section 4. Section 5 describes our main results and some robustness checks. Section 6 provide possible explanations for our finding. We conclude in Section 7.

4.2 Residential Property Market and Policies in Singapore

4.2.1 Residential Property Market in Singapore

Residential properties in Singapore are grouped into three categories: private non-landed properties (including private apartments and condominiums), private landed properties, and public housing, locally known as Housing and Development Board (HDB) flats. Based on the 2015 General Household Survey, about 80.1% of resident households live in HDB dwelling.

Private non-landed properties are occupied by 13.9 % of resident households, 5.6 % of resident households live in landed properties, and the rest 0.3% live in other properties.[52]

For our analysis, we restrict our sample to the private non-landed residential market before the properties are completed. We make this restriction for several reasons. First, private residential housing is likely to be affected by any market force that impacts the price of housing, unlike HDB flats which are heavily subsidized by the government and there are policies that restrict the demand and supply of public housing.[53] In addition, we focus on uncompleted property which does not have consumption feature.

In addition, compared to other market segments of private properties, private non-landed housing units are very homogenous within each residential project. This provides an opportunity to explore price variation of hedonically adjusted units that are essentially the "same." Landed private properties is very heterogeneous, is not frequently transacted and make up a very small portion of the market, less than 5%. In contrast, private non-landed housing units within the same housing project are very homogenous in terms of the attributes of the units (Baltagi and Li, 2015; Huang, Li and Ross, 2016). This feature allows us to track the price over sales sequence of almost identical units in the same project.

Singapore offers a unique opportunity to study the price trend over sales sequence in real estate market. Developers are allowed to sell housing once they get sale licence from the Urban Redevelopment Authority, which allows the developer to commence construction and start selling the units upon the issue of building plan approval for the housing project.[54] The initial

[52] https://www.singstat.gov.sg/docs/default-source/default-document-library/publications/publications_and_papers/GHS/ghs2015/ghs2015.pdf

[53] For more information on the policies and the nature of the subsidy for HDB housing flats in Singapore, see: https://lkyspp.nus.edu.sg/wp-content/uploads/2014/11/Public-Housing-in-Singapore.pdf.

[54] Developers who are developing a housing project with more than four units are required to obtain a licence from the Controller of Housing before commencing construction works. There are two types of licences: sale licence and no-sale licence. No-sale licence allows the developer to commence construction, but is not allowed to sell any units

sales time would be correspondent to the time when the property is launched, and the construction period allows about 90% units have been sold out before completion in Singapore.

We define uncompleted property as houses that are transacted before the issue of Certificate of Statutory Completion (CSC) or a Temporary Occupation Permit (TOP) from the government. The building can only be occupied when a CSC or TOP is granted.[55] Uncompleted properties is widely believed to attract speculative activities in Asian market (Fu and Qian, 2014; Fu, Qian, and Yeung 2015; Wong, Yiu, Tse and Chau, 2006) and are more frequently transacted compared to the market for completed properties (Jiang, Phillips, and Yu, 2015).

4.2.2 Policies in Residential Property Market

We focus on four policies in housing market in Singapore, three of which apply to uncompleted property market and the last policy is designed to deter speculators. In response to the Asian economic crisis in 1997, government announced the Concession to Defer Stamp Duty Payment in 1998 that allowed uncompleted property buyers to pay the stamp duty until the property is completed. With accelerated housing price increase, the government withdraw the Concession to Defer Stamp Duty Payment in December 2006. The government further removed the Deferred Payment Scheme (DPS) in 2007. Under the Deferred Payment Scheme, government allowed developers to offer to purchasers of uncompleted private properties the option to defer part of the progress payments from 1997 and further allowed developers to offer the option to defer up to half of the initial down payment in November 2001.[56]

---

in the development without the prior written approval of the Controller. The minimum paid-up capital, security or deposit for sale licence is between S$1 million and S$4 million, and it is S$100,000 for non-sale licence. https://www.ura.gov.sg/uol/-/media/User%20Defined/URA%20Online/Guidelines/Housing-Developers/Criteria%20for%20Housing%20Developers%20Licence%20Apr%202016.pdf.

[55] For more details, please see https://www.bca.gov.sg/TOPCSC/csc_inspection.html.

[56] Being carried out in 1997, Deferred Payment Scheme (DPS) allowed developers to offer to purchasers of uncompleted private properties the option to defer part of the progress payments due after the initial 20% down payment, to a later stage. In November 2001, the Government further allowed developers to offer the option to defer up to half of the initial 20% down payment up to the issue of Temporary Occupation Permit or any time before that.

Housing price starts to increase immediately and rapidly after global financial crisis in 2008 which poses tremendous pressure on policy makers to react with countercyclical measures. From September 2009, government has announced ten rounds of cooling measures to curb investment demand for housing. Each measure was announced with immediate effect. Among these measures, the first round is specific to uncompleted properties. The Sellers' Stamp Duty in February 2010, August 2010, and January 2011 apply to both completed properties and uncompleted properties. The policy requires sellers' stamp duty if buyers purchase housing units after the policy announcement date and sell the house within a short period. For example, policy in January 2011 requires 16%, 12%, 8%,4% tax rate of transaction price if one flips a house within 1 year, 2 years, 3 years and 4 years.[57]

4.3 Identification Strategy

We are interested in determining the degree to which policies affect the amount of speculative trading. We look at speculative transactions that are purchased by speculators and will be sold. We are also interested in the housing price trend over sales sequence after policies as persistent housing price trend over sales sequence might imply arbitrage opportunities.

To do so, we first study the policies on speculative trading by using the following specification:

$$Purchase_{p,i,t} = \Phi\left(\rho_1 Months_{p,i,t} + \rho_2 Policy_t + \rho_3 X_{p,i} + \tau_t + \nu_{p,i,t}\right) \quad (1)$$

Where Φ is the standard normal cumulative distribution, $Purcanse_{p,i,t}$ in specification (1) is an indicator variable equal to one if unit *i*, in project *p*,[58] is purchased in month *t* and will be sold before the construction is completed. $Months_{p,i,t}$ is the number of months from the first sale

[57] Please see Table B1 for the detail of the policies from 1998-2016, and Table B2 for the detail of Sellers' Stamp Duty.

[58] In Singapore, "project" means "real estate development". One project includes several buildings and hundreds of units.

within the same project p when unit i was transacted at time t , $Policy_t$ equals one if transaction at time t is after policy, zero otherwise. $X_{p,i}$ is unit controls, such as floor and area. τ_t is year-by-month fixed effects. We include a planning-region specific linear time trend or a planning-area specific linear time trend.[59] We do not control for project fixed effect and area specific year trend simultaneously as the function in Probit regression becomes non-concave after including so many dummy variables. Our result holds if area characteristics do not change significantly different among areas over years in the specifications without area specific year trend. We address this issue in the robustness checks.

We then study the housing price along sales sequence. To do so, we use

$$\log(P_{p,i,t}) = \beta_1 Months_{p,i,t} + \beta_2 Months_{p,i,t} \times Policy_t + \beta_3 X_{p,i} + \gamma_p + \tau_t + u_{p,i,t} \quad (2)$$

where the dependent variable, $\log(P_{p,i,t})$, is the log of area-adjusted t house price in unit i in project p in month t. $Months_{p,i,t}$, $Policy_t$, $X_{p,i}$, τ_t are the same as defined in equation (1). γ_p is project fixed effects or building fixed effects, to control for project-specific or building specific characteristics that could affect the price of housing, τ_t is year-by-month fixed effects. To estimate the effect of policy, we exclude uncompleted units that speculator purchased before the policies and sell after policies. If speculators have bargaining power to purchase units at low price and have power to charge higher price when they sell units, this could confounding our study of price pattern overall. We address this issue in the robustness checks.

To demonstrate the dynamics of price over sales sequence before and after policies, we explicitly include before policy dummies into the following regression:

[59] There are 5 planning regions in Singapore, including Central Region, East Region, North Region, North-East Region, and West Region. There are 55 urban planning areas spanning five planning regions. Each planning area has a population of about 150,000 people and is served by a town center and several neighborhood commercial/shopping centers. More details can be found at http://www.ura.gov.sg/uramaps/?config=config_preopen.xml&preopen=Planning Boundaries&pbIndex=1.

$$\log(P_{p,i,t}) = \sum_{m=1}^{47} \beta_{1,\mathrm{m}} \times \text{dummy\_}months_{p,i,t} \times Before\_Policy_t + \sum_{m=1}^{47} \beta_{2,\mathrm{m}} \times \text{dummy\_}months_{p,i,t} \times After\_Policy_t + \beta_3 X_{p,i} + \gamma_p + \tau_t + u_{p,i,t} \quad (4)$$

The coefficient $\beta_{1,\mathrm{m}}$ measures the average price at months m from the first sale within the same project before the policy, and coefficient $\beta_{2,\mathrm{m}}$ measures the average price at months m from the first sale within the same project after the policy, $\text{dummy\_}months_{p,i,t}$ is months m from the first sale within the same project. $\text{Before\_}Policy_t$ equals one if the transaction date t is before the policy and zero otherwise. $After\_Policy_t$ equals one if the transaction date t is after the policy and zero otherwise.

4.4 Data and Summary Statistics

To conduct our analysis, we rely on transaction-level price data for all private residential transactions in Singapore from the Real Estate Information System (REALIS) maintained by the Urban Redevelopment Authority of Singapore (URA). [60] The REALIS database provides proprietary information on the universe of all residential property sales since January 1, 1995.[61] The data contains information on the transaction date, transaction price, unit attributes (project identity, building block, floor level, and living area), and project attributes (project size, location by postal district, completion date, and land title).

We exclude transactions that took place under en bloc sales (collective sales) agreement as they are not conducted in a standard market and thus may bias our results.[62] Also, we exclude executive condominium, which is subsidized by the government and only citizens are eligible to purchase. We use transactions from December 1, 2001 when the Deferred Payment Scheme was implemented in November and was later removed in 2007. We are interested in sales sequence,

[60] https://spring.ura.gov.sg/lad/ore/login/index.cfm.
[61] Sales are logged with the Singapore Land Authority (SLA) by the purchasers' lawyers shortly after the property is sold.
[62] En bloc sales refer to the sale of all the units within a housing development to a single party or a consortium/joint venture. The price of housing bought through an en bloc sale is usually higher than the market price.

so we use projects with at least 10 floors and at least 40 transactions to avoid some very small projects.

To keep our definition of speculative transactions consistent, we further restrict samples to uncompleted housing units that are transacted within 48 months from the first sale of their project. One major policy that we will study later requires one to pay seller's stamp duty if he sells house with holding period less than 48 months. This restriction will not alter our result given that more than 99 % of uncompleted houses are purchased from developers within 48 months from the time when the sales are launched,[63] and 95.13% of units that speculators hold are sold out within that period.

Table 4.1 provides summary statistics for the area-adjusted house price, months from the first sale, policy details, floor and area. We have 111,160 observations, and the average area-adjusted transaction price over our sample period is 12,751 Singapore dollars. Speculative purchase account for 9% of the total transactions. The average months from the first sale within the same project is about 8.19, which means units are sold out quickly on average once projects are launched, much earlier before the construction is completed. We have enough observations after policies with 83%, 72%,61%, 57%, 51%, 47% of observations after the policies in 2006, 2007, 2009, February 2010, August 2010 and 2011. The mean floor is 11.99 with 70 as the highest floor. The average size of housing unit is 122.83 square meters, and smallest house is 31 square meters in our sample. Housing price index varies from 79.5 to 148.9 in our sample.

4.5 Main Results and Robustness Checks

4.5.1 Main Result

[63] 99.47 % is based on the whole sample, 99.49% if we confine sample to project with first sale after policy in June 1998 and 99.68%% if we confine sample to project with first sale after policy in November 2001.

We begin our analysis by estimating equation (1), and Table 4.2 shows the result. We control for project fixed effect, floor, area and housing price index in Column (1), and control for year-quarter fixed effect instead of price index in Column (3). Column (2) and (4) are corresponding marginal effect. The evidence for Seller's Stamp Duty in 2011 is more prominent, although there are some evidences for other policies. It shows that the probability of speculative purchase decreases by 10.35% after the huge increase in transaction cost in 2011.

We then look at the effect of policies on price over sales sequence. Table 4.3 studies policies before the financial crisis, Table 4.4 presents policies after the financial crisis and Table 4.5 shows all policies. In each table, Column (1) provides our baseline specification, which includes project fixed effects, unit characteristics, policy dummies and year-quarter fixed effect.[64] In column (2), we use year-month fixed effect. In column (3) we add a planning region specific linear time trend. Column (4) we add a planning area specific linear time trend. Column (5) - (8) are the same with column (1) – (4), except that we use building fixed effect instead of project fixed effect. The most extensive specification is column (8). T-statistics are reported in parentheses below each coefficient, which are calculated using standard errors clustered at the project level.[65]

Looking at Table 4.3, we see that price have upward trend over sales sequence overall. Policy in 2006 does not have significant effect on price on average or price sequence, but policy in 2007 have effect on price sequence at 5% significant level. If one unit that is transacted 12 months later than another similar unit that was sold immediately once the sale was launched, the difference of area adjusted price between two units increase 0.0288 % after the policy. The sign

[64] We do not present result of column (1) in Table 4.5 for space purpose. Result are available upon request.

[65] For probit regression, Z-statistics are reported in parentheses below each coefficient, which are calculated using standard errors clustered at the planning area level. Results hold if we cluster standard errors clustered at the project level.

of floor and area are consistent with the practice in Singapore where the area adjusted price increase with floor and decreases with the total area.

Then we look at recent cooling measures in Table 4.4. Only the harsh increase in transaction tax have significant and strong effect on sales sequence. Table 4.4 shows that the price trend become much steeper after the dramatic increase in sellers' stamp duty. For example, if unit A was sold 12 months later than unit B that was sold at the beginning of the sales sequence, the area adjusted price difference between unit A and unit B would increase 0.0276% after the dramatic increase in Sellers' Stamp Duty.

We study all the policies together in Table 4.5. The results are similar to that in Table 4.3 and Table 4.4. The significance on the interaction term of months from the first sale and policy 2007 changes from 5% to 1%, but the result of Seller's Stamp Duty in 2011 is very consistent. Policy in 2007 and 2011 have significant effect on price pattern while other policies do not have significant effect. Housing unit that was purchase within one month and another units that was sold 12 months later, the price could increase 0.0324% after policy in 2007 and could further increase 0.0276% after policies in 2011.

One may want to look at price per square meter dynamics over sales sequence visually. We control for building fixed effect, floor, area, year-month fixed effect and area planning specific year trend. Our dynamic results have very strong and significant evidence for Seller's Stamp Duty,[66] we show the effect of policy in 2011 in Figure 3. The figure shows that the price increases rapidly over sales sequence after policy. It seems that more arbitrage opportunities exist along sequence if we do not take transaction cost into consideration.

4.5.2 Robustness Checks

[66] Regression results are available upon request.

To show that the results presented above are robust, we perform several additional tests. For the probability of speculative purchase, we run regression without project fixed effect but with region or area specific year trend. As we control for less variable, we find the policy dummies are more significant. Result in Table B3 show that the probability of speculative trade decreases after Seller's Stamp Duty was imposed.

We then test the robustness of our price trend result. In Table B4 we restrict our sample to projects with only one construction stage as large project may have two construction stages. As we can see from Table B4, when we restrict our sample to these units, we continue to find that as the transaction cost increases, the price over sales sequence increases more than the absence of sharp increase in transaction cost. In Table B5 we enlarge sample by including house units that were purchased by speculators before the policies and then were sold after policies. The results are similar with that in Table 4.5 and it would suggest that speculators do not have strong bargaining power to push down the price when they purchase units or push up the price when they sell them. Overall, our results are consistent across various specifications, suggesting that as transaction cost increase, short term speculators decrease dramatically, and price over sales sequence increases more.

4.6 Mechanism

REALIS transaction level data shows that 82.99% speculative purchases happen within 12 months from the sale is launched, and 10.76%, 21.52%, 44.84%, 22.88% speculative units are then sold within 12 months, 12- 24 months, 24-36 months, and 36-48 months from the first sale within the same development. To explain our result, we try to investigate the changes in housing price from demand and supply perspectives. We analyse demand by confining sample to units sold within 12 months, and investigate supply side by using housing units that are transacted 24-36 months.[67]

We start from the demand side to analyze our findings. When speculators participate in the market, they purchase houses at the early stage of sales sequence, which could increase the demand at the beginning of sales sequence, so the price at the early stage of sales increases and thus the price trend will be flatter, holding the price at later stages unchanged. Table 4.6 shows our analysis of demanding from speculators. Column (1) - (3) shows that price at the early stage of sales decrease with less speculators purchasing in the market after Seller's Stamp Duty in 2011, after controlling for building fixed effect, area, floor, time fixed effect and region specific time trend. To see whether speculators have market power to purchase units at lower price, we exclude units purchased by speculators in column (4) - (6), with same specification as in column (1)-(3). The result shows similar coefficient, which suggest that speculators does not have specific market power to affect individual housing unit they purchased.

We then move to the supply side. When speculators sell the units at the late stage of sales sequence, it increases supply at the late stage of sales increases and therefore the price trend become flatter, holding the price at early stages is unchanged. Table 4.7 shows that the price at later stages of sales sequence increases after policy when speculative sale is less. To see whether speculators push up price of units they hold, we exclude units sold by speculators in column (4) - (6), the magnitude of coefficient is the same and the T value is very closed to column (1)-(3). This implies that speculators do not have strong power to push up price when they sell housing units.

4.7 Conclusions

[67] We also run regression for units transacted 12-24, and 36-48 months, but we do not find significant result.

We estimate the effect of transaction cost on trading volume and housing price pattern of properties before the construction is completed. We find that price increases significantly along sales sequence without short-term speculators after policies, which is mainly resulting from the decreased demand from speculators at the early stage of sales sequence and the decreased supply from speculators at later stages. We also find that speculators in our study does not have significant market power to push down the price when they purchase the units or push up price when they sell their house units. The more significantly upward trend over sales sequence within the same real estate development may suggest that price does not reflect the true value of houses from the perspective of market efficiency hypothesis.

Our study has policy implications. On the one hand, as housing price increases with more demand from speculators who step into market once the sale of new project is launched, the government may want to deter speculators, if they aim at the affordability of the majority. On the other hand, it is only when price does not reflect all information, speculators could get return by flipping house units, which suggest that speculators could transmit information into the price by their trading. The government may want to relax this regulation from the perspective of market efficiency. Actually, the government relax seller's stamp duty on March 11, 2017 for some reason we do not know.[68] Accordingly, sales of new private homes surged to a near four-year high, which might provide evidence to support our finding. [69]

[68] Home owners now only have to wait three years before selling their properties to avoid paying the SSD, down from four years previously. This applies to residential properties bought on or after March 11, 2017. The SSD was also cut by four percentage points for each tier. As the construction takes about 3 years, this policy is expected to affect demand and speculative trading.
https://www.iras.gov.sg/irashome/Other-Taxes/Stamp-Duty-for-Property/Working-out-your-Stamp-Duty/Selling-or-Disposing-Property/Seller-s-Stamp-Duty--SSD--for-Residential-Property/

[69] http://www.straitstimes.com/business/property/march-new-private-home-sales-jump-82-from-february-more-than-double-from-year-ago

References

Akinci, O. and Olmstead-Rumsey, J., 2017. How effective are macroprudential policies? An empirical investigation. *Journal of Financial Intermediation*.

Allen, F. and Carletti, E., 2013. Systemic risk from real estate and macro-prudential regulation. *International Journal of Banking, Accounting and Finance*, *5*(1-2), pp.28-48.

Ardeni, Pier Giorgio,1989. Does the Law of One Price Really Hold for Commodity Prices? *American Journal of Agricultural Economics*, 71 (3), pp.661-69.

Ashenfelter, Orley, 1989. How Auctions Work for Wine and Art. *Journal of Economic Perspectives*, 3(3), pp. 23–36.

Ashenfelter, Orley and David Genesove. 1992. Testing for Price Anomalies in Real-Estate Auctions. *American Economic Review*, 82(2), pp.501–505.

Baffes, John,1991. Some further evidence on the law of one price: The law of one price still holds. *American Journal of Agricultural Economics*, 73 (4), pp.1264-1273.

Baltagi, B.H. and Li, J., 2015. Cointegration of matched home purchase and rental price indexes – Evidence from Singapore. *Regional Science and Urban Economics,* 55, pp. 80-88.

Beggs, Alan and Kathryn Graddy, 1997. Declining Values and the Afternoon Effect: Evidence from the Art Auctions. *RAND Journal of Economics*, 28(3), pp.544–565.

Bianchi, J. and Mendoza, E.G., 2010. Overborrowing, financial crises and'macro-prudential'taxes (No. w16091). *National Bureau of Economic Research*.

Brown, A. and Yang, F., 2016. The role of speculative trade in market efficiency: Evidence from a betting exchange. *Review of Finance*, pp.rfw027.

Brunnermeier, M.K., 2005. Information leakage and market efficiency. *Review of Financial Studies*, 18(2), pp.417-457.

Burguet, Roberto, 2005. The Condominium Problem; Auctions for Substitutes. *Review of Economic Design*, 9,73–90.

Case, K.E. and Shiller, R.J., 2003. Is there a bubble in the housing market?. *Brookings Papers on Economic Activity*, *2003*(2), pp.299-342.

Cerutti, E., Claessens, S. and Laeven, L., 2017. The use and effectiveness of macroprudential policies: new evidence. *Journal of Financial Stability*.

Chang, E.C., Luo, Y. and Ren, J., 2014. Short-selling, margin-trading, and price efficiency: Evidence from the Chinese market. *Journal of Banking & Finance*, 48, pp.411-424.

Claessens, S., 2015. An overview of macroprudential policy tools. *Annual Review of Financial Economics*, *7*, pp.397-422.

Constantinides, G.M., 1986. Capital market equilibrium with transaction costs. *Journal of political Economy*, *94*(4), pp.842-862.

Cornell, W.B. and Dietrich, J.K., 1978. The efficiency of the market for foreign exchange under floating exchange rates. *The Review of Economics and Statistics*, pp.111-120.

Crowe, C., Dell'Ariccia, G., Igan, D. and Rabanal, P., 2013. How to deal with real estate booms: Lessons from country experiences. *Journal of Financial Stability*, *9*(3), pp.300-319.

Danthine, J.P., 1978. Information, futures prices, and stabilizing speculation. *Journal of Economic Theory*, *17*(1), pp.79-98.

Dell'Ariccia, G., Igan, D., Laeven, L. and Tong, H., 2008. *Policies for Macrofinancial Stability: How to Deal with Credit Booms*. IMF Working Paper WP/08/106.

Dusansky, R. and Koç, Ç., 2007. The capital gains effect in the demand for housing. *Journal of Urban Economics*, *61*(2), pp.287-298.

Easley, D., Kiefer, N.M. and O'Hara, M., 1997. The information content of the trading process. *Journal of Empirical Finance*, *4*(2), pp.159-186.

Easley, D., O'hara, M. and Srinivas, P.S., 1998. Option volume and stock prices: Evidence on where informed traders trade. *The Journal of Finance*, *53*(2), pp.431-465.

Fama, E.F., 1965. The behavior of stock-market prices. *The journal of Business,* 38(1), pp.34-105.

Fama, E.F., 1970. Efficient capital markets: A review of theory and empirical work. *The journal of Finance,* 25(2), pp.383-417.

Figlewski, S., 1978. Market" efficiency" in a market with heterogeneous information. *Journal of Political Economy,* 86(4), pp.581-597.

Frino, A. and West, A., 2003. The impact of transaction costs on price discovery: Evidence from cross-listed stock index futures contracts. *Pacific-Basin Finance Journal*, *11*(2), pp.139-151.

Froot, K.A. and Perold, A.F., 1995. New trading practices and short-run market efficiency. *Journal of Futures Markets*, *15*(7), pp.731-765.

Froot, K.A., Scharfstein, D.S. and Stein, J.C., 1992. Herd on the street: Informational inefficiencies in a market with short-term speculation. *The Journal of Finance*, 47(4), pp.1461-1484.

Fu, Yuming, and Wenlan Qian, 2014. Speculators and price overreaction in the housing market. *Real Estate Economics*, 42(4), pp.977-1007.

Fu, Yuming, Wenlan Qian, and Bernard Yeung, 2015. Speculative Investors and Transactions Tax: Evidence from the Housing Market. *Management Science*, 62(11), pp.3254-3270.

Galati, G. and Moessner, R., 2013. Macroprudential policy–a literature review. *Journal of Economic Surveys*, *27*(5), pp.846-878.

Garleanu, Nicolae, and Lasse Heje Pedersen, 2011. Margin-based asset pricing and deviations from the law of one price. *Review of Financial Studies*, 24(6), pp.1980-2022.

Glosten, L.R. and Milgrom, P.R., 1985. Bid, ask and transaction prices in a specialist market with heterogeneously informed traders. *Journal of financial economics*, *14*(1), pp.71-100.

Grossman, S., 1976. On the efficiency of competitive stock markets where trades have diverse information. *The Journal of finance*, *31*(2), pp.573-585.

Grossman, S.J., 1977. The existence of futures markets, noisy rational expectations and informational externalities. *The Review of Economic Studies*, pp.431-449.

Grossman, S.J. and Stiglitz, J.E., 1976. Information and competitive price systems. *The American Economic Review*, *66*(2), pp.246-253.

Grossman, S.J. and Stiglitz, J.E., 1980. On the impossibility of informationally efficient markets. *The American economic review*, *70*(3), pp.393-408.

Hanson, S.G., Kashyap, A.K. and Stein, J.C., 2011. A macroprudential approach to financial regulation. *The Journal of Economic Perspectives*, *25*(1), pp.3-28.

Himmelberg, C., Mayer, C. and Sinai, T., 2005. Assessing high house prices: Bubbles, fundamentals and misperceptions. *The Journal of Economic Perspectives*, *19*(4), pp.67-92.

Huang, N., Li, J. and Ross, A., 2016. The Impact of the Cost of Car Ownership on the Housing Price Gradient in Singapore.

Jaffe, J.F. and Winkler, R.L., 1976. Optimal speculation against an efficient market. *The Journal of Finance*, 31(1), pp.49-61.

Jiang, L., Phillips, P.C. and Yu, J., 2015. New methodology for constructing real estate price indices applied to the Singapore residential market. *Journal of Banking & Finance*, *61*, pp.S121-S131.

Kannan, P., Rabanal, P. and Scott, A., 2009. Monetary and macroprudential policy rules in a model with house price booms. *International Monetary Fund, Research Department.*

Kiefer, D.W., 1990. The securities transactions tax: An overview of the issues. *Congressional Research Service, Library of Congress.*

Krainer, J., 2001. A theory of liquidity in residential real estate markets. *Journal of urban Economics*, *49*(1), pp.32-53.

Kyle, A.S., 1985. Continuous auctions and insider trading. *Econometrica: Journal of the Econometric Society*, pp.1315-1335.

Lin, Z. and Vandell, K.D., 2007. Illiquidity and pricing biases in the real estate market. *Real Estate Economics*, *35*(3), pp.291-330.

Milgrom, P. and Weber, R.J., 1982. The value of information in a sealed-bid auction. *Journal of Mathematical Economics*, *10*(1), pp.105-114.

Munneke, H., Ooi, J.T., Sirmans, C.F. and Turnbull, G.K., 2011. Sequential sales of similar assets: the law of one price and real estate. *Journal of Regional Science*, *51*(2), pp.355-370.

Rauch, J.E., 1993. Does history matter only when it matters little? The case of city-industry location. *The Quarterly Journal of Economics*, *108*(3), pp.843-867.

Richardson, J. David. "Some empirical evidence on commodity arbitrage and the law of one price." *Journal of International Economics* 8, no. 2 (1978): 341-351.

Roll, R., Schwartz, E. and Subrahmanyam, A., 2007. Liquidity and the law of one price: the case of the futures-cash basis. *The Journal of Finance*, *62*(5), pp.2201-2234.

Ross, S.A., 1976. The arbitrage theory of capital asset pricing. *Journal of economic theory*, 13(3), pp.341-360.

Samuelson, P.A., 1965. Proof that properly anticipated prices fluctuate randomly.

Sirmans, C.F., Turnbull, G.K. and Dombrow, J., 1997. Residential development, risk, and land prices. *Journal of Regional Science*, *37*(4), pp.613-628.

Tirole, J., 1982. On the possibility of speculation under rational expectations. *Econometrica: Journal of the Econometric Society*, pp.1163-1181.

Wong, S.K., Yiu, C.Y., Tse, M.K.S. and Chau, K.W., 2006. Do the forward sales of real estate stabilize spot prices?. *The Journal of Real Estate Finance and Economics*, 32(3), pp.289-304.

Wurgler, J., 2000. Financial markets and the allocation of capital. *Journal of financial economics*, *58*(1), pp.187-214.

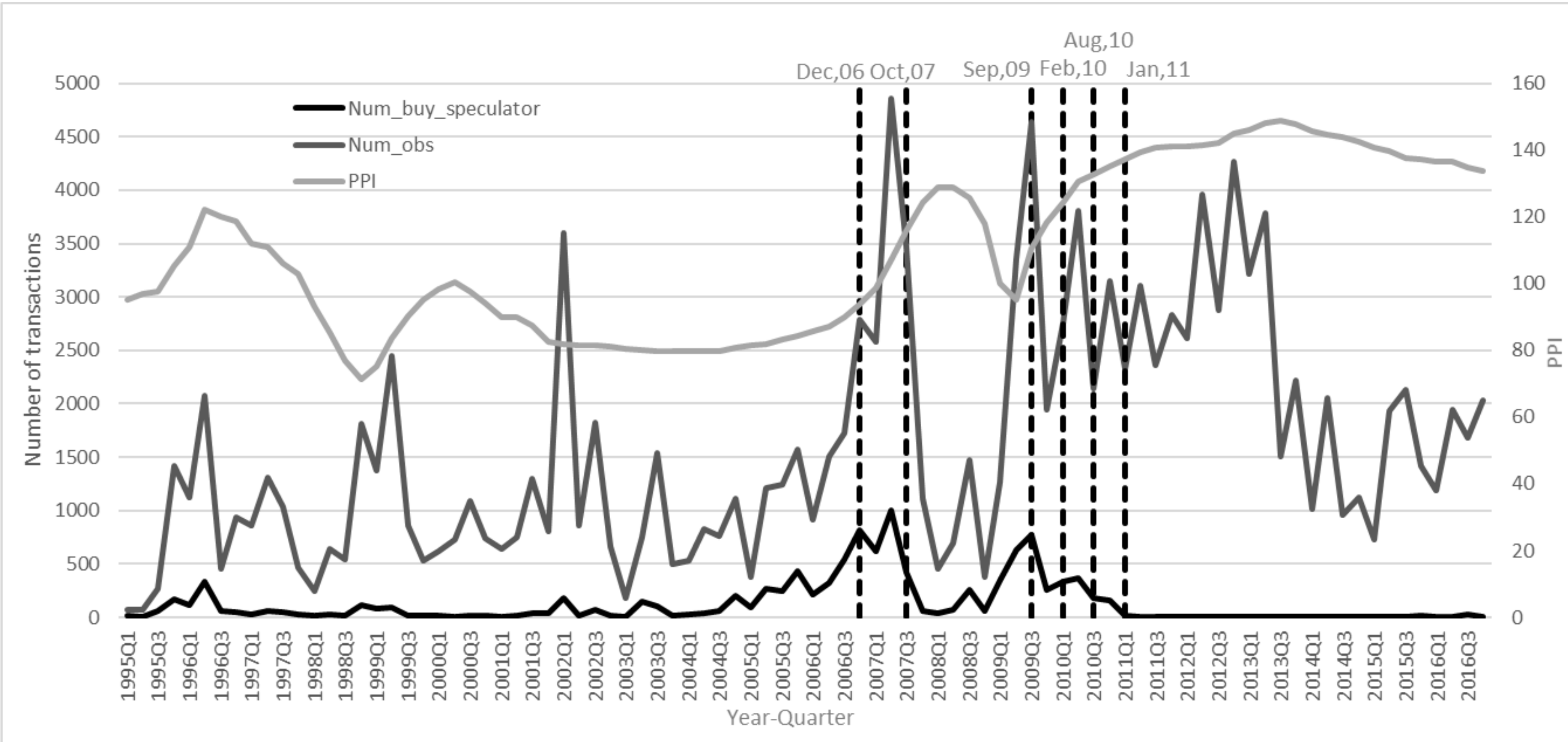


Figure 4.1a: Number of Transactions That Will Be Flipped Before Completion

Notes: This figure presents property price index for non-landed residential properties, the number of transactions of uncompleted units, and the number of units that "are purchased and will be flipped by speculators before completion" at year-month level. The prices in 1Q2009 are used as the base reference price of the total index. I define transactions that "are purchased and will be flipped by speculators before completion" as follows. For example, a unit A is transacted on January 15, 2006, April 15 2006 and January 15 2007 before completion date. The transaction on January 15 and on April 15 2006 are defined as "are bought by speculators". Transaction on January 15 2007 is not considered as "are bought by speculators". For unit B that is transacted only once before completion date, it is not considered as "are bought by speculators", either. I use "Apartment" and "Condo" and exclude "Executive Condo". Source: Real Estate Information System.

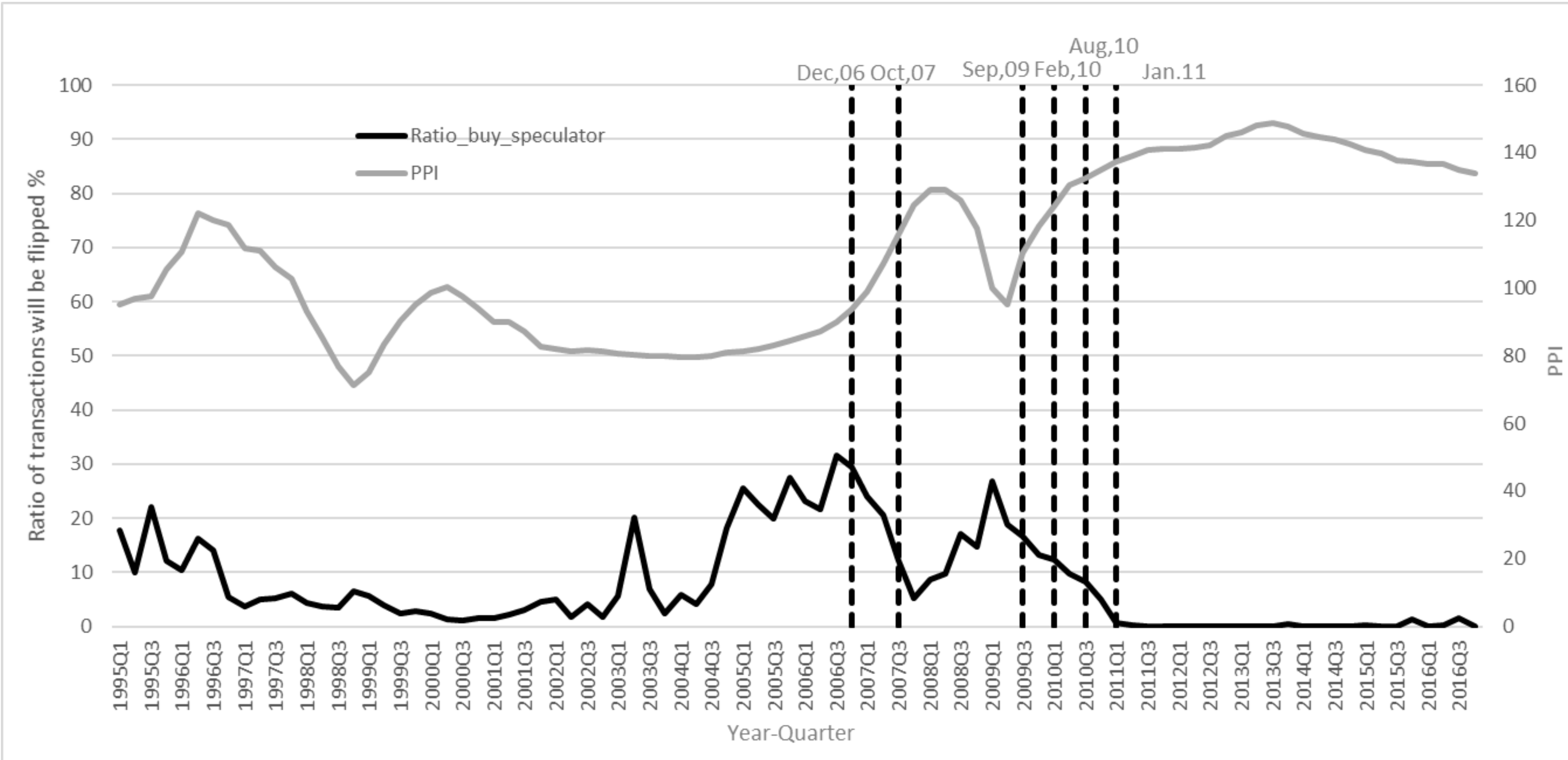


Figure 4.1b: Ratio of Transactions That Will Be Flipped Before Completion

Notes: This figure presents property price index for non-landed residential properties and the ratio of units that "are purchased and will be flipped by speculators before completion" at year-month level. The ratio is defined by dividing the number of units that "are purchased and will be flipped by speculators before completion" by the total number of transactions of uncompleted units. The prices in 1Q2009 are used as the base reference price of the total index. I define transactions that "are purchased and will be flipped by speculators before completion" as follows. For example, a unit A is transacted on January 15, 2006, April 15 2006 and January 15 2007 before completion date. The transaction on January 15 and on April 15 2006 are defined as "are bought by speculators". Transaction on January 15 2007 is not considered as "are bought by speculators". For unit B that is transacted only once before completion date, it is not considered as "are bought by speculators", either. I use "Apartment" and "Condo" and exclude "Executive Condo". Source: Real Estate Information System.

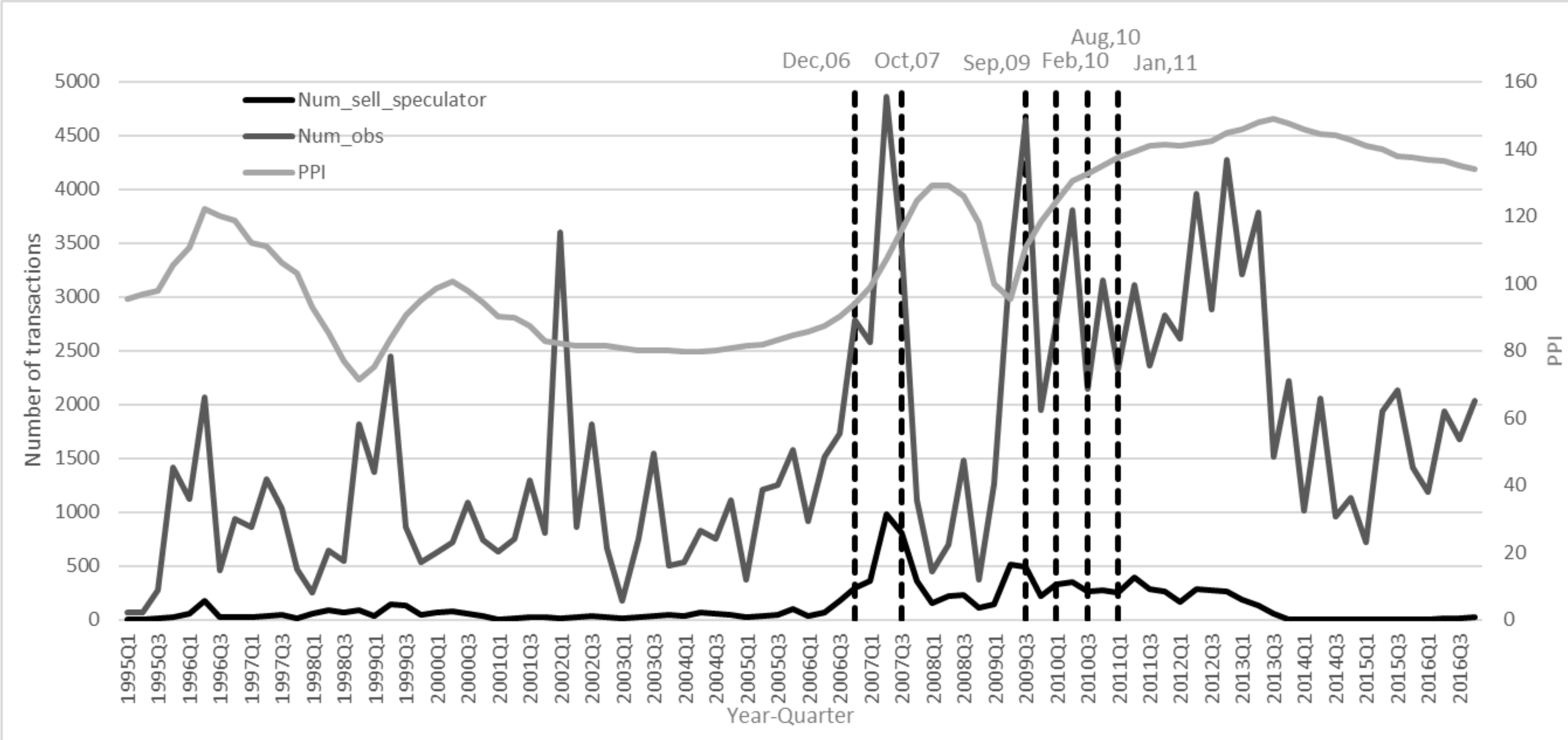


Figure 4.2a: Number of Transactions That Are Flipped Before Completion

Notes: This figure presents property price index for non-landed residential properties, the number of transactions of uncompleted units, and the number of transactions that “are flipped by speculators” of uncompleted units at year-month level. The prices in 1Q2009 are used as the base reference price of the total index. I define transactions that “are flipped by speculators” of uncompleted units as follows. For example, a unit A is transacted on January 15, 2006, April 15 2006 and January 15 2007 before completion date. The first transaction on January 15 2006 is not considered as “was sold by speculators”. Transaction on April 15 2006 and January 15 2007 are defined as “was flipped by speculators.

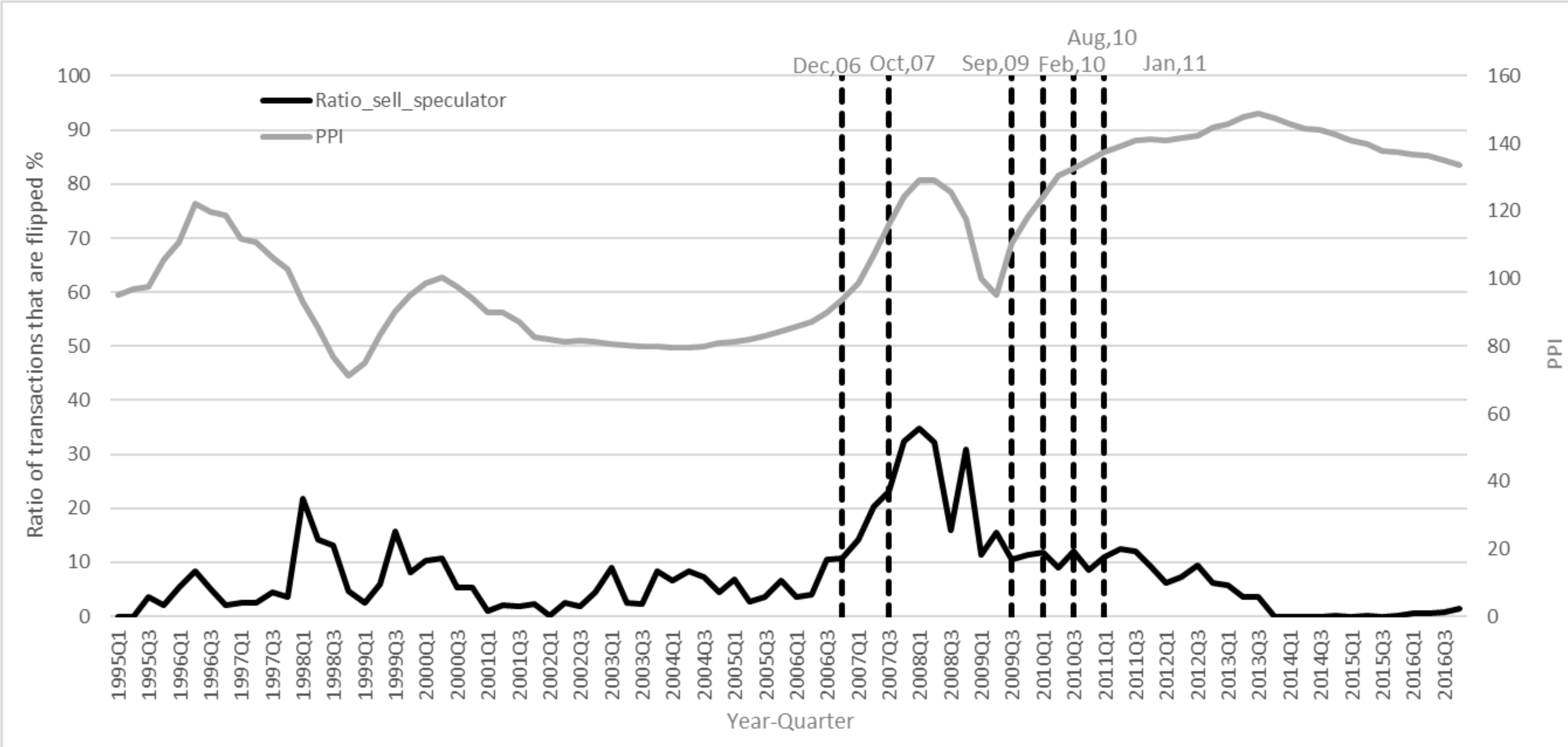


Figure 4.2b: Ratio of Transactions That Are Flipped Before Completion

Notes: This figure presents property price index for non-landed residential properties and the ratio of transactions that "are flipped by speculators" over all transactions of uncompleted units at year-month level. The ratio is defined by dividing the number of units that "are flipped by speculators" by the total number of transactions of uncompleted units. The prices in 1Q2009 are used as the base reference price of the total index. I define transactions that "are flipped by speculators" of uncompleted units as follows. For example, a unit A is transacted on January 15, 2006, April 15 2006 and January 15 2007 before completion date. The first transaction on January 15 2006 is not considered as "was sold by speculators". Transaction on April 15 2006 and January 15 2007 are defined as "was flipped by speculators.

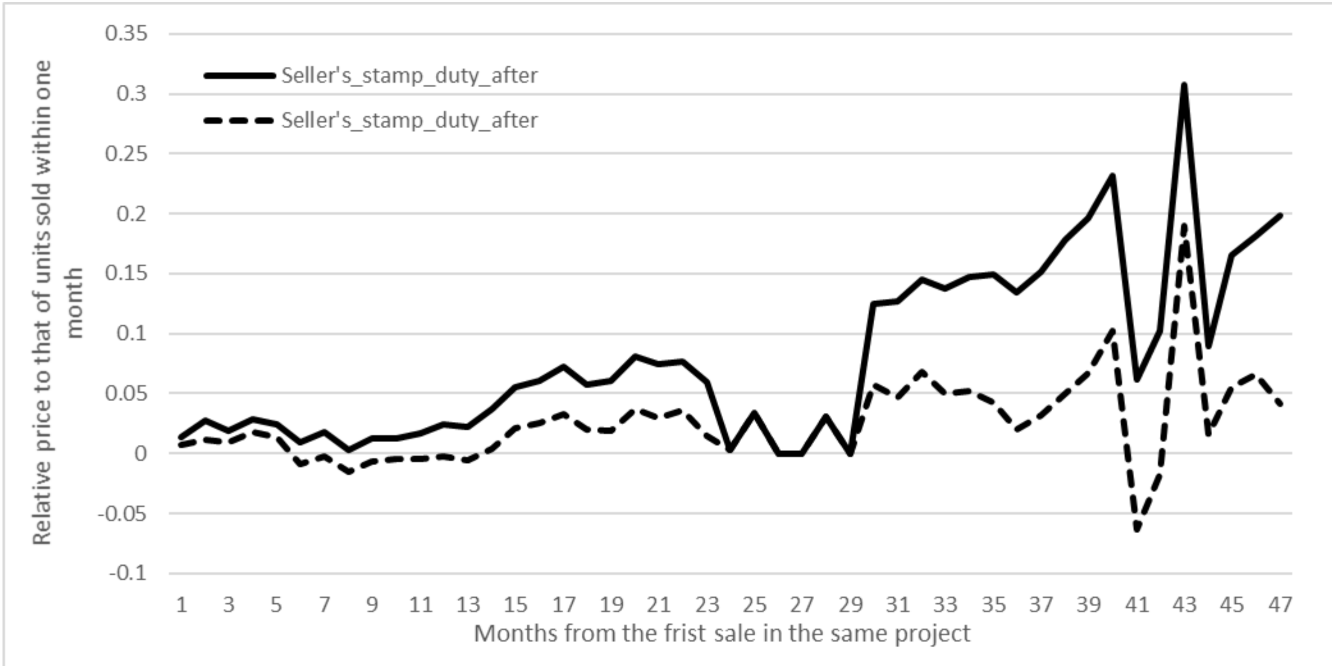


Figure 4.3: Estimated Price Dynamics Over Sales Sequence

Notes: This figure presents entire path of coefficients $\beta_{1,m}$ and $\beta_{2,m}$, $m = 1, \ldots, 47$ for the Seller's Stamp Duty (SSD) in January 2011. Most coefficient are significant at 1% level. We use price per square meter as dependent variable, and control for building fixed effect, floor, area, year-month fixed effect, and planning area specific year trend. Regression results are available upon request.

Table 4.1: Summary Statistics

	Observations	Mean	Std. Dev.	Min	Max
Area-adjusted Transaction Price[1]	111,160	12751.41	5410.34	3211	53816
Speculative purchase	111,160	0.09	0.28	0	1
Months from the first sale[2]	111,160	8.19	11.36	0	47
After Policy in Dec 2006[3]	111,160	0.83	0.38	0	1
After Policy in Oct 2007[3]	111,160	0.72	0.45	0	1
After Policy in Sep 2009[3]	111,160	0.61	0.49	0	1
After Policy in Feb 2010[3]	111,160	0.57	0.49	0	1
After Policy in Aug 2010[3]	111,160	0.51	0.50	0	1
After Policy in Jan 2011[3]	111,160	0.47	0.50	0	1
Floor	111,160	11.99	8.65	-1	70
Area	111,160	101.40	45.44	31	495
Housing Price Index	111,160	122.83	22.70	79.5	148.9

[1] Area adjustment is achieved by dividing the unit transaction price by the corresponding floor area.
[2] It is months from the first transaction date of uncompleted unit in the same property project.
[3] Details of policies are stated in the paper.

Table 4.2: Probit Regressions – Units That Will be Flipped Before the Construction is Completed[1]
(z statistics are reported in parentheses using clustered standard errors at the planning area level)

	(1)	(2)	(3)	(4)
	Probit coefficient	Marginal Effect	Probit coefficient	Marginal Effect
Months from the first sale[2]	-0.0153***	-0.0021***	-0.0190*	-0.0026*
	(-3.74)	(-3.77)	(-1.65)	(-1.65)
Log of housing price index[3]	-1.0429***	-0.1404***		
	(-4.47)	(-4.49)		
After policy in December 2006[3]	-0.0349	-0.0047	-0.1144**	-0.0158**
	(-0.34)	(-0.34)	(-2.51)	(-2.51)
After policy in October 2007[3]	-0.5825***	-0.0784***	-0.3000**	-0.0416
	(-8.92)	(-8.97)	(-1.99)	(-1.99)
After policy in September 2009[3]	-0.0568	-0.0077	-0.0055	-0.0008
	(-1.06)	(-1.06)	(-0.05)	(-0.05)
After policy in Feb 2010[3]	-0.1991***	-0.0268***	-0.2187***	-0.0303***
	(-3.10)	(-3.09)	(-2.91)	(-2.91)
After policy in Aug 2010[3]	-0.3546***	-0.0477***	-0.2949***	-0.0409
	(-8.17)	(-8.09)	(-3.21)	(-3.19)
After policy in Jan 2011[3]	-1.1334***	-0.1526***	-0.7467***	-0.1035***
	(-13.04)	(-12.74)	(-4.43)	(-4.42)
Floor	-0.0002	0-.0000	-0.0001	-0.0000
	(-0.19)	(-0.19)	(-0.10)	(-0.10)
Area	-0.0030***	-0.0004***	-0.0031***	-0.0004***
	(-8.19)	(-8.21)	(-7.93)	(-7.95)
Project Fixed Effect	YES	YES	YES	YES
Year × Quarter Fixed Effect			YES	YES
Observations	93,562	90,427	93,562	90,427

[1] We use projects whose first sale is from December 2001.
[2] It is months from the first transaction date of uncompleted unit in the same property project.
[3] Details of policies are stated in the paper.

Table 4.3: Regression Results – Policy in December 2006 and October 2007[1]
Dependent Variable: Log of Transaction Price Per Square Meter
(t statistics are reported in parentheses Cluster Standard Errors at Project Level)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Months from the first sale[2]	0.0079***	0.0067***	0.0072***	0.0090***	0.0076***	0.0058***	0.0061***	0.0076***
	(4.47)	(3.23)	(3.58)	(4.51)	(4.69)	(2.95)	(3.11)	(3.88)
After policy in Dec 2006[3]	-0.0313*				-0.0330*			
	(-1.79)				(-1.78)			
After policy in Oct 2007[3]	-0.0141				-0.0115			
	(-0.54)				(-0.54)			
Months × After policy in Dec 2006[3]	0.0030***	0.0021***	0.0020***	0.0008	0.0029***	0.0020**	0.0019***	0.0008
	(3.45)	(2.91)	(2.92)	(1.07)	(3.12)	(2.59)	(2.66)	(1.06)
Months × After policy in Oct 2007[3]	0.0038***	0.0037***	0.0029***	0.0024**	0.0031***	0.0032***	0.0027***	0.0024**
	(3.06)	(3.37)	(3.57)	(2.57)	(2.80)	(3.21)	(3.68)	(2.56)
Floor	0.0058***	0.0058***	0.0058***	0.0057***	0.0060***	0.0060***	0.0060***	0.0059***
	(8.53)	(8.67)	(8.64)	(8.09)	(8.14)	(8.21)	(8.17)	(7.58)
Area	-0.0006***	-0.0006***	-0.0006***	-0.0006***	-0.0007***	-0.0007***	-0.0007***	-0.0007***
	(-3.28)	(-3.26)	(-3.26)	(-3.12)	(-3.85)	(-3.83)	(-3.82)	(-3.76)
Project Fixed Effect	YES	YES	YES	YES				
Building Fixed Effect					YES	YES	YES	YES
Year × Quarter Fixed Effect	YES				YES			
Year × Month Fixed Effect		YES	YES	YES		YES	YES	YES
Year × Planning Region Fixed Effect			YES				YES	
Year × Planning Area Fixed Effect				YES				YES
Observations	33,564	33,564	33,564	33,564	33,564	33,564	33,564	33,564
R-squared	0.965	0.966	0.967	0.969	0.970	0.971	0.972	0.973

[1] We use projects whose first sale is from December 2001. To isolate the effect of Cooling Measures from September 2009, I restrict to projects whose last sale before September 2009. We further exclude units with transactions across policies in December 2006 and October 2007, respectively.
[2] It is months from the first transaction date of uncompleted unit in the same property project.
[3] Details of policies are stated in the paper.

Table 4.4: Regression Results – Cooling Measures from September 2009[1]
Dependent Variable: Log of Transaction Price Per Square Meter
(t statistics are reported in parentheses Cluster Standard Errors at Project Level)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Months from the first sale[2]	0.0032*	0.0034*	0.0027	0.0034**	0.0022	0.0024	0.0019	0.0023*
	(1.66)	(1.77)	(1.53)	(2.28)	(1.42)	(1.51)	(1.26)	(1.72)
After policy in Sep 2009	0.0257*				0.0233*			
	(1.86)				(1.84)			
After policy in Feb 2010	0.0263**				0.0252**			
	(2.43)				(2.55)			
After policy in Aug 2010	0.0033				0.0119			
	(0.37)				(1.19)			
After policy in Jan 2011	-0.0208				-0.0109			
	(-1.05)				(-0.75)			
Months × After policy in Sep 2009	0.0004	0.0007	0.0011	0.0010	0.0007	0.0009	0.0010	0.0008
	(0.39)	(0.83)	(1.30)	(1.37)	(0.73)	(1.20)	(1.32)	(1.23)
Months × After policy in Feb 2010	-0.0002	-0.0002	0.0001	0.0000	-0.0002	-0.0001	0.0000	0.0001
	(-0.29)	(-0.25)	(0.13)	(0.08)	(-0.30)	(-0.22)	(0.01)	(0.22)
Months × After policy in Aug 2010	-0.0005	-0.0002	-0.0003	-0.0003	-0.0009	-0.0007	-0.0006	-0.0008
	(-0.73)	(-0.29)	(-0.42)	(-0.64)	(-1.54)	(-1.23)	(-1.08)	(-1.59)
Months × After policy in Jan 2011	0.0023***	0.0024***	0.0027***	0.0022***	0.0023***	0.0024***	0.0026***	0.0023***
	(4.43)	(5.19)	(5.11)	(4.79)	(4.32)	(5.02)	(4.81)	(5.09)
Project Fixed Effect	YES	YES	YES	YES				
Building Fixed Effect					YES	YES	YES	YES
Year × Quarter Fixed Effect	YES				YES			
Year × Month Fixed Effect		YES	YES	YES		YES	YES	YES
Year × Planning Region Fixed Effect			YES				YES	
Year × Planning Area Fixed Effect				YES				YES
Observations	70,763	70,763	70,763	70,763	70,763	70,763	70,763	70,763
R-squared	0.955	0.956	0.957	0.959	0.962	0.963	0.964	0.965

We control for floor, area in all specifications.
[1] We use projects whose first sale after policy in October 2007 and further exclude units with transactions across each policy in 2009-2011.
[2] It is months from the first transaction date of uncompleted unit in the same property project.

Table 4.5: Regression Results – Policy in 2006, 2007, 2009 and Sellers' Stamp Duty[1]
Dependent Variable: Log of Transaction Price Per Square Meter
(t statistics are reported in parentheses Cluster Standard Errors at Project Level)

	(1)	(2)	(3)	(4)	(5)	(6)
Months from the first sale[2]	0.0004	0.0002	0.0027*	0.0002	-0.0001	0.0018
	(0.19)	(0.12)	(1.78)	(0.12)	(-0.08)	(1.25)
Months × After policy in December 2006[3]	0.0020***	0.0020***	0.0007	0.0019**	0.0018**	0.0007
	(2.80)	(2.91)	(0.96)	(2.40)	(2.44)	(0.88)
Months × After policy in October 2007[3]	0.0048***	0.0036***	0.0028***	0.0038***	0.0034***	0.0027***
	(3.60)	(4.31)	(2.96)	(3.13)	(4.09)	(2.85)
Months × After policy in September 2009[3]	-0.0006	0.0004	0.0008	-0.0002	0.0002	0.0007
	(-0.61)	(0.45)	(1.12)	(-0.22)	(0.26)	(1.06)
Months × After policy in Feb 2010[3]	-0.0004	0.0001	-0.0002	-0.0003	-0.0002	-0.0002
	(-0.60)	(0.09)	(-0.27)	(-0.48)	(-0.28)	(-0.27)
Months × After policy in Aug 2010[3]	-0.0010	-0.0009	-0.0005	-0.0017*	-0.0013	-0.0010**
	(-0.99)	(-0.94)	(-0.89)	(-1.71)	(-1.47)	(-2.07)
Months × After policy in Jan 2011[3]	0.0031***	0.0032***	0.0023***	0.0030***	0.0032***	0.0023***
	(4.52)	(4.63)	(4.74)	(4.20)	(4.32)	(5.07)
Floor	0.0061***	0.0061***	0.0061***	0.0063***	0.0063***	0.0062***
	(18.54)	(18.32)	(17.24)	(17.73)	(17.53)	(16.32)
Area	-0.0011***	-0.0011***	-0.0011***	-0.0012***	-0.0012***	-0.0012***
	(-10.59)	(-10.56)	(-10.33)	(-11.04)	(-11.00)	(-10.82)
Project Fixed Effect	YES	YES	YES			
Building Fixed Effect				YES	YES	YES
Year × Month Fixed Effect	YES	YES	YES	YES	YES	YES
Year × Planning Region Fixed Effect		YES			YES	
Year × Planning Area Fixed Effect			YES			YES
Observations	95,830	95,830	95,830	95,830	95,830	95,830
R-squared	0.965	0.966	0.968	0.971	0.971	0.973

We do not present specifications with policy dummies and year × quarter fixed effect to save space. The results are similar in Table 4.3 and Table 4.4.
[1] We use projects whose first sale is from December 2001 and further exclude units with transactions across each policy in this table.
[2] It is months from the first transaction date of uncompleted unit in the same property project.
[3] Details of policies are stated in the paper.

Table 4.6: Regression Results – Units that are transacted within 12 Months[1]
Dependent Variable: Log of Transaction Price Per Square Meter
(t statistics are reported in parentheses Cluster Standard Errors at Project Level)

	(1)	(2)	(3)	(4)	(5)	(6)
Months from the first sale[2]	0.0070**	0.0058**	0.0059**	0.0059**	0.0046*	0.0044*
	(2.54)	(2.15)	(2.30)	(2.19)	(1.75)	(1.76)
Months × After policy in December 2006[3]	-0.0006	0.0011	0.0032	-0.0006	0.0011	0.0039
	(-0.33)	(0.60)	(1.35)	(-0.33)	(0.57)	(1.46)
Months × After policy in October 2007[3]	0.0006	0.0000	-0.0036	0.0026	0.0020	-0.0018
	(0.14)	(0.00)	(-0.90)	(0.62)	(0.48)	(-0.46)
Months × After policy in September 2009[3]	0.0035*	0.0030	0.0031	0.0033*	0.0029	0.0030
	(1.79)	(1.55)	(1.57)	(1.69)	(1.45)	(1.48)
Months × After policy in Feb 2010[3]	-0.0041*	-0.0032	-0.0014	-0.0043*	-0.0034	-0.0016
	(-1.76)	(-1.49)	(-0.66)	(-1.86)	(-1.59)	(-0.77)
Months × After policy in Aug 2010[3]	-0.0008	-0.0004	-0.0004	-0.0011	-0.0007	-0.0007
	(-0.48)	(-0.24)	(-0.25)	(-0.63)	(-0.39)	(-0.39)
Months × After policy in Jan 2011[3]	-0.0024	-0.0033**	-0.0036**	-0.0026	-0.0034**	-0.0037**
	(-1.42)	(-2.37)	(-2.05)	(-1.50)	(-2.45)	(-2.12)
Floor	0.0064***	0.0064***	0.0064***	0.0065***	0.0065***	0.0064***
	(18.52)	(18.43)	(18.22)	(20.16)	(19.92)	(19.50)
Area	-0.0012***	-0.0012***	-0.0012***	-0.0013***	-0.0013***	-0.0013***
	(-10.28)	(-10.27)	(-10.23)	(-11.65)	(-11.65)	(-11.63)
Building Fixed Effect	YES	YES	YES	YES	YES	YES
Year × Month Fixed Effect	YES	YES	YES	YES	YES	YES
Year × Planning Region Fixed Effect		YES			YES	
Year × Planning Area Fixed Effect			YES			YES
Include units purchased by speculators	YES	YES	YES	NO	NO	NO
Observations	73,949	73,949	73,949	72,320	72,320	72,320
R-squared	0.975	0.976	0.976	0.976	0.976	0.977

[1] We confine units that are transacted within 12 months once the sales are launched. We use projects whose first sale is from December 2001 and further exclude units with transactions across each policy in this table.
[2] It is months from the first transaction date of uncompleted unit in the same property project.
[3] Details of policies are stated in the paper.

Table 4.7: Regression Results – Units That are Transacted between 24 - 36 Month[1]
Dependent Variable: Log of Transaction Price Per Square Meter
(t statistics are reported in parentheses Cluster Standard Errors at Project Level)

	(1)	(2)	(3)	(4)	(5)	(6)
Months from the first sale[2]	0.0067*	0.0061*	0.0062*	0.0054*	0.0050	0.0048
	(1.94)	(1.82)	(1.85)	(1.66)	(1.54)	(1.48)
Months × After policy in December 2006[3]	-0.0004	-0.0001	-0.0003	-0.0004	-0.0002	0.0000
	(-0.35)	(-0.10)	(-0.29)	(-0.46)	(-0.14)	(0.04)
Months × After policy in October 2007[3]	-0.0036	-0.0033	-0.0033	-0.0029	-0.0027	-0.0028
	(-1.32)	(-1.23)	(-1.22)	(-1.27)	(-1.19)	(-1.19)
Months × After policy in September 2009[3]	0.0001	0.0002	0.0000	0.0003	0.0003	0.0002
	(0.15)	(0.16)	(0.02)	(0.31)	(0.33)	(0.18)
Months × After policy in Feb 2010[3]	-0.0013	-0.0014	-0.0014	-0.0013	-0.0013	-0.0013
	(-1.48)	(-1.51)	(-1.52)	(-1.41)	(-1.45)	(-1.46)
Months × After policy in Aug 2010[3]	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001
	(0.22)	(0.38)	(0.22)	(0.27)	(0.42)	(0.24)
Months × After policy in Jan 2011[3]	0.0015	0.0015	0.0023**	0.0015	0.0015	0.0023***
	(1.37)	(1.36)	(2.58)	(1.39)	(1.37)	(2.65)
Floor	0.0059***	0.0059***	0.0059***	0.0061***	0.0061***	0.0061***
	(12.22)	(12.11)	(11.99)	(13.67)	(13.52)	(13.37)
Area	-0.0008***	-0.0008***	-0.0007***	-0.0007***	-0.0007***	-0.0007***
	(-4.48)	(-4.48)	(-4.23)	(-4.31)	(-4.31)	(-4.07)
Building Fixed Effect	YES	YES	YES	YES	YES	YES
Year × Month Fixed Effect	YES	YES	YES	YES	YES	YES
Year × Planning Region Fixed Effect		YES			YES	
Year × Planning Area Fixed Effect			YES			YES
Include units sold by speculators	YES	YES	YES	NO	NO	NO
Observations	7,397	7,397	7,397	6,904	6,904	6,904
R-squared	0.977	0.978	0.978	0.977	0.978	0.978

[1] We confine units that are transacted between 24 months and 36 months once the sales are launched. We use projects whose first sale is from December 2001 and further exclude units with transactions across policies in this table.
[2] It is months from the first transaction date of uncompleted unit in the same property project.
[3] Details of policies are stated in the paper.

Appendix B

Table B1: Government Policies Affecting the Property Sector (1998 to 2016)

Time	Policy Details
Jun 1998[1]	The Government allow property buyers to pay the Stamp Duty at a later date. For uncompleted properties, the due date is the date of Temporary Occupation Permit (TOP). For completed properties, the payment is due when the property sale is completed.
Dec 2006[1]	The Government withdraw the concession to defer Stamp Duty payment. As a transaction measure, buyers who accept the Option to Purchase or sign the Sale & Purchase Agreement between 15 December and 31 December 2006 will have up until 14 March 2007 to pay the Stamp Duty without any penalty.
Oct 2007[2]	Removal of the Deferred Payment Scheme (DPS). In Oct 1997, the Government allowed developers to offer to purchasers of uncompleted private properties the option to defer part of the progress payments due after the initial 20% down payment, to a later stage. In Nov 2001, the Government further allowed developers to defer up to half of the initial 20% down payment up to the issue of Temporary Occupation Permit or any time before that.
Sep 2009[3]	Removal of Interest Absorption Scheme (IAS) and Interest-Only Housing Loans (IOL). The IAS and IOL were introduced by developers. The IAS allows purchasers who, after paying the upfront down payment, to defer making any further installment payments until the units are completed, i.e. issued a Temporary Occupation Permit (TOP). Prior to TOP, the bank requires only interest payments to be made on the loan and these payments will be paid by the developer. The IOL is a housing loan whereby the borrower makes only interest payments on the loan for a period of time, with no repayments of the loan principal. For uncompleted properties, the interest-only period could be from the inception of the IOL to TOP of the project.
Feb 2010[4]	Seller's Stamp Duty (SSD) was introduced on residential properties that were bought on or after Feb 20, 2010 and sold within one year of purchase. Loan-to-Value (LTV) ratio limit was lowered from 90% to 80%.
Aug 2010[4]	The holding period for Seller's Stamp Duty (SSD) was increased to three years. For holding years up to one year, the full SSD rate (1% on first $180,000, 2% on next $180,000, and 3% on remainder) will be imposed. For holding years more than one year and up to two years, 2/3% of full SSD rate will be imposed. For holding years more than two years and up to three years, 1/3% of full SSD rate will be imposed. For borrowers with existing housing loan(s), their LTV ratio was lowered to 70% and the minimum cash-component down-payment was raised to 10% from 5%.
Jan 2011[4]	The holding period for Seller's Stamp Duty (SSD) was increased to four years and SSD rate was increased to 16%, 12%, 8% and 4% for properties sold in the first, second, third, and fourth year, respectively. For borrowers with existing housing loan(s), their LTV ratio was lowered to 60%.
Dec 2011[5]	Additional Buyer's Stamp Duty (ABSD) was imposed. Singapore citizens buying their third and subsequent residential property pay 3%, Singapore permanent residents buying their second and subsequent residential property pay 3%, and foreigners buying their first and subsequent residential property pay 10%.
Oct 2012[6]	The Monetary Authority of Singapore (MAS) restricts the maximum tenure of all new residential property loans to be 35 years. LTV limit was lowered to be 60% for a borrower with no outstanding residential property loan and 40% for a borrower with one or more outstanding residential property loans if the tenure exceeds 30 years or the loan period extends beyond the retirement age of 65 years.

Table B1: Government Policies Affecting the Property Sector (1998 to 2016) (Continue)

Time	Policy Details
Jan 2013[5,7]	Additional buyer's stamp duty(ABSD) rates was raised. Singapore citizens buying their second residential property pay 7% and those buying their third and subsequent residential property pay 10%, Singapore permanent residents buying their first residential property pay 5% and those buying their second and subsequent residential property pay 10%, and foreigners buying their first and subsequent residential property pay 15%. LTV ratio was lowered from 60% to 50%, or from 40% to 30% for individuals obtaining a second housing loan if the loan tenure exceeds 30 years or the loan period extends beyond the borrower's retirement age of 65. For individuals obtaining third or subsequent housing loans, the LTV limits will be lowered to 40% or 20% if the loan tenure exceeds 30 years or the loan period extends beyond the borrower's retirement age of 65. The minimum cash down payment for individuals applying for a second or subsequent housing loan was raised from 10% to 25%.
Jun 2013[8]	The Monetary Authority of Singapore (MAS) introduced a Total Debt Servicing Ratio (TDSR) framework. Financial Institutions (FIs) are required to compute the TDSR, or the percentage of total monthly debt obligations to gross monthly income, on a consistent basis when granting property loans. It seeks to ensure the effectiveness of the LTV limits.
Aug 2013[9]	New Singapore permanent residents (PRs) have to wait for 3 years before they are eligible to purchase resale HDB flats.
Dec 2013[10]	The Government implement three measures for Executive Condominium (EC), which is closer to public housing in terms of buying and selling restrictions. Cancellation fees for ECs will be reduced from 20% to 5% of the purchase price. Second-timer applicants who buy EC units directly from property developers have to pay a resale levy. The Monetary Authority of Singapore (MAS) cap the Mortgage Servicing Ratio (MSR) for housing loans for EC units bought directly from property developers at 30% of a borrower's gross monthly income.

[1] Source: https://www.iras.gov.sg/irashome/News-and-Events/Newsroom/Media-Releases-and-Speeches/Media-Releases/
2006/Withdrawal-of-1998-Off-Budget-Concession-on-Stamp-Duty-Deferment/.

[2] Source: https://www.ura.gov.sg/uol/media-room/news/2007/oct/pr07-120.aspx.

[3] Source: https://www.ura.gov.sg/uol/-/media/User%20Defined/URA%20Online/media-room/2009/sep/pr09-63a1.pdf?la=en.

[4] Source: https://www.iras.gov.sg/irashome/Other-Taxes/Stamp-Duty-for-Property/Working-out-your-Stamp-Duty/Selling-or-Disposing-Property/Seller-s-Stamp-Duty--SSD--for-Residential-Property/.

[5] Source: https://www.iras.gov.sg/IRASHome/Other-Taxes/Stamp-Duty-for-Property/Working-out-your-Stamp-Duty/Buying-or-Acquiring-Property/What-is-the-Duty-that-I-Need-to-Pay-as-a-Buyer-or-Transferee-of-Residential-Property/Additional-Buyer-s-Stamp-Duty--ABSD-/.

[6] Source: http://www.mas.gov.sg/news-and-publications/media-releases/2012/
mas-restricts-loan-tenure-for-residential-properties.aspx.

[7] Source: http://www.mas.gov.sg/~/media/resource/news_room/press_releases/2013/Annex%20II.pdf.

[8] Source:
http://www.mas.gov.sg/~/media/MAS/Regulations%20and%20Financial%20Stability/Regulations%20Guidance%20and%20Licensing/Commercial%20Banks/Regulations%20Guidance%20and%20Licensing/Guidelines/
TDSR_Guidelines_Refin_10Feb14.pdf.

[9] Source: http://www.hdb.gov.sg/cs/Satellite?c=HDBArticle&cid=1383801213783&
pagename=InfoWEB%2FHDBArticle%2FLetterKEOLayout.

[10] Source: http://app.mnd.gov.sg/Newsroom/News-Page/ID/856/year/2013/RA1/RA2/RA3?category=Press%20Release.

Table B2: Seller's Stamp Duty (SSD) for Residential Property[1]

Date of Purchase	Holding Period	SSD Rate of Price
Between 20 Feb 2010 and 29 Aug 2010	Up to 1 year	1% on first \$180,000 2% on next \$180,000 3% on remainder
	More than 1 year	No SSD payable
Between 30 Aug 2010 and 13 Jan 2011	Up to 1 year	1% on first \$180,000 2% on next \$180,000 3% on remainder
	More than 1 year and up to 2 years	0.67% on first \$180,000 1.33% on next \$180,000 2% on remainder
	More than 2 years and up to 3 years	0.33% on first \$180,000 0.67% on next \$180,000 1% on remainder
	More than 3 years	No SSD payable
On and after 14 Jan 2011	Up to 1 year	16%
	More than 1 year and up to 2 years	12%
	More than 2 years and up to 3 years	8%
	More than 3 years and up to 4 years	4%
	More than 4 years	No SSD payable

[1] Source: https://www.iras.gov.sg/irashome/Other-Taxes/Stamp-Duty-for-Property/Working-out-your-Stamp-Duty/Selling-or-Disposing-Property/Seller-s-Stamp-Duty--SSD--for-Residential-Property/

Table B3: Probit Regressions – Units that Will be Flipped – Area Specific Year Trend[1]
(z statistics are reported in parentheses using clustered standard errors at the planning area level)

	(1)	(2)	(3)	(4)
Months from the first sale[2]	-0.0225***	-0.0229***	-0.0231***	-0.0237***
	(-8.63)	(-6.94)	(-8.25)	(-7.38)
Log of housing price index[3]	-0.0153***	-0.0141***		
	(-3.45)	(-3.44)		
After policy in December 2006[3]	0.0195	-0.1338	-0.1054	-0.2730***
	(0.29)	(-1.44)	(-1.38)	(-3.97)
After policy in October 2007[3]	-0.5336***	-0.5749***	-0.3313**	-0.3837***
	(-5.94)	(-5.99)	(-2.35)	(-2.62)
After policy in September 2009[3]	-0.0679	-0.1057	-0.1427**	-0.1889***
	(-1.18)	(-1.47)	(-2.43)	(-3.11)
After policy in Feb 2010[3]	-0.1448	-0.1733**	-0.2955***	-0.2383***
	(-1.29)	(-2.13)	(-3.18)	(-2.96)
After policy in Aug 2010[3]	-0.3980***	-0.4502***	-0.3876***	-0.3862***
	(-4.89)	(-3.57)	(-3.56)	(-3.29)
After policy in Jan 2011[3]	-0.5464***	-0.6644***	-0.5759***	-0.6205***
	(-7.24)	(-5.40)	(-4.23)	(-3.75)
Floor	0.0087***	0.0044***	0.0075***	0.0047***
	(4.46)	(3.31)	(4.76)	(3.44)
Area	-0.0027***	-0.0026***	-0.0027***	-0.0027***
	(-4.65)	(-4.74)	(-5.06)	(-4.90)
Year × Quarter Fixed Effect			YES	YES
Year × Planning Region Fixed Effect	YES		YES	
Year × Planning Area Fixed Effect		YES		YES
Observations	106,023	91,351	99,576	87,557

[1] We use projects whose first sale is from December 2001.
[2] It is months from the first transaction date of uncompleted unit in the same property project.
[3] Policy details are in the paper

Table B4: Regression Results – Projects with Only One Construction Phase[1]
Dependent Variable: Log of Transaction Price Per Square Meter
(t statistics are reported in parentheses Cluster Standard Errors at Project Level)

	(1)	(2)	(3)	(4)	(5)	(6)
Months from the first sale[2]	0.0007	0.0007	0.0030*	0.0004	0.0001	0.0020
	(0.38)	(0.41)	(1.95)	(0.24)	(0.08)	(1.35)
Months × After policy in December 2006[3]	0.0020***	0.0020***	0.0007	0.0019**	0.0018**	0.0006
	(2.84)	(2.92)	(0.93)	(2.40)	(2.43)	(0.79)
Months × After policy in October 2007[3]	0.0041***	0.0029***	0.0024**	0.0035***	0.0031***	0.0026**
	(2.79)	(3.43)	(2.49)	(2.66)	(3.49)	(2.55)
Months × After policy in September 2009[3]	-0.0005	0.0004	0.0008	-0.0001	0.0002	0.0007
	(-0.52)	(0.45)	(1.11)	(-0.15)	(0.28)	(1.07)
Months × After policy in Feb 2010[3]	-0.0004	0.0000	-0.0002	-0.0003	-0.0002	-0.0002
	(-0.60)	(0.05)	(-0.29)	(-0.47)	(-0.29)	(-0.28)
Months × After policy in Aug 2010[3]	-0.0010	-0.0009	-0.0004	-0.0017*	-0.0013	-0.0010**
	(-0.95)	(-0.92)	(-0.81)	(-1.67)	(-1.42)	(-1.97)
Months × After policy in Jan 2011[3]	0.0031***	0.0033***	0.0023***	0.0030***	0.0032***	0.0023***
	(4.52)	(4.64)	(4.72)	(4.21)	(4.32)	(5.05)
Floor	0.0061***	0.0061***	0.0061***	0.0063***	0.0063***	0.0062***
	(18.41)	(18.19)	(17.18)	(17.58)	(17.37)	(16.23)
Area	-0.0011***	-0.0011***	-0.0011***	-0.0012***	-0.0012***	-0.0012***
	(-10.57)	(-10.54)	(-10.30)	(-11.01)	(-10.96)	(-10.79)
Project Fixed Effect	YES	YES	YES			
Building Fixed Effect				YES	YES	YES
Year × Month Fixed Effect	YES	YES	YES	YES	YES	YES
Year × Planning Region Fixed Effect		YES			YES	
Year × Planning Area Fixed Effect			YES			YES
Observations	95,318	95,318	95,318	95,318	95,318	95,318
R-squared	0.966	0.967	0.968	0.971	0.972	0.973

[1] We use projects whose first sale is from December 2001. I restrict sample to projects with only one construction phrase in this table. I exclude units with transactions across each policy in this table.
[2] It is months from the first transaction date of uncompleted unit in the same property project.
[3] Policies are the same as in Table 4.2 and Table 4.3.

Table B5: Regression Results – Include Units across Policies[1]
Dependent Variable: Log of Transaction Price Per Square Meter
(t statistics are reported in parentheses Cluster Standard Errors at Project Level)

	(1)	(2)	(3)	(4)	(5)	(6)
Months from the first sale[2]	0.0019	0.0011	0.0033**	0.0014	0.0005	0.0025*
	(1.10)	(0.65)	(2.41)	(0.81)	(0.31)	(1.85)
Months × After policy in December 2006[3]	0.0034***	0.0032***	0.0012	0.0034***	0.0031***	0.0013
	(3.78)	(3.51)	(1.45)	(3.58)	(3.33)	(1.52)
Months × After policy in October 2007[3]	0.0020**	0.0022***	0.0021***	0.0017*	0.0020***	0.0019***
	(2.02)	(3.07)	(2.82)	(1.78)	(3.05)	(2.68)
Months × After policy in September 2009[3]	-0.0004	0.0005	0.0011**	-0.0003	0.0005	0.0011***
	(-0.58)	(0.80)	(2.47)	(-0.39)	(0.73)	(2.59)
Months × After policy in Feb 2010[3]	0.0003	0.0002	-0.0002	0.0005	0.0003	0.0000
	(0.42)	(0.43)	(-0.39)	(0.83)	(0.58)	(0.06)
Months × After policy in Aug 2010[3]	-0.0015*	-0.0014*	-0.0012**	-0.0019**	-0.0016**	-0.0016***
	(-1.79)	(-1.81)	(-2.16)	(-2.24)	(-2.10)	(-3.02)
Months × After policy in Jan 2011[3]	0.0030***	0.0032***	0.0028***	0.0028***	0.0032***	0.0028***
	(4.84)	(5.68)	(6.39)	(4.72)	(5.51)	(6.80)
Floor	0.0058***	0.0058***	0.0058***	0.0059***	0.0060***	0.0059***
	(13.64)	(13.53)	(12.87)	(12.90)	(12.82)	(12.25)
Area	-0.0011***	-0.0011***	-0.0011***	-0.0011***	-0.0011***	-0.0011***
	(-9.75)	(-9.72)	(-9.55)	(-9.46)	(-9.43)	(-9.30)
Project Fixed Effect	YES	YES	YES			
Building Fixed Effect				YES	YES	YES
Year × Month Fixed Effect	YES	YES	YES	YES	YES	YES
Year × Planning Region Fixed Effect		YES			YES	
Year × Planning Area Fixed Effect			YES			YES
Observations	111,160	111,160	111,160	111,160	111,160	111,160
R-squared	0.961	0.962	0.965	0.966	0.967	0.969

[1] We use projects whose first sale is from December 2001. I include units with transactions across policies in this table.
[2] It is months from the first transaction date of uncompleted unit in the same property project.
[3] Policies are the same as in Table 4.2 and Table 4.3.