The Effect of Housing on Portfolio Choice: House Price Risk and Liquidity Constraint *

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Abstract

Although numerous studies have examined the crowding-out effect of housing on stock holdings via the house price risk channel and the liquidity constraint channel concurrently, separate influences on the crowding-out effect via the two channels have received less attention. In this paper, by exploiting a unique Korean housing tenure type called *jeonse*, which affects a household's investment decision only through the liquidity constraint channel, I study both effects separately. A calibrated life-cycle portfolio choice model with endogenous housing tenure choice and stock market participation shows that the liquidity constraint channel only affects young households and households with a low net wealth-to-income ratio and does not affect old or wealthier households. The house price risk channel, on the other hand, affects all types of households, including households with a high wealth-to-income ratio. Regressions using a household level panel survey show that the crowding-out effect of jeonse exists only for households with a low net wealth-to-income ratio and young households, whereas the crowding-out effect of homeownership affects all types of households.

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JEL Classification: G11, G51, D15, R21

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1 Introduction

Housing has gotten a lot of attention from researchers as the single most important asset[1] for most households, and the crowding-out effect of housing on households' risky financial investment has been extensively studied. Most argue that housing crowds out demand for risky financial assets via the *liquidity constraint channel* and the *house price risk channel* (Grossman and Laroque 1990, Cocco 2005, Yao and Zhang 2005, Flavin and Yamashita 2002). Specifically, the liquidity constraint channel means that households are forced to hold a significant portion of their wealth as a form of illiquid housing assets[2] rather than as a form of liquid financial assets. The house price risk channel means that households are exposed to unexpected changes in housing prices after purchasing a house, which increases the risk in their overall portfolio.

However, past studies were not able to examine the distinct influences of each channel independently, because households are exposed to both channels when they buy a house. Though Cocco (2005) and Yao and Zhang (2005) conducted brief assessments of the independent role of the house price risk channel, they did so by using model comparative statics rather than actual data and the heterogeneous implications of these two channels on different types of households were not completely investigated.

Without understanding the distinct influences of both channels independently, we cannot determine how housing choice differently affects households' stock investment depending on household characteristics such as age or liquidity constraints. Also, since the relative magnitude of each channel can differ depending on the household's characteristics, understanding each channel's contribution to the total crowding-out effect is important.

In this paper, I contribute to the literature by studying the separate influences of the two channels independently. I exploit a unique housing tenure type known as *jeonse*, which is unique to South Korea, to resolve this identification issue. Jeonse is a housing contract between a landlord and a jeonse tenant. At the beginning of the contract, they agree on the contract period and the size of the jeonse deposit. Usually, the contract period is 2 years and the jeonse deposit size is around 60%-70% of the house price. Once they agree, the jeonse tenant pays the jeonse deposit to the homeowner. In return, the jeonse tenant can reside in the house for the agreed contract period, and does not have to pay any rent during the contract period. Once the contract is finished, the homeowner must return exactly the same amount of jeonse deposit to the jeonse tenant, and the jeonse tenant must leave the house. In some sense, this is collateralized lending in which house is used as collateral and the housing service from

[1] According to Yao and Zhang (2005), the 2001 Survey of Consumer Finance (SCF) showed that more than 66% of households own their houses, and the values of those houses account for 55% of their total wealth. In comparison, about 50% of households hold risky financial assets, and those account for only 12% of total wealth.

[2] Boar et al. (2022) found that in the US, four-fifths of homeowners are liquidity constrained and are willing to give up 13 cents, on average, for every additional dollar of liquidity extracted from their homes. This demonstrates the substantial illiquidity of housing assets—and in countries with less developed housing finance markets, the illiquidity should be even more severe than that of the US.

the houses is interest. In this paper, I examine the crowding-out effect of housing from the jeonse tenant's perspective, and do not consider the landlord's problem.

On the one hand, households that use jeonse contracts for housing service effectively expose themselves to the liquidity constraint channel because in most cases, the jeonse deposit amounts to 60%-70% of the house price. Consequently, for most households using jeonse contracts, this deposit accounts for most of their net wealth or is even larger than their net wealth, which forces them to use the mortgage loan for preparing to pay the jeonse deposit. This means that a significant portion of their net wealth remains in the form of an illiquid jeonse deposit.

On the other hand, households that use jeonse contracts as tenants are not exposed to the house price risk channel because they will receive their jeonse deposit without any change. Unlike housing purchase, there is no uncertainty regarding how much they will get back. This effectively eliminates the house price risk channel and adds no additional risk to their overall portfolio.[3]

Given these jeonse contracts' unique nature, by comparing the portfolio patterns of renter and jeonse tenant, we can observe the crowding-out effect of jeonse, which is caused only via the liquidity constraint channel. In addition, if we compare the jeonse tenants' stock investment behavior with that of homeowners, it will demonstrate the additional role of the house price risk channel.

Surely, these all are endogenous choices. To clearly see the separate effects of the two channels while controlling for the characteristics of households such as age, human capital, or level of wealth, I augment the life-cycle portfolio choice model used by Cocco (2005) and Yao and Zhang (2005). Whereas the models in those papers have only either a stock market participation cost or an endogenous housing tenure choice, my model features both components. In addition, to incorporate the intermittent exit and entry of households in the stock market, as in Brandsaas (2018), I use per-period stock market participation cost. Adding jeonse contract as a viable housing tenure option is also new to the literature.

The model implies a heterogeneous crowding-out effect, depending on households' characteristics. I show that as households get less liquidity constrained, the crowding-out effect of jeonse, which consists of only the liquidity constraint channel, goes away. This means that young households or households with low wealth-to-income ratios are more likely to be affected by this liquidity constraint channel. This is because young households and households with low wealth-to-income ratios have the largest portion of their lifetime wealth in the form of illiquid future labor income and only scant liquid assets.[4] Those types of households

[3] If homeowners refuse to pay back the jeonse deposit, the jeonse tenant has the right to auction the homeowner's house and get their money back. Because it is rare that a house price goes down lower than the jeonse deposit, most households in South Korea consider this contract to be risk free.

[4] Note that, in a life-cycle perspective, lower wealth-to-income ratio implies that the sum of their future incomes is relatively larger than what they currently have as a current liquid wealth. Usually, young households

already suffer from the liquidity constraint, and the jeonse contract imposes additional liquidity constraints on them. On the other hand, the house price risk channel affects all types of households, and the effect does not disappear even though households are not at all liquidity constrained. Also, my results show that the magnitude of the house price risk channel is related to the covariance structure between housing return and stock return.

To see whether such patterns exist in the data, I analyze the South Korean household panel survey, which contains comprehensive information on the households' housing tenure choices and risky financial asset holdings. By using two-way fixed effects, I estimate the crowding-out effect of jeonse and homeownership while controlling for individual fixed components such as attitude toward the stock market, peer effects, knowledge about the stock market, or year-specific components such as stock market boom in certain years.

I find that the crowding-out effect of from jeonse is weak and not recognizable for the jeonse tenants who are old or have high wealth-to-income ratios. Whereas the jeonse housing tenure indicator variables interacted with dummy variables for young households or households with low wealth-to-income ratio have a significant negative effect on risky financial asset holdings, when interacted with dummy variables for old households or households with high wealth-to-income ratios, they do not show any significant effects. Being a jeonse tenant decreases the risky financial asset over net wealth ratio (hereafter RFAR) by 0.8% for households in the bottom 20th to 40th percentiles of the net wealth-to-income ratio, and decreases the RFAR by 0.59% for households in the bottom 0th to 20th age percentiles. Since the renters' average RFAR is 0.87% (including households not participating in stock market), this is an economically significant effect. However, for households in the top 20th percentile of the net wealth-to-income ratio or households in the top 20th percentile of the age, there is no crowding-out effect of being a jeonse tenant.

On the other hand, the crowding-out effect of homeownership, which likely contains the influence of both the house price risk channel and the liquidity constraint channel, persists and has a significantly negative effect on risky financial asset holdings. Homeownership decreases the RFAR by 0.78%, even for households in the top 20th percentile of the net wealth-to-income ratio and decreases the RFAR by 0.62% for households in the top 20th age percentile. The house price risk channel thus affects all types of households.

Model predictions and data patterns are consistent regarding the crowding-out effect of jeonse, which effectively only concerns the liquidity constraint channel. As households get wealthier or older, they are less affected by the liquidity constraint channel; they are affected more when they are young or have less present net wealth. This is the first paper to empirically suggest the evidence regarding the the existence of the liquidity constraint channel separate from the house price risk channel.

For the crowding-out effect of homeownership that contains both channels' influences, data

show low wealth-to-income ratios.

and model predictions are consistent in the sense that homeownership is predicted to affect all types of households. One notable difference is that while the model predicts that the crowding-out effect from homeownership gets smaller as households get less liquidity constrained, the data show that the effect does not decrease and, instead, increases. This is likely coming from the fact that richer households purchase more expensive houses, and more expensive houses' prices are more correlated with stock returns. This is because these houses' prices behave more like financial assets, being more procyclical and volatile, since they are often purchased by investors and not normal households. This effectively increases the correlation between housing prices and stock returns, and the model predicts that higher correlation results in the larger crowding-out effect. To perfectly match the data, the model should feature different types of correlation structures of housing returns with stock returns, depending on the house price level, and this is not considered in my model.

In Section 2, I explore previous studies and describe in what respects my research differs. In Section 3, I explore the mechanism and economic significance of jeonse contracts. After that, I explain the liquidity constraint channel and house price risk channel in more detail. At the end of the section, I explain why jeonse contracts are only related to the liquidity constraint channel and how I will exploit jeonse to decompose these two main channels of the crowding-out effect. In Section 4, I set up the life-cycle portfolio choice model and examine what it says about these two main channels of the crowding-out effect. In Section 5, by using Korean household panel survey data, I empirically study the crowding-out effect. In Section 6, I compare and discuss the implications from the model and data analysis, and I conclude in Section 7.

2 Literature

This paper is related to the effect of housing on households' portfolio choices, especially risky financial asset demands. In an early paper, Grossman and Laroque (1990) analyzed household portfolio choices with durable consumption goods. They propose a household that consumes a single durable good and assume that the household needs to pay an adjustment cost when it adjusts its consumption of durable goods. They argue that the optimal consumption policy is characterized by three values: Two are threshold values and the other is the optimal consumption level. The interval created by the two threshold values always contains the optimal consumption level. Whenever a household changes the consumption level, it tries to target the optimal consumption level. However, the household decides to change the consumption level only when their current consumption level is out of the interval created by the threshold values. Though their current consumption level is not equal to the optimal consumption level, if the value is within the interval constructed by the threshold values they decide not to change their consumption level because the adjustment cost is too high. Then, for portfolio choice, the authors argue that a household becomes less risk-averse when their consumption level is closer to the threshold values and becomes more risk-averse when their consumption level is closer to the optimal consumption level. My model also captures such optimal housing consumption behavior. Once a household purchases a house, they sell it only when its value deviates too far from the optimal consumption level, which means that my model also contains the effect of housing on the investment decision Grossman and Laroque (1990) discuss.

Faig and Shum (2002) argue that households are more likely to hold liquid assets if they have some illiquid projects that require constant financing in the future. They also use 1995 Survey of Consumer Finance to do cross-section regression to see the effect of these projects such as a small business or home purchase. Their model predicts that more productive personal projects and larger penalties from discontinuing induce households to be risk-averse. Because housing is also one of the most important illiquid assets, Faig and Shum (2002) show that housing can crowd out risky financial asset investment.

Flavin and Yamashita (2002) solve a static portfolio choice problem given the house value over net wealth as a state variable. They assume that households are leveraged for this home purchase. Their model predicts that under reasonable risk aversion, high house value over net wealth (i.e, young households) induces households to hold a smaller ratio of risky assets compared with low house value over net wealth (i.e, old households). Their leveraged position increases the risk, which causes households to respond by reducing their stock holdings. Also, the leveraged position due to the mortgage actually induces the household to change not only the portfolio choice between risky asset and risk-free assets, but also the portfolio choice over risky assets.

The first comprehensive life-cycle context analysis for the effect of housing on portfolio choice was made by Cocco (2005). He finds that, due to a huge down payment for housing purchase, households end up having limited financial wealth to invest in stocks. This is connected to the liquidity constraint channel in this paper, which reduces the benefits of stock market participation. Consequently, with the fixed costs of stock market participation, households choose not to participate. Also, in their model, the house price risk channel crowds out stock holdings, and this effect is larger for households with low financial net worth. Though Cocco (2005) suggests these two important concepts, he only shows the empirical evidence on the crowding-out effect as a whole, not by component. In addition, he considers only homeowners without the endogenous choice of housing tenure, which is important for understanding the size of the crowding-out effect.

On the other hand, Yao and Zhang (2005) make housing tenure choice endogenous in their life-cycle model so that households in the model can choose between renting and owning. They compare renters and homeowners, and obtain results similar to those of Cocco (2005). They also show how the low correlation between housing return and stock return generates the diversification effect, so that homeowners have a higher stock ratio over financial assets than renters.

Whereas Yao and Zhang (2005) explain the joint mechanism of housing tenure choice and stock investment choice, their model cannot explain the stock market participation puzzle. Their model predicts that renters should participate in the stock market more aggressively than homeowners because expected labor income is a close substitute for safe bonds. However, the data show that homeowners participate in the stock market more and hold more stocks than renters in general. Vestman (2019) explains this puzzle. To make the model compatible with these patterns in the data, he introduces preference heterogeneity with Epstein-Zin preferences and participation cost heterogeneity. He argues that though a crowding-out effect exists in theory, the main forces that shape the joint distribution of the homeownership rate and stock market participation rate in the data are the preference heterogeneity and heterogeneous stock market participation costs. High-saving-type households save much throughout their lifetime, which naturally gives them incentives to participate in the stock market and to become homeowners, while low-saving-type households save less, which leads them to remain renters and not participate in the stock market with their limited savings.

My paper is closest in spirit to these two papers, Yao and Zhang (2005) and Vestman (2019). As a new contribution, I add another housing tenure type—jeonse,—and provide the actual portfolio choice data pattern from household-level panel survey data, and especially for jeonse tenants. As a result, I newly contribute to the literature by studying the liquidity constraint channel and the house price risk channel separately. In addition, I study the heterogeneous effects from the liquidity constraint channel and house price risk channel with respect to household characteristics, such as age and net wealth-to-income ratio, in the data.

3 A Unique Korean Housing Tenure Type: Jeonse

In this section, I explain the contract structure of jeonse[5] and how I decompose the crowding-out effect into the liquidity constraint channel and the house price risk channel. Note that I do not focus on why the jeonse contract emerged in South Korea (Kim 2013), the general equilibrium effect of jeonse contracts (Shin and Kim 2013), or how the jeonse deposit size is determined (Jing et al. 2022). I instead study the portfolio choice of households given a jeonse contract as one of the possible housing tenure choices. Consequently, I only focus on how a jeonse contract is processed, and what it means for households, not the aggregate economy.

When households make jeonse contracts, potential jeonse tenant and homeowner decide the size of the jeonse deposit and the contract period. At the beginning of the contract, the jeonse tenant gives a jeonse deposit to the landlord. After that, the jeonse tenant lives in the house for a period predetermined by the contract. During the period, the jeonse tenant does

[5]In other papers, this is referred to as *chonsei* or *chonsae*. I use "jeonse" throuhgout this paper.

not have to pay any rent or they pays little rent compared with a conventional rent contract. After the contract period ends, the landlord must return exactly the same amount of money to the jeonse tenant, and the jeonse tenant must leave the house. Jeonse can be understood as a contract that has characteristics of both conventional rent and home-ownership.

The unique structure of the jeonse contract represented in Figure 1 allows me to identify the

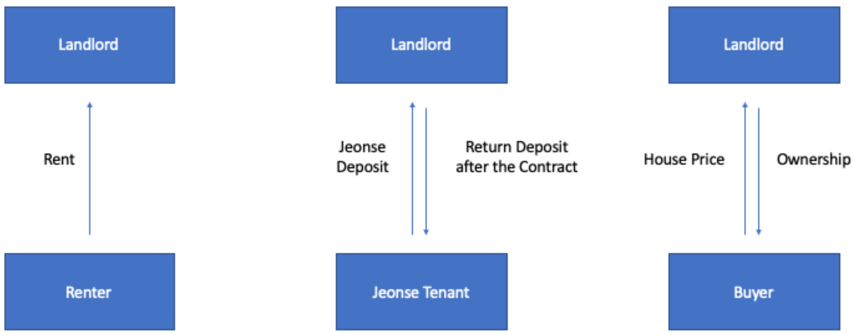


Figure 1: Housing Tenure Contracts

liquidity constraint channel separate from the house price risk channel. First, jeonse tenants face the large liquidity constraint channel when they make a jeonse contract. The national average jeonse deposit size from 2012 to 2019 was about 66.7% of the house price, according to the Korea Appraisal Board. In addition, there is a mortgage market for jeonse tenants similar to that of home purchasers in Korea. Consequently, if we think in terms of down payment, the jeonse contract also requires a huge amount of down payment, like a housing purchase contract does. Assuming that households transition from a rent contract to jeonse contract, we can easily imagine that they should experience a substantial liquidity constraint channel.[6]

Second, jeonse tenants are not exposed to the house price risk channel. Since they are guaranteed to receive, at the end of the contract, the same amount of deposit they paid at the beginning of the contract, they do not have to worry about the house price risk channel. Even though they are exposed to the rent fluctuation risk as shown in Sinai and Souleles (2005), we can still say that they are exposed to the same rent risk a renter is exposed because they have to renew the contract, which is usually every 2 years. I naturally conclude that households that transition from rent to a jeonse contract experience the liquidity constraint channel only

[6]If we assume that the house price is $1,000,000 and the jeonse deposit ratio is 65%, households need to come up with $650,000. If the mortgage down payment ratio is 20% for any mortgage product, home buyer's mortgage down payment will be $200,000 while the jeonse tenant's mortgage down payment is $130,000. It shows that it takes substantial amount of money to initiate the jeonse contract even though households use the mortgage.

and not the house price risk channel. [7]

Figure 2 is the life-cycle pattern of housing tenure choice in Korea and the United States.

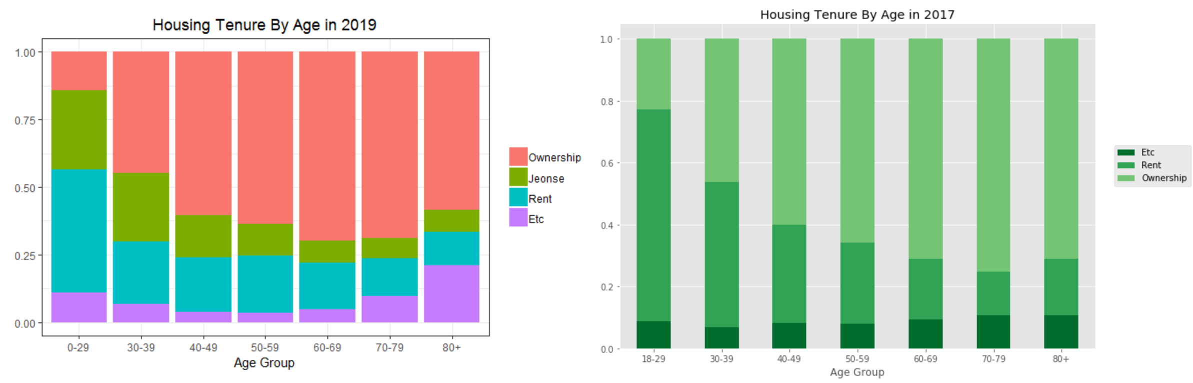


Figure 2: Housing Tenure Distribution in South Korea (Left) and the U.S. (Right)

The data are from the 2017 Survey of Consumer Finance (hereafter SCF) and the 2019 Korean Survey of Household Finances and Living Conditions (hereafter SHFLC). We can see that the jeonse contract does account for a significant portion of housing tenure types in Korea. Also, many young households in Korea start as renters while saving money for a jeonse deposit down payment. After they save enough amount of money for a jeonse deposit down payment, they transition to a jeonse contract while saving more money. After that, most households transition to homeownership. In particular, this life-cycle pattern implies that the crowding-out effect of housing on stock holdings will be more pronounced among young households that have small savings and seek to purchase a house using a mortgage.

4 Model

To understand the mechanism behind the joint life-cycle decision on housing tenure choice, stock market participation, and the implied crowding-out effect, based on Vestman (2019), Yao and Zhang (2005), and Cocco (2005), I present a quantitative life-cycle model in which households endogenously choose whether to rent, make a jeonse contract, or purchase a house. In addition, households decide how much to consume, save, and invest in risky assets. The labor income process, risky asset return process, and housing return process are exogenous in this model, which renders it a partial equilibrium model.

[7]Default by landlords can be one potential risk to jeonse tenants. However, according to statistics from the Korea Housing and Urban Guarantee Cooperation (hereafter HUG), the number of landlord default cases in 2016 they worked on was 23, while the number was 258 in 2018. Though there has been a rapid increase in cases recently, it is very still low compared with the total number of jeonse contracts; the monthly average of the number of jeonse contracts is roughly 100,000 nationally. In addition, HUG and Seoul Guarantee Insurance (SGI) provide good insurance products for jeonse contracts, which leads me to assume that households are not concerned about landlord default when they make a jeonse contract.

4.1 Demographics and Risks

Households start their lives at 30 and die for sure at 100. In the model, one period (a) corresponds to 2 years, which is a conventional rent and jeonse contract periods. Consequently, households will solve a 35-period problem that corresponds to 70 years. At every period, they face the mortality risk, which causes them to die in the next period with probability π_a. Accordingly, $1 - \pi_a$ means the probability that the household survives and continuously solves the household problem in the next period $a + 1$ conditional on the households surviving until age a.

4.2 Labor Income Process

Following Yao and Zhang (2005), the labor income process has an age-dependent deterministic growth rate of $[g_a]_{a=1}^{a=35}$. In addition, its growth rate is under an identically and independently distributed Gaussian shock, denoted as ν_{a+1}. I also include two other shocks, ϵ^o_{a+1} and n^o_{a+1}, which are perfectly correlated WITH ϵ_{a+1} and n_{a+1}. These are for generating correlations between labor income growth, stock return, and housing return, which is a structure also used by Vestman (2019). In the following formula, in which Y_{a+1} is the labor income (or can be interpreted as the non-capital income) level, we have a full characterization of the labor income process.

$$log(Y_{a+1}) - log(Y_a) = g_{a+1} + \nu_{a+1} + \epsilon^o_{a+1} + n^o_{a+1}, \text{ for } a = 0, 1, ..., 34 \tag{1}$$

Unlike the specification in Cocco (2005), this process allows only transitory shock to the growth rate of labor income.e., A permanent shock to labor income level. Lastly, I assume that households retire at age 64, which is the most common retirement age in Korea. Once the household retires, they only receive λ portion of the labor income they received right before retirement, and thereafter receive the same amount as a retirement pension until their death.

$$Y_{17} = \lambda Y_{16} \tag{2}$$

$$Y_{a+1} = Y_a, \quad a \geq 17 \tag{3}$$

4.3 Stock Returns

Stock returns are assumed to follow a normal distribution with constant risk premium μ. Specifically, R_{a+1} is the gross stock return households will experience at age $a + 1$. R_f is the gross risk-free rate, and μ is the log risk premium. Stock return innovation ϵ_{a+1} follows i.i.d. normal distribution with mean zero. Note that ϵ_{a+1} is perfectly correlated with ϵ^o_{a+1} in the labor income growth rate process, which will generate correlation between labor income growth and stock returns. The following formula fully characterizes the stock return process in the model.

$$log(R_{a+1}) - log(R_f) = \mu + \epsilon_{a+1} \tag{4}$$

4.4 Housing Returns

Housing returns are assumed to be similar to stock returns. However, as in the labor income process, to assume a correlation between the stock return and house price growth rate, I include additional term ϵ^H_{a+1}, which is perfectly correlated with ϵ_{a+1}. Specifically, P^H_{a+1} is the unit house price that households face at age $a+1$, μ_H is the mean housing return, and housing return shock n_{a+1} follows i.i.d. mean zero normal distribution. So the following characterizes the housing return process:

$$log(P^H_{a+1}) - log(P^H_a) = \mu_H + n_{a+1} + \epsilon^H_{a+1} \tag{5}$$

4.5 Bequest Motive

Whenever households die, it is assumed that their descendants spend their remaining asset and households get utility from their descendants' utility. This is a common feature that appears in most life-cycle models to match the saving behaviors of old households. X_{a+1} represents the asset left to the descendants, α_f represents the annuity factor, and $\alpha_f X_{a+1}$ accordingly represents the money descendants receive every period for T_b periods. Consequently, α_f is a function of T_b given interest rate R_f. I assume that the bequeathed wealth will always be invested 50-50 in risky and risk-free assets. Then, every period, this money is optimally used by descendants, who have the same Cobb-Douglas utility functions over consumption and housing. Consequently, the utility households receive from bequeathing is the following. This approach is similar to that of Yao and Zhang (2005).

$$\sum_{k=1}^{T} \beta^k (\alpha_f X_{a+1}(1-\omega))^{1-\omega} (\frac{\alpha_f X_{a+1}\omega}{\tau P^H_a})^{\omega} \tag{6}$$

4.6 Preference

Given the above specifications, I define the household's finite horizon problem formally. Households have Cobb-Douglas preference over a non-durable consumption good C_a and durable housing good H_a where ω denotes the expenditure share for the housing good. Households have CRRA utility function over the combined consumption.

4.7 First-stage Problem

At the beginning of each age period, households solve the first-stage problem regarding the housing tenure choice. Depending on whether households purchased the house in the previous period or not (also whether they received a moving shock or not), households solve either the owner's problem or the non-owner's problem.

4.7.1 The Owner's Problem

For the owner, state variables are cash-in-hand X_a, which is the sum of net wealth and contemporaneous labor income (or can also be understood as non-capital income); the labor income Y_a; the quantity of housing purchased in previous period H_{a-1}; and the unit price of housing good P_a^H. In addition, I assume that households have information about the probabilistic structures of stock and housing return processes and labor income shock processes. Also, households know the deterministic future life-cycle profile of the labor income growth rate. Owners who chose to buy a house in the previous period and did not get the exogenous moving shock solve the following problem:

$$\widehat{V}_a(X_a, H_{a-1}, Y_a, P_a^H) = \max(\bar{V}_a(X_a, Y_a, P_a^H), V_a^s(X_a, H_{a-1}, Y_a, P_a^H)) \quad (7)$$

Here, they can sell the house and move back to the non-owner's problem, or they can solve the stayer's problem by deciding to stay. Here, $\widehat{V}_a$ denotes the optimal utility households can achieve as an owner at age a. Similarly, $\bar{V}_a$ represents the optimal utility of a non-owner, and V_a^s is the optimal utility that households can achieve by staying in the previously purchased house. By choosing the maximum value between these two value functions, households effectively decide which housing tenure to choose.

4.7.2 The Non-owner's Problem

Non-owners who chose to rent or to enter a jeonse contract and moving owners who chose to sell solve the following problem.

$$\bar{V}_a(X_a, Y_a, P_a^H) = \max(V_a^r(X_a, Y_a, P_a^H), V_a^j(X_a, Y_a, P_a^H), V_a^b(X_a, Y_a, P_a^H)) \quad (8)$$

Here, $V_a^r(X_a, Y_a, P_a^H)$ means the optimal value households can achieve under the constraint whereby households must rent. $V_a^j(X_a, Y_a, P_a^H)$ and $V_a^b(X_a, Y_a, P_a^H)$ represent the counterparts for jeonse contract and purchasing. Again, by choosing the maximum value among these three value functions, households effectively decide which housing tenure to choose.

4.8 Second-stage Problem

After households solve the first-stage problem, depending on their housing tenure choice (rent, jeonse, purchase, stay), they solve the second-stage problem in which they choose the optimal level of consumption, housing value, saving, and risky asset share. The problems solved by households with different housing tenure types are described below.

4.8.1 The Renter's Problem

Households that decide to rent a house solve the following problem:

$$
\begin{aligned}
V_a^r(X_a, Y_a, P_a^H) = \max_{C_a, H_a, A_a, \alpha_a} & \frac{(C_a^{1-\omega} H_a^{\omega})^{1-\sigma}}{1-\sigma} + \beta E_a[(1-\pi_a)\bar{V}_{a+1} + \pi_a \alpha_3 (\frac{X_{a+1}}{(P_a^H)^{\omega}})^{1-\sigma}] \\
s.t \qquad & X_a \geq A_a + C_a + \tau P_a^H H_a + 1[\alpha_a > 0]\gamma Y_a \\
& X_{a+1} = A_a R_f + \alpha_a A_a (R_{a+1} - R_f) + Y_{a+1} \\
& \alpha_a \in [0,1], \; A_a \geq 0, \; C_a \geq 0, \; H_a \geq 0
\end{aligned}
$$

C_a represents non-durable consumption, H_a represents the quality of house to live in, A_a represents the amount of savings, and α_a represents the share of financial savings invested in risky financial assets. Since this is the problem solved by households that decide to rent for this period, they are expected to solve the non-owner's problem and to get $\bar{V}_{a+1}$ in the next period. τ is the rent-to-price ratio.

One thing to note here is the stock market participation cost γ. A one-time stock market participation cost has been used in many papers, such as by Haliassos and Michaelides (2003) and Gomes and Michaelides (2005), to explain the fact that many households do not participate in the stock market. However, a one-time stock market participation cost often fails to explain the intermittent stock market participation studied by Fagereng et al. (2017) and Brandsaas (2018). Thus, I use a per-period stock market participation cost specification.

Lastly, I use a stock market participation cost proportional on income Y_a. Once households invest in the stock market, they often spend time on investing by checking brokerage accounts or finding new information, which supports the proportional participation cost I used here with opportunity cost interpretation. These types of participation costs can be found in numerous papers, such as by Alan (2006), Ball (2008), and Gomes and Michaelides (2008).

4.8.2 The Jeonse Tenant's Problem

Households that decide to make a jeonse contract solve the following problem:

$$
\begin{aligned}
V_a^j(X_a, Y_a, P_a^H) = & \max_{C_a, A_a, H_a, \alpha_a} \frac{(C_a^{1-\omega} H_a^{\omega})^{1-\sigma}}{1-\sigma} + \beta E_a[(1-\pi_a)\bar{V}_{a+1} + \pi_a \alpha_3 (\frac{X_{a+1}}{(P_t^H)^{\omega}})^{1-\sigma}] \\
s.t. \quad & X_a \geq A_a + C_a + (\delta_J + \phi_J)\bar{J} P_a^H H_a + 1[\alpha_a > 0]\gamma Y_a \\
& X_{a+1} = A_a R_f + \alpha_a A_a (R_{a+1} - R_f) + Y_{a+1} + P_a^H H_a \bar{J}(1 - (1-\delta_J) R_M) \\
& \alpha_a \in [0,1],\ A_a \geq 0,\ C_a \geq 0,\ H_a \geq 0,\ X_a \geq \delta_J \bar{J} P_a^H \underline{H}
\end{aligned}
$$

Note that the value function form is the same as that of a renter, except for the budget constraint. From the budget constraint, we can see that households have to pay for housing service in a different way. $\bar{J}$ represents the ratio of jeonse deposit to house price, and δ^J denotes the down-payment ratio for using a jeonse mortgage. Lastly, ϕ_J is the transaction cost for a jeonse contract. So, unlike renters, they pay a substantial amount of money to the landlord. I add an additional constraint whereby cash-in-hand X_a should be larger than the down payment for a jeonse deposit for minimum quality housing $\underline{H}$. Consequently, we have $X_a \geq \delta_J \bar{J} P_a^H \underline{H}$.[8] Even for the lowest quality of housing, the average jeonse deposit is the size of a multiple of the average worker's annual income, which is why many households cannot choose jeonse.

Another thing to note is that, in the law of motion of net wealth, households receive back the exact same amount of jeonse deposit they paid in the previous period, which means there is no house price risk for jeonse tenants. Here, the mortgage structure is continuous refinancing. To make model tractable, I assume that after one period, households pay interest rate R_M, receive the down-payment they paid, and decide to refinance or not depending on their next-period housing tenure choice.

4.8.3 The Buyer's Problem

Households that decide to buy a house solve the following problem:

$$
\begin{aligned}
V_a^b(X_a, Y_a, P_a^H) = & \max_{C_a, A_a, H_a, \alpha_a} \frac{(C_a^{1-\omega} H_a^{\omega})^{(1-\sigma)}}{1-\sigma} + \beta E_a[(1-\pi_a)(\xi \bar{V}_{a+1} + (1-\xi)\hat{V}_{a+1}) + \pi_a \alpha_3 (\frac{X_{a+1}}{(P_a^H)^{\omega}})^{1-\sigma}] \\
s.t \quad & X_a \geq A_a + C_a + (\chi + \delta + \phi_b) P_a^H H_a + 1[\alpha_a > 0]\gamma Y_a \\
& X_{a+1} = A_a R_f + \alpha_a A_a (R_{a+1} - R_f) + Y_{a+1} + P_a^H H_a (R_{a+1}^H (1-\phi) - (1-\delta) R_M) \\
& \alpha_a \in [0,1],\ A_a \geq 0,\ C_a \geq 0,\ H_a \geq 0,\ X_a \geq \delta P_a^H \underline{H}
\end{aligned}
$$

Note that now households expect two types of future value functions in the next period.

[8] In the normalized model, I impose $\frac{X}{Y} \geq 1.064$ based on the median household income and the median jeonse deposit for an apartment in 2015.

If they do not receive a moving shock, they are expected to solve the owner's problem $\widehat{V}_a$ in the next period. On the other hand, if they receive a moving shock, they solve the non-owner's problem $\bar{V}_a$. As an owner, households should pay the maintenance cost χ. In addition, households should buy houses through a mortgage to obtain a housing service, where δ is the down-payment ratio and ϕ is a transaction cost. Here, household wealth in the next period depends on the house price realization in the next period, R^H_{a+1}, which can be interpreted as a house price risk. I add a down-payment constraint similar to that in the jeonse tenant's problem.[9]

One last thing to note is that households actually pay the selling cost ϕ in the next period regardless of whether they get a moving shock and decide to sell. This is for tractability of the model. If households decide to stay in the house they purchased previously in the next period, they will be compensated for this cost.

4.8.4 The Stayer's Problem

If households decide to stay in the house they purchased before, they take H_{a-1} into account as an additional state variable and solve the following problem:

$$
\begin{aligned}
V^s_a(X_a, Y_a, P^H_a, H_{a-1}) = \max_{C_a, A_a, \alpha_a} \frac{(C_a^{1-\omega} H_{a-1}^{\omega})^{(1-\sigma)}}{1-\sigma} + \beta E_a[(1-\pi_a)(\xi \bar{V}_{a+1} + (1-\xi)\hat{V}_{a+1}) + \pi_a \alpha_3 (\frac{X_{a+1}}{(P^H_a)^{\omega}})^{1-\sigma}] \\
s.t \qquad X_a \geq A_a + C_a + (\chi + \delta - \phi) P^H_a H_{a-1} + 1[\alpha_a > 0]\gamma Y_a \\
X_{a+1} = A_a R_a + \alpha_a A_a (R_{a+1} - R_f) + Y_{a+1} + P^H_a H_{a-1}(R^H_{a+1}(1-\phi) - (1-\delta) R_M) \\
\alpha_a \in [0,1], \ A_a \geq 0, \ C_a \geq 0
\end{aligned}
$$

Notice that the value function structure is the as that in the buyer's problem; the only difference is that households get compensated for selling cost ϕ. In addition, they do not have to pay the buying cost ϕ_b. This captures the benefit of staying in the same house, which comes from being exempt from adjustment costs.

4.9 Solution Method

Since this model is a finite-horizon problem, we can solve it through backward induction. At the last period, since households surely die, they solve an optimization problem with a trade-off between bequest and consumption only, which is a simple one-period problem. After solving the last-period value functions, we move backward and solve the problem of one period before the last period, given these last-period value functions. I use a grid method and standard linear interpolation for next-period value functions. Shocks are discretized via

[9] In the normalized model, I impose $\frac{X}{Y} \geq 1.7304$ based on the median household income and the median apartment price in 2015.

Gaussian quadrature. In addition, before actually solving the problem, to reduce the number of state variables I normalize the value function with $\frac{X_a}{(P_a^H)^\omega}$ and choice variables with X_a so that the policy variables will be $c_a = C_a/X_a$, $a_a = A_a/X_a$, $h_a = (P_a^H H_a/X_a)$, and $\alpha_a = \alpha_a$ following Yao and Zhang (2005).

5 Calibration

For most of the parameters, I externally calibrate by using the data counterpart of the corresponding periods. For example, for π, I use the 2020 Life Table from Statistics Korea. Regarding household preference parameters, including discount factor β, concavity of the utility function σ, housing expenditure ratio ω, bequest motives T_b, and stock market participation cost γ, I follow the parameter values used by Gomes and Michaelides (2005); Yao and Zhang (2005); Vissing-Jorgensen (2002); and Gomes and Michaelides (2008).

For other housing tenure-relevant parameters such as τ and $\bar{J}$, I use the sample average of periods from 2012 to 2018 with aggregate time-series data from the Korea Real Estate Board. For δ and δ_J, using the Survey of Household Finances and Living Conditions (SHFLC), which is another survey that contains detailed information on households' mortgage debt, I collect households that actually transitioned from rent to jeonse or homeownership through mortgage, and calculate the weighted average of their initial loan-to-value ratios according to the survey weight. Lastly, for ϕ_J, χ, ϕ_b, and ϕ, I use the acquisition tax rate, brokerage fee for each housing tenure, and the 2015 wealth tax law. For progressive taxes, I use the tax rate for the house price for the bin containing the largest number of houses' market values in the data.

Moving to asset returns, for R_f I use the rate for the average 2-year saving deposit rate across banks from 2012 to 2018 and for μ, μ_h, σ_ϵ, and σ_h, I use the KOSPI index and national housing price index statistics from Korea Real Estate Board for the period from 2004 to 2018 in my calculations, since these concerns households' expectations, and the longer periods capture the property of exogenous price processes more realistically.

Regarding the life-cycle labor income profile, I regress the logged non-capital income (which will be defined in more detail in the empirical analysis section) on *Age* dummy variables for each year of data set. Then, I calculate the average of estimates across years. Finally, I fit the fifth-order polynomial of *Age* on the average estimates of *Age* dummy variables estimated from the initial regressions. From this generated life-cycle labor income profile, I calculate the non-capital income growth rate life-cycle profile ($[\hat{g}_a]_{a=1}^{a=35}$). For the labor income shock, I calculate the average (2009-2016) of the estimated variance of permanent income level shock in Ahn et al. (2021), which uses Korea Labor Income Panel Studies (KLIPS) and which I also use in the empirical analysis. As I only have transitory shocks to the growth rate, which can be interpreted as permanent shocks to the income level in my model, I use

Calibrated Parameters 1		**Value**	**Source**
Discount Rate	(β)	0.96^2	Gomes and Michaelides (2005)
CRRA Parameter	(σ)	5	Gomes and Michaelides (2005)
Housing Expenditure	(ω)	0.2	Yao and Zhang (2005)
Bequest Period	(T_b)	20/2	Yao and Zhang (2005)
Participation Cost	(γ)	2*0.0057	Vissing-Jorgensen (2002) & Gomes and Michaelides (2008)
Calibrated Parameters 2		**Value**	**Source**
Rent to House Price Ratio	(τ)	2*0.035	Korea Real Estate Board (2012-2018).
Jeonse Deposit to House Price Ratio	(J)	0.645	Korea Real Estate Board (2012-2018)
Down Payment Ratio for Jeonse	(δ_J)	0.416	SHFLC (2012-2018)
Down Payment Ratio for Home Purchase	(δ)	0.482	SHFLC (2012-2018)
Jeonse Contract Cost	(ϕ_J)	0.003	Brokerage Fee (Jeonse) (2015)
House Purchase Cost	(ϕ_b)	0.0165	Acquisition Tax + Brokerage Fee (Purchase/Sell) (2015)
Selling Cost	(ϕ)	0.004	Brokerage Fee (Purchase/Sell) (2015)
Maintenance Cost	(χ)	2*0.003	Wealth Tax (2015)
Calibrated Parameters 3		**Value**	**Source**
Gross Risk Free Rate	(R_f)	1.023^2	Bank of Korea ECOS (2012-2018)
Gross Mortgage Rate	(R_M)	1.047^2.	Bank of Korea ECOS (2012-2018)
Expected Log Risk Premium	(μ)	2*0.012	Bank of Korea ECOS (2004-2018)
Expected Log Housing Return	(μ_h)	2*0.011	Korea Real Estate Board (2004-2018)
Standard Deviation of Labor Income Shock.	(σ_y)	2*0.045	Ahn et al. (2021)
Standard Deviation of Stock Return Shock	(σ_ϵ)	2*0.104	Bank of Korea ECOS (2004-2018)
Standard Deviation of Housing Return Shock	(σ_h)	2*0.013	Korea Real Estate Board (2004-2018)
Correlation between Housing and Stock Return	(ρ_{hs})	0.00	Bank of Korea ECOS / Korea Real Estate Board (2012-2018)
Correlation between Labor Income and Stock Return	(ρ_{ys})	0.00	KLIPS / Bank of Korea ECOS(2012-2018)
Correlation between Housing Return and Labor Income	(ρ_{hy})	0.00	KLIPS / Korea Real Estate Board (2012-2018)
Moving Shock	(ξ)	2*0.04	KLIPS

Table 1: Calibrated Parameters

this variance of permanent income shocks only. By taking the square roots of it, I calculate the standard deviation of the labor income shock. To account for the fact that I do not have a transitory income-level shock in my model, when I estimate the life-cycle income profile I include all types of income other than capital income. This includes any transfers from family members, government agencies, or social welfare programs. This definition of income allows me to view this income process as containing all of households' endogenous responses to the transitory shocks to income level. Consequently, using this definition of income rather than conventional labor income for the model allows me to have no transitory income level shock in the model. For the covariance structure among exogenous processes, I use the procedure used by Vestman (2019) and Cocco (2005) with minor modifications[10]. For both methods, it turns out that correlations among stock returns, housing returns and labor income shocks are not statistically significant at all. This might be because I use only 11 years of observations. However, this statistical non-significance was also observed in several papers, such as by Fagereng et al. (2017) and Brandsaas (2018), and thus I set correlations to zero. Lastly, for the exogenous moving probability (ξ), I calculate the portion of homeowners who moved out of their original house for every year, and I calculate the average of such probability, which gives me 0.044. For the sample selection process I use for the above calibration procedures, I explain further in the empirical analysis section later when I use the same sample for these calibrations and the empirical analysis.

[10] More details are in the Appendix

6 Optimal Policies

In this section, I present households' optimal policies for the first-stage problem and the second-stage problem to explain how the model works and what it says about the crowding-out effect.

6.1 Optimal Policies for The First-stage Problem

First, I analyze the non-owner's problem in which households choose a tenure type —rent, jeonse, or homeownership. The left subplot in Figure 3 shows the optimal housing tenure policy for the non-owner's problem. It is remarkable that these optimal policies can generate the housing tenure pattern in Figure 2 if I assume young households that start with a low cash-in-hand-to-income ratio (hereafter $\frac{X}{Y}$) and move to higher $\frac{X}{Y}$ through their net wealth accumulation. We can see that as households have a higher $\frac{X}{Y}$, their optimal tenure choices move from rent to homeownership. The intuition is the following. If we compare jeonse and renting, because jeonse is cheaper than renting in terms of the cost of unit housing service,[11] it is better to choose jeonse. However, when households have very low savings compared with future labor income, it is better to rent because jeonse forces households to save a substantial portion of their assets in the form of a jeonse deposit, which hampers the consumption-smoothing problem. With low accumulated wealth compared with upcoming future income, becoming a jeonse tenant will force households to oversave and sacrifice high marginal utility for the current period. In addition, the fact that households need to have enough net wealth for the down payment prevents households with low $\frac{X}{Y}$ from becoming jeonse tenants or homeowners.

On the other hand, if households have very large assets compared with future labor income, which means high $\frac{X}{Y}$, using most of their assets for the jeonse deposit, which corresponds to a risk-free asset with housing service as dividends, renders their asset position too safe. Given the positive expected return on housing, once households accumulate enough wealth, purchasing a house is better than living on a jeonse contract. Also, households prefer to buy a house because once they move in, unless they move out, they do not have to pay the moving costs they have to pay every period if they choose to use jeonse. Moving costs proportional to housing prices becomes nonnegligible as households buy more expensive houses. These optimal policies can generate a pattern similar to the distribution of housing tenures in the actual data depicted in Figure 2. In addition, it quantitatively matches the sample mean of the $\frac{\textit{Net Wealth}}{\textit{Income}}$ ratio for each tenure of the actual household survey data presented in Table 2. One period in the model corresponds to 2 years. In addition, cash-in-hand X in the model

[11] If a household rents a house, they have to pay $\tau P_a^H H$, which is $0.07 \times P_a^H H$. On the other hand, if a household chooses jeonse contract, they have to pay, including the opportunity costs, $\phi_J \bar{J} P_a^H H + (1-\delta_J)\bar{J} P_a^H H(R_M - 1/R_f) + \delta_J \bar{J} P_a^H H(R_f - 1/R_f)$, which is $0.0484 P_a^H H$. Consequently, jeonse is cheaper in unit housing level.

corresponds to the sum of net wealth and contemporaneous labor income. Consequently, $\frac{X}{Y}$ in the model corresponds to $\frac{1}{2} \times \frac{Net\ Wealth}{Income} + 1$ in the data. Based on this relationship, my model predicts that households with $\frac{X}{Y}$ between 1 and 1.5 choose renting, which means, in the data, the $\frac{Net\ Wealth}{Income}$ of the renter should be between 0 and 1 while the actual sample mean of renters' $\frac{Net\ Wealth}{Income}$ is 1.47, which is very close to the model's prediction. The model also predicts the $\frac{Net\ Wealth}{Income}$ of a jeonse tenant should be between 1 and 7, where the sample mean of the $\frac{Net\ Wealth}{Income}$ of jeonse tenant is 5.83, and the model predicts that the $\frac{Net\ Wealth}{Income}$ of homeowners should be larger than 7, where the sample mean of $\frac{Net\ Wealth}{Income}$ of homeowners is 16.82. One thing to note is that in the data, there are still many renters and jeonse tenants whose $\frac{Net\ Wealth}{Income}$ is very high, which is out of my model's predictions. Since households live in different areas with different housing markets that have different rent-to-price ratio τ or different jeonse deposit size $\bar{J}$, it is natural that we have some misprediction here. I believe that there are some exogenous forces which affect tenure choices, but are not in my model, such as homeownership tax considerations or uncertainty about moving.

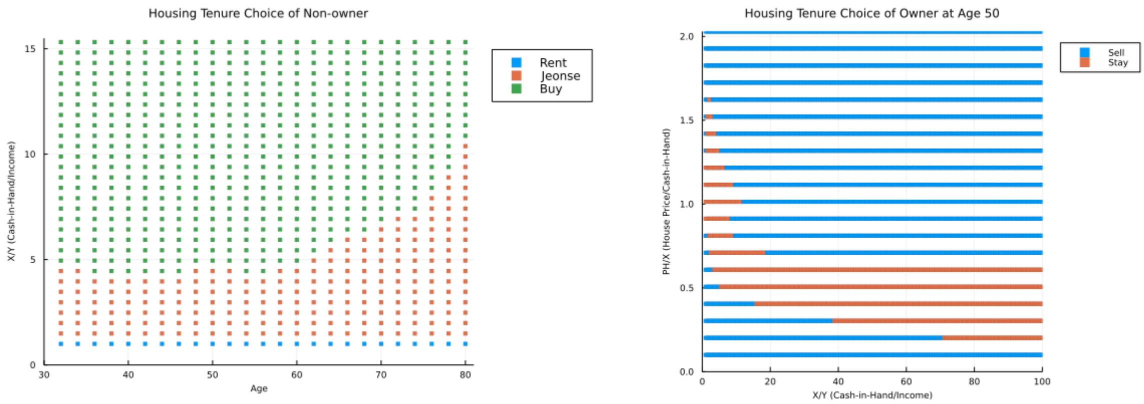


Figure 3: Optimal Housing Tenure Policy

The right subplot of Figure 3 also shows the first-stage optimal policy for the owner's problem. This decision concerns about whether they will move to a new house or stay. As we can see in the figure, the optimal policy is defined as a threshold rule. For the specific value of $\frac{X}{Y}$, there is an optimal level of housing consumption $\frac{p^H H}{X}$, and even though the current housing consumption level exhibits a minor deviation from the optimal level, households do not adjust their housing consumption to avoid moving costs. However, once they deviate too much from their optimal housing consumption level, they sell their houses. This pattern is also observed in Grossman and Laroque (1990) and Yao and Zhang (2005), which means that my model also captures the crowding-out effects discussed in both papers.

6.2 Optimal Policies for the Second-stage Problem

The second-stage problem is defined for each tenure type. Thanks to the normalization, at each age, I can depict optimal policies as ratios over cash-in-hand as consumption share $\frac{C}{X}$ and housing expenditure share ($\frac{\tau P^H H}{X}$, $\frac{\delta_J \bar{J} P^H H}{X}$, $\frac{\delta P^H H}{X}$) for renters, jeonse tenants, and homeowners, respectively. In this subsection, rather than considering the consumption behavior, I will directly jump into portfolio choices.

To understand the model's implications for portfolio choices correctly, carefully defining the model's portfolio choice variables is crucial. First, I define net worth in the following ways. For renters, A_a is equal to their net worth W_a^r, since they have no any other asset. On the other hand, for jeonse tenants, I define the sum of $\delta_J \bar{J} P^H H_a$ and A_a as their net worth W_a^J, since the downpayment for the jeonse deposit can also be understood as an asset. Lastly, I define the sum of A_a and $\delta P^H H_a$ as net worth W_a^b for homeowners in a similar vein. I consider A_a to correspond to a financial asset (or it can be interpreted as an asset other than a housing-related asset.), and $\alpha_a A_a$ to correspond to a risky financial asset (or it can be understood as a risky asset other than a housing-related asset.)

Then, with the above definitions, I can define three portfolio choice variables for each tenure: (1) the ratio of financial assets over net worth $\frac{A_a}{NW_a}$, (2) the ratio of risky financial assets over financial assets $\frac{\alpha_a A_a}{A_a} = \alpha_a$, and (3) the ratio of risky financial assets over net worth $\frac{\alpha_a A_a}{NW_a}$.

$\frac{A_a}{NW_a}$ shows how net worth is distributed over financial assets versus housing assets. Housing serves not only as a consumption but also as an asset in this model. As we will see, housing assets substitute financial asset out, which is the *substitution effect*. As households invest more in housing asset, $\frac{A_a}{NW_a}$ will be lower, and it means that households are left with smaller portion of net worth for financial asset. Next, $\frac{\alpha_a A_a}{A_a} = \alpha_a$ is a risky financial asset portfolio weight among financial assets. This measures how much of the risk is assumed by households in their financial assets. Yao and Zhang (2005) show, in their model, that while homeowners at the trigger bound of owning versus renting have a lower of proportion equity in net worth compared with renters, homeowners actually hold a higher proportion of equity in their financial assets compared with renters. They argue that this is because housing return and stock return have low correlation, which provides a portfolio diversification benefit for homeowners if they hold both housing and stocks; this is called a *diversification effect.* This measure allows us to better understand how the diversification effect works in each tenure. In my context, this can be understood as part of the house price risk channel, which shows the stochastic nature of the return on the housing asset. Lastly, $\frac{\alpha_a A_a}{NW_a}$ shows how total the crowding-out effect is. By comparing this measure across housing tenures, we clearly see how the total crowding-out effect works.

Under an ideal identification condition, different housing tenures should be forcefully imposed on otherwise identical households to see the true causal effect of housing on portfolio choices. In addition, those crowding-out effects should depend on parameters $(\Phi_{OW}, \Phi_J, \tau)$ that define the characteristics of tenures such as the wealth tax, adjustment cost, and rent-to-price ratio. In addition, the characteristics of households and asset return processes (Z), such as correlations across returns on assets, stock market participation costs, and households' belief on asset return processes, also affect the crowding-out effect size, as in Equation 9 and Equation 10.

$$E(PF|\frac{X}{Y}, Age, Renter(\tau), Z) - E(PF|\frac{X}{Y}, Age, Homeowner(\Phi_{OW}), Z) \tag{9}$$

$$E(PF|\frac{X}{Y}, Age, Renter(\tau), Z) - E(PF|\frac{X}{Y}, Age, Jeonse(\Phi_J), Z) \tag{10}$$

$$PF \in [\frac{A_a}{NW_a}, \frac{\alpha_a A_a}{A_a}, \frac{\alpha_a A_a}{NW_a}]$$

My model provides theoretical predictions on these crowding-out effects, because I can forcefully impose different housing tenures on identical households by comparing the optimal policies for the second-stage problems of different housing tenures. Note that in the actual model, only one housing tenure is optimally chosen for each combination of $\frac{X}{Y}$ and Age. Thus this is a hypothetical exercise that differs from the model simulation. However, on the other hand, as we have some households in the data who do not follow the optimal housing tenure policies in the model and who are likely affected by other exogenous tenure shifters, this practice should provide a good lens for interpreting the data. Below, I present figures that represent optimal portfolio choice, and the resulting crowding-out effects. To understand the model's implications for the crowding-out effect intuitively, I present the optimal portfolio choices and the resulting crowding-out effects (1) across $\frac{X}{Y}$ at the age of 50 and (2) across ages at $\frac{X}{Y}$ equals 10, which represent the cross-sectional pattern best.

First, I present the optimal portfolio choices across $\frac{X}{Y}$ for each tenure at the age of 50. In Figure 4, the top row shows the size of each measure and the bottom row shows the difference between each measure of for the jeonse tenant and homeowner with that for the renter. First, in (a), we clearly see the substitution effect happening with respect to each housing tenure. Because jeonse tenants and homeowners save not only in financial assets (A_a) but also in housing assets $(\delta_J \bar{J} P^H H_a)$ or $(\delta P^H H)$, the portion of financial assets in their total net worth is much lower. This substitution effect is strongest for households with the lowest $\frac{X}{Y}$. As households get less liquidity constrained, which means higher $\frac{X}{Y}$, this substitution effect decreases as noted in (d), but does not go to zero. For jeonse tenants, even though households have high $\frac{X}{Y}$, 13% of their total net worth is still in the form of the jeonse deposit while, for homeowners, 25% of their total net worth is in the form of housing assets. This may stem from the fact that housing assets are a good investment, given the housing return stochastic process with

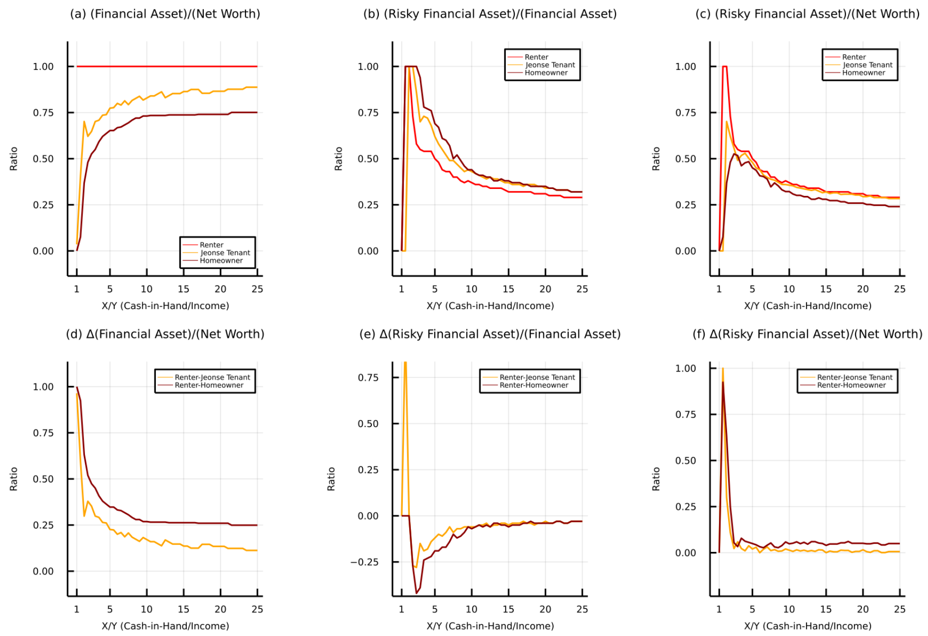


Figure 4: Optimal Portfolio Choices for All Tenures over $(\frac{X}{Y})$ Cross-section

high return and low standard deviation. In addition, the difference is because these housing tenures force households to save much of their wealth in the form of housing-related assets to consume housing services. This substitution effect can be understood as coming from the liquidity constraint channel of the housing crowding-out effect. It decreases as households get less liquidity constrained, which means higher $\frac{X}{Y}$.

Moving to (b), we see that the $\frac{\alpha_a A_a}{A_a} = \alpha_a$ measure is higher for jeonse tenants and homeowners than renters, which is called the diversification effect by Yao and Zhang (2005). Since renters have all of their assets in the form of financial assets, investing all of them in a risky financial asset is too risky. However, since jeonse tenants and homeowners also have housing assets, they may take more risks in their financial portfolios. In particular, the jeonse deposit corresponds to the risk free asset where the dividend is housing service. Consequently, it is natural that jeonse tenants have higher $\frac{\alpha_a A_a}{A_a} = \alpha_a$ than renters. In addition, since I assume no correlations across housing return and stock return, investing in housing also provides a diversification benefit from investing in stocks. Again, as households go to higher $\frac{X}{Y}$, this diversification effect also gets smaller, as depicted in (e). As the ratio of financial assets over net worth goes up, they have less need to have a high portion of equity in their financial assets.

In the end, households also adjust the margin of their stock proportion over total net worth not only through $\frac{\alpha_a A_a}{A_a} = \alpha_a$ but also through $\frac{A_a}{NW_a}$. In the end, we should check $\frac{\alpha_a A_a}{NW_a}$ to see the total crowding-out effect. Lastly, shifting to the total effect on $\frac{\alpha_a A_a}{NW_a}$ in (c), we see that the crowding-out effect clearly exists for both jeonse tenants and homeowners. The two effects in (a) and (b) are combined and generate this pattern. One notable observation is that the crowding-out effect is higher for households with low $\frac{X}{Y}$. As households get higher $\frac{X}{Y}$, which means less liquidity constrained, most of the effect goes away. The other notable observation is that while the crowding-out effect from jeonse completely goes away with high $\frac{X}{Y}$, which is 0.006, the crowding-out effect for homeowners remains even with the high $\frac{X}{Y}$, which is estimated as 0.0497. It seems that the liquidity constraint channel disappears once households are no longer liquidity constrained, while the house price risk channel remains. In the case of jeonse tenants, even though the financial assets are crowded out by the jeonse deposit, by adjusting $\frac{\alpha_a A_a}{A_a} = \alpha_a$, they achieve the optimal risk exposure.

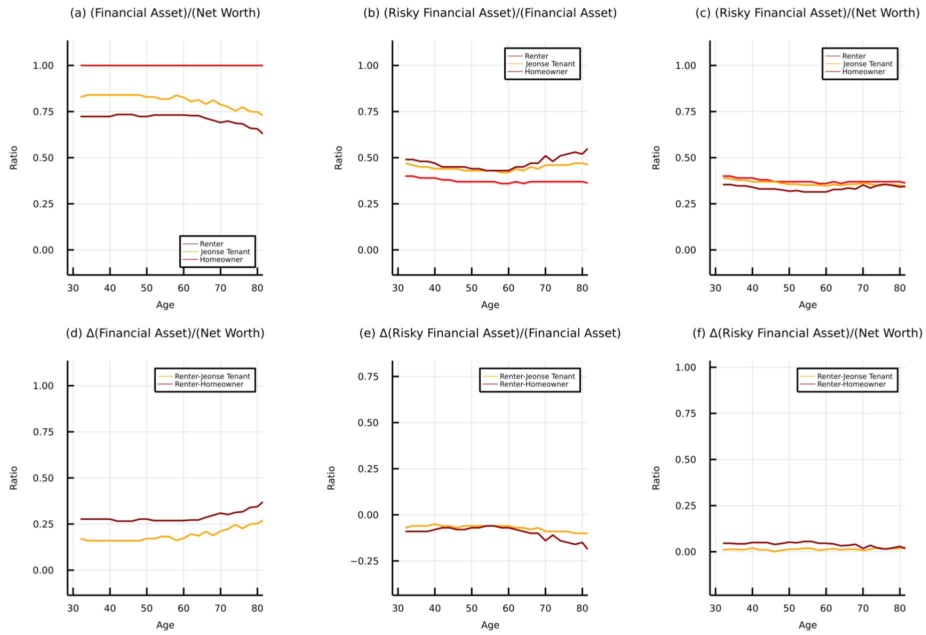
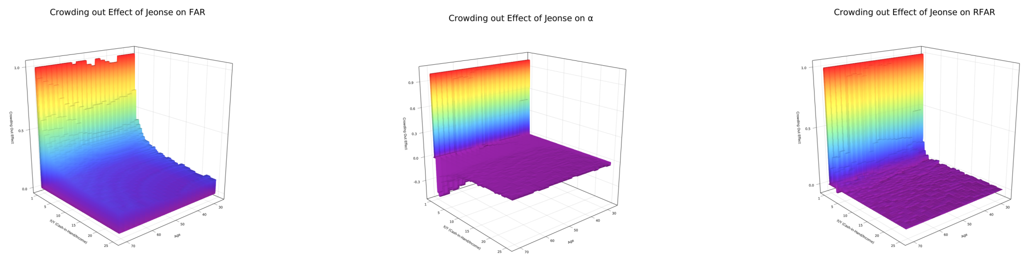


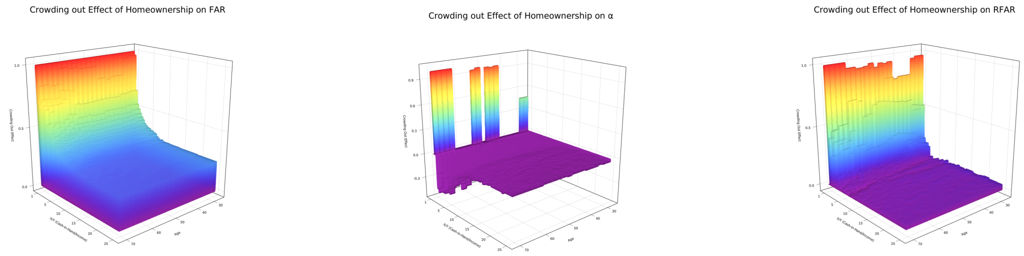
Figure 5: Optimal Portfolio Choices for All Tenures over (Age) Cross-section

Moving to the age cross-section, I present the optimal portfolio choices of all housing tenures with $\frac{X}{Y}$ equal to 10 across all ages. Other than the case of extremely low $\frac{X}{Y}$, I find similar patterns for any $\frac{X}{Y}$. In Figure 5, in (a) and (d), I find that the ratio of financial assets over net worth goes down as households get older, for both jeonse renters and homeowners. This stems from the fact that housing is not only a kind of asset but also a kind of consumption. Following consumption-smoothing motives, households consume more and save less as they get closer to the end of their lifetime. Interestingly, in (b) and (e), we can see that α gets higher as they get older for both jeonse tenants and homeowners. Since they have lower financial assets, to achieve the optimal equity exposure level, they try to increase their risky asset ratio of their financial assets. Finally, in (c) and (f), we see that the total crowding-out effect differs for jeonse tenants and homeowners. For jeonse tenants, given the relatively high $\frac{X}{Y}$, there is no liquidity constraint channel, which generates zero crowding-out effect. However, homeowners exhibit a sustained crowding-out effect, which goes away only when they are older than 70. This again demonstrates the nature of crowding-out effect. The house price risk channel persists even though households are not liquidity constrained.

Figure 15 shows the crowding-out effects for all ages and $\frac{X}{Y}$. We can see that the overall patterns that we saw in Figure 4 and Figure 5 again appear across Age and $\frac{X}{Y}$. The crowding-out effect from jeonse fades away, while the crowding-out effect from homeownership persists. We see some exotic optimal policies in 15(e) with low $\frac{X}{Y}$, especially for homeowners and jeonse renters. However, keep in mind that when $\frac{X}{Y}$ is low, because they only have a very small portion of A, either having a very high α or very low α do not make much difference in terms of total portfolio choices $\frac{\alpha_a A_a}{NW_a}$.



((a)) Jeonse on $\frac{A_a}{NW_a}$ ((b)) Jeonse on α_a ((c)) Jeonse on $\frac{\alpha_a A_a}{NW_a}$



((d)) Homeowner on $\frac{A_a}{NW_a}$ ((e)) Homeowner on α_a ((f)) Homeowner on $\frac{\alpha_a A_a}{NW_a}$

Figure 6: Crowding-out Effect in the Baseline Calibration

6.3 Liquidity Constraint from the Life-cycle versus Housing

In the end, it is important to understand the relationship between the liquidity constraint channel of the crowding-out effect and the nature of the incomplete market for households' life-cycle, which is well-established in early literature. The fact that households have to smooth their consumption and achieve the optimal portfolio choices while they cannot borrow against their future labor income (*liquidity constraint of the life-cycle*) affects households' portfolio choices. Because they are forced to have most of their lifetime income in the form of illiquid labor income, their portfolio choices are affected.

Housing contracts affect the stock investment behavior by adding the additional liquidity constraint channel of the crowding-out effect of housing on the liquidity constraint of the life-cycle. Being a homeowner or jeonse tenant forces households to save a substantial amount of their asset in the form of illiquid housing to consume a housing service.

This is why young households are affected more by the liquidity constraint channel, given the same $\frac{X}{Y}$, compared with older households. They are already experiencing the liquidity constraint of the life-cycle, and housing exacerbates. Older households, who are relatively free from the liquidity constraint of the life-cycle are get much affected by it.

On the other hand, the house price risk channel is independent of such a mechanism. It directly affects the risk-return trade-off of a household's overall portfolio regardless of households characteristics. Consequently, this channel affects all types of households.

6.4 Determinants of the Crowding-out Effect

In this subsection, I show how these crowding-out effects change depending on stock market participation costs γ and the correlation structure between the housing returns and stock returns, ρ_{hs}.

These two comparative statics analyses have important meanings. For γ, it is related to the liquidity constraint channel. As households have to pay γY participation costs, in the model, if households do not have enough financial assets A, they have no incentive to participate in the stock market, since they cannot get much from participating in the stock market compared with the participation cost. This is especially the case for the households who have large portion of their assets as housing assets. Through this, the crowding-out effect can be affected nonlinearly via two channels with the stock market participation cost. First, purchasing a house or making a jeonse contract leads households to hold a large portion of their wealth in the form of housing assets, which decreases A as we saw above. Given the decreased A, higher stock market participation costs prevent homeowners and jeonse tenants from participating in the stock market, which exacerbates the crowding-out effect defined in Equation 9 and Equation 10. Second, too high participation costs eliminates all participation, even by the renter who is not affected by the substitution effect, which causes the crowding-out effect to be zero. These comparative statics can show us how this intuition works. In addition, assuming with higher stock market participation costs for Korean households compared with US households seems reasonable based on historical experiences and the different levels of development of financial markets in Korea and the US.

On the other hand, for ρ_{hs}, this parameter affects the house price risk channel: The negative correlation between housing return and stock return effectively decreases the additional risk from housing when households have both stocks and housing, due to the diversification effect observed above and also that of Yao and Zhang (2005). While my baseline calibration assumes no correlation, I assume high positive correlation in these comparative statics to see how the crowding-out effect behaves. Consequently, these two comparative statics analyses will show how we should think about the crowding-out effect present in the data in the empirical analysis section.

6.4.1 High Correlation between Stock Return and Housing Return

In this subsection, I present the optimal portfolio choices of households with higher correlation between stock return and housing return processes. While I set correlation ρ_{hs} as zero in the baseline case, here I set the correlation as 0.3. Figure 7 shows the optimal portfolio choices at the age of 50 across $\frac{X}{Y}$. Though it is very similar to Figure 4, it has some notable differences. As we see in (e), the α_a of homeowners is similar (and even lower with high $\frac{X}{Y}$) to that of jeonse tenants while homeowners' α_a was much higher in the baseline case. Consequently, the resulting crowding-out effect in (f) is much stronger and more prominent, and can be understood as a decreased benefit of diversification.

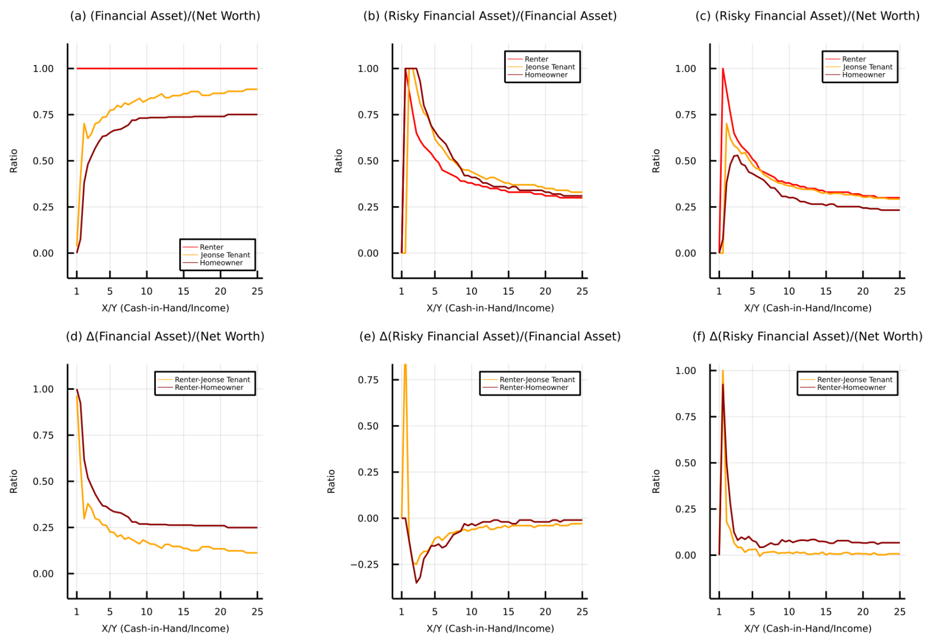


Figure 7: Optimal Portfolio Choices for All Tenures over $\frac{X}{Y}$ Cross-section with High ρ_{hs}

Moving to the optimal portfolio choices of households across ages, we again see similar patterns qualitatively; the only difference is that the magnitude of the crowding-out effect from homeownership becomes larger. Graphs for all $\frac{X}{Y}$ and ages are in the Appendix.

6.4.2 High Stock Market Participation Costs

In this subsection, I analyze the case with high stock market participation cost (γ). This change in particular can cause qualitative change in optimal portfolio choices due to the nonlinear effect discussed above. Whereas I set γ as 0.0057 in the baseline case, here I set it as 0.05.

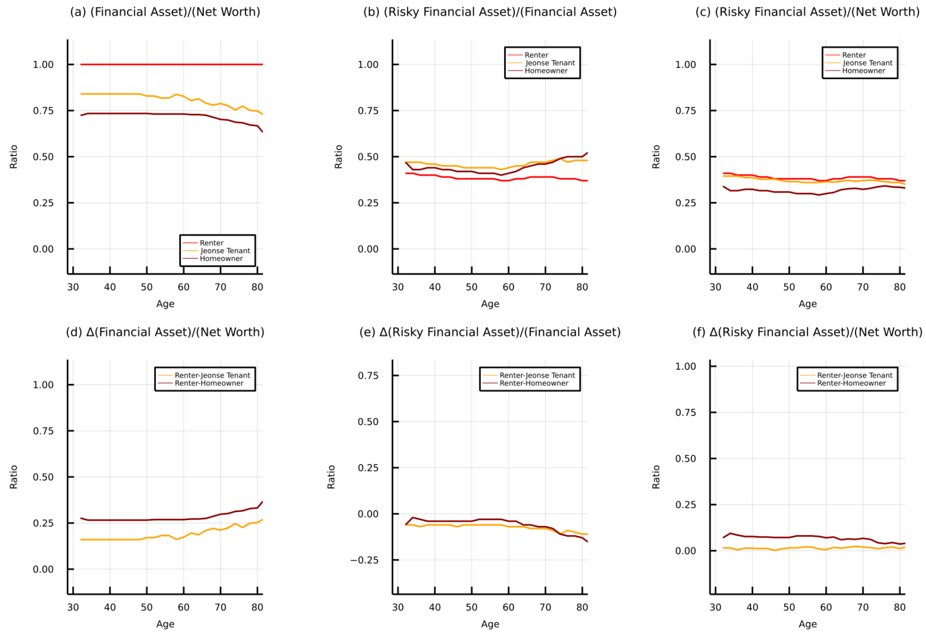


Figure 8: Optimal Portfolio Choices for All Tenures over (Age) Cross-section with High ρ_{hs}

In Figure 9, we see that the crowding-out effect pattern is strikingly different: The behavior of $\frac{A_a}{NW_a}$ is very similar to that of the baseline case. However, the α_a pattern is now very different. Due to high stock market participation costs, only renters who have $\frac{X}{Y}$ higher than 10.5 participate in the stock market. With the decreased A due to housing tenure, if that household is a jeonse tenant or homeowner, they participate in the stock market only with $\frac{X}{Y}$ higher than 14. Consequently, it eliminates the crowding-out effect for households with $\frac{X}{Y}$ lower than 10.5 and suddenly increases the crowding-out effect for households with $\frac{X}{Y}$ between 10.5 and 14. Once a household has $\frac{X}{Y}$ more than 14, the crowding-out effect again drops and converges to zero, as we saw in the baseline cases.

Such nonlinearity is strikingly represented in Figure 10. Since this is the optimal policy for households with $\frac{X}{Y}$ equal to 10 at different ages, the figure shows zero crowding-out effect across any Age. It is natural to imagine that households should have stock market participation costs very different from each other, based on their different peer groups, or education levels. Consequently, it should be difficult to capture any strong pattern of such an effect by exploiting panel data. In the next section, will strive to capture the crowding-out effect patterns from household survey panel data.

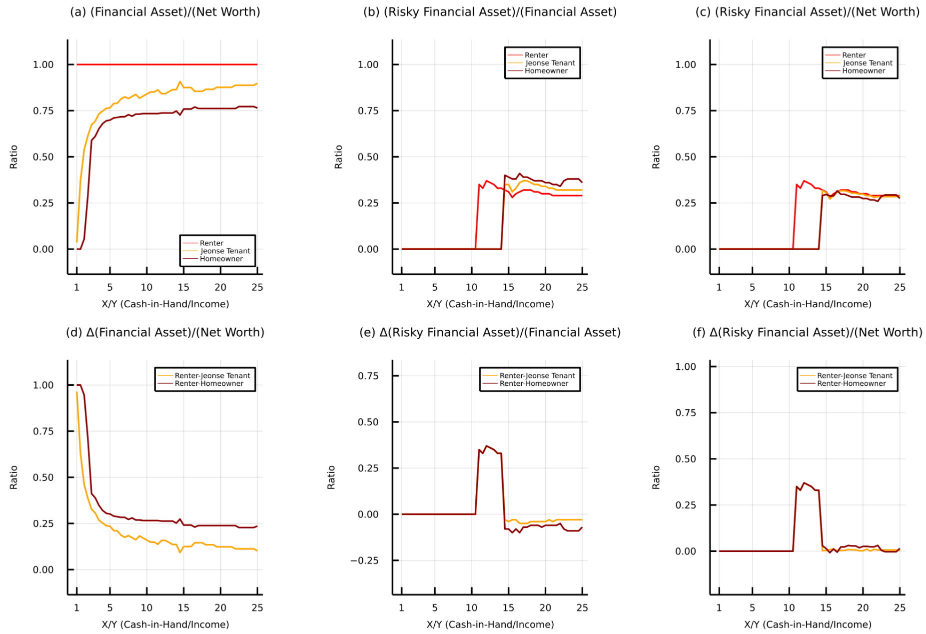


Figure 9: Optimal Portfolio Choices for All Tenures over $\frac{X}{Y}$ Cross-section with High γ

7 Empirical Analysis

To study whether these patterns of the crowding-out effect are present in the data, I examine how renters, jeonse tenants, and homeowners make portfolio choices using household panel data from the Korea Labor and Income Panel Study (hereafter KLIPS.) KLIPS started in 1998 with 5,000 households as the initial household samples. All new households generated from the initial household sample are also tracked. As of 2009, 1,721 households had been added to the sample, and with the addition of more households in 2018, currently 12,134 households are being tracked. This household panel survey sample was constructed to represent the whole Korean population. Every year, between April and September, households in the sample are surveyed. The data contain detailed information on households' demographics, income, expenditures, assets, and debts. I standardized all variables as real variables at 2020 price level using the consumer price index.

7.1 Descriptive Statistics

To study the portfolio choices of households properly, deriving the proper definitions of portfolio variables and balance sheet variables is important. I define households' net wealth, financial assets, risky financial assets, liabilities, and households' non-capital income as follows. Net wealth (hereafter W) is defined as the sum of financial assets (herefater FA) and real assets (hereafter RA) minus any type of liabilities (hereafter LB). Defining FA requires additional consideration, especially when we consider the jeonse deposit. This can be interpreted

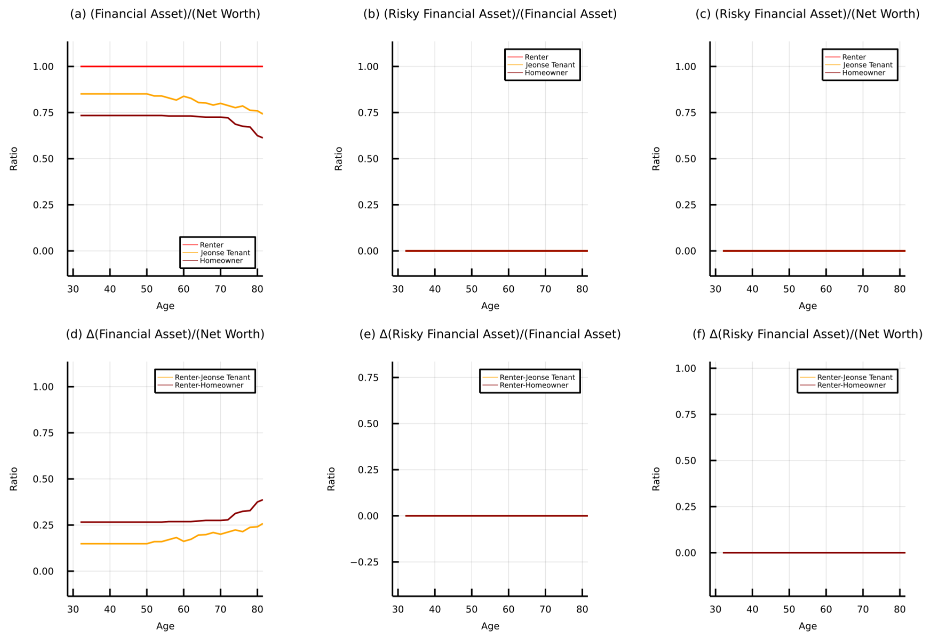


Figure 10: Optimal Portfolio Choices for All Tenures over (Age) Cross-section with High γ

as a risk-free financial asset, which is a kind of collateralized lending with housing services as dividends. On the other hand, the jeonse deposit can be interpreted as a housing-related asset, in the sense that it crowds out any other type of financial assets. I define FA as including bank deposits, mutual funds, stocks, bonds, saving insurances, and private lending but not jeonse deposit or rent deposit. This is to facilitate comparison of its crowding-out effect with that of the model. Of these financial assets, I consider the sum of stocks, bonds, and mutual funds as risky financial assets (hereafter RFA). RA include real estate assets including the house lived in, cars, land, and any other type of real assets. LB includes any type of borrowing from the bank (including mortgages) and private borrowing from individuals. Jeonse deposits and rent deposits are also included in LB if responding households are landlords. Lastly, non-capital income (hereafter Y) includes labor income, pensions, social insurance, and other family transfer income. I include all types of income other than income from housing or financial investments to incorporate households' ability to cope with idiosyncratic labor income shock, which is not present in my model.

Based on these assets and liabilities variables, I define portfolio choice variables as follows. The financial asset ratio (hereafter FAR) is defined as $\frac{FA}{W}$, while the risky financial asset ratio (hereafter $RFAR$) is defined as $\frac{RFA}{W}$. Also, I define the risky financial asset ratio over financial assets (hereafter $Alpha$) as $\frac{RFA}{FA}$. When I study the above variables only for households who ever participated in the stock market, I put $c-$ in front of these variables to represent "conditional" (e.g., $c - RFAR$.) As a participation dummy, I define stock market participation (hereafter SMP) as $1[Risky\ Fin\ Asset > 0]$. Lastly, the net wealth-to-income ratio will be denoted by $(\frac{W}{Y})$ following the above definitions as a variable corresponding to the model's most important state variable $\frac{X_{model}}{Y_{model}}$. Note that X_{model} in the model is cash-in-hand, which is a sum of net wealth and contemporaneous labor income. In addition, one period in the model is 2 years. Consequently, the following relationship holds: $\frac{X_{model}}{Y_{model}} = \frac{W_{data}+2Y_{data}}{2Y_{data}}$. Note that FAR corresponds to $\frac{A_a}{NW_a}$, $Alpha$ corresponds to $\frac{\alpha_a A_a}{A_a} = \alpha_a$, and $RFAR$ corresponds to $\frac{\alpha_a A_a}{NW_a}$ in the model. By using each variable, I will compare model predictions with the data pattern.

	Renters	**Jeonse Tenants**	**Homeowner**
Fraction of households	0.129	0.228	0.584
Age	45.93	43.59	54.66
Net Wealth (W)	3455.43	13066.38	28364.04
Real Assets (RA)	1903.60	5129.64	29411.29
Financial Assets (FA)	828.52	2143.89	2922.23
Risky Financial Asset (RFA)	137.43	354.83	364.80
Liabilities (LB)	987.38	2816.77	4381.23
Non-capital Income (Y)	3083.27	4303.13	4512.95
Financial Asset Ratio (FAR)	0.2962	0.1897	0.1003
Risky Financial Asset Ratio ($RFAR$)	0.0087	0.0154	0.0096
Risky Financial Asset Ratio over Financial Assets ($Alpha$)	0.0181	0.0595	0.0444
Conditional Risky Financial Asset Ratio ($c - RFAR$)	0.2688	0.1207	0.1083
Conditional Risky Financial Asset Ratio over Financial Assets ($c - Alpha$)	0.5549	0.4654	0.4960
Stock Market Participation (SMP)	0.0326	0.1279	0.0894
Net Wealth over Income Ratio ($\frac{W}{Y}$)	1.4705	5.8382	16.8268
House Price	0	0	23483.21
Jeonse Deposit	0	8310.23	0
Rent Deposit	1538.40	0	0

1 means 10,000 Korean won, which corresponds to $8.81 in 2010. I use only THE 2010 survey to show the data pattern.

Table 2: Summary Statistics

Table 2 reports summary statistics for the variables of interest. It reveals stark differences across housing tenures. While owners are usually older than renters and jeonse tenants, they also have more net wealth W, more income Y, and higher $\frac{W}{Y}$ ratio, as predicted by my model. Keep in mind that one period in the model is 2 years, which means that the model's $\frac{X_{model}}{Y_{model}}$ corresponds to $\frac{W_{data}+2Y_{data}}{2Y_{data}} = \frac{1}{2}\frac{W_{data}}{Y_{data}} + 1$ in the data. If we compare each tenure's sample mean $\frac{W}{Y}$ by dividing by 2 and add 1 with $\frac{X_{model}}{Y_{model}}$ in the model's optimal housing tenure policy in Figure 3, we find that the model matches remarkably well each tenure's $\frac{W_{data}}{Y_{data}}$ as I discussed in the modeling section. Another interesting point is that South Korea exhibits a very low stock market participation rate compared with major developed countries. This may stem from the fact that the Korean stock market is valued as low with a high risk premium due to its geopolitical risks and high dependence on exports. In addition, several financial crises, including the East Asia Crisis in 1997, may have led many households to believe that the stock market is too risky to participate in. The stock market participation rate presented here is the direct participation rate and does not take indirect participation through pensions fund into account. Lastly, while renters show very low stock market participation, jeonse tenants and homeowners participate more in the stock market. On the other hand, renters show higher FAR, $c - RFAR$, and $c - Alpha$ compared with others and lower $RFAR$ and $Alpha$ compared with jeonse tenants and homeowners. While FAR and $c - RFAR$ are similar to the predictions from model with higher level of stock market participation costs, $Alpha$ seems to follow the predictions made by the model with the high positive correlation between housing return and stock return.

7.2 Sample Selection

To avoid the abnormalities of the Great Recession and the COVID-19 crisis, I use survey data only survey years from 2009 to 2019. In addition, to validate the accuracy of responses, I collect only households who ever responded more than 4 times, because several households respond only 1 or 2 times, with missing responses for many questions. Also, I removed households with negative net wealth and households with yearly non-capital income Y less than 1,200,000 Korean won, which is equivalent to $1,057.45 at the 2010 exchange rate. Households with too low Y show too high $\frac{W}{Y}$, and some unrealistic portfolio weights that are larger than 100%. I also removed the bottom 1% and top 1% of households in terms of $\frac{W}{Y}$ to remove any abnormal data patterns from outliers. Lastly, I removed renters and jeonse tenants whose value of other real estate assets is twice as large as their jeonse or rent deposit. If they have other large housing asset, and only temporarily use jeonse or rent contracts for their housing needs, I decided not to consider them as jeonse tenant or renters.

7.3 Housing Tenure and Portfolio Choice

There is substantial variation across years, especially for the stock market participation rate. To more clearly see the relationship between housing tenure and households' portfolio choices, while controlling for region and year fixed effects, I run the following regression in which dependent variable PF_{it} can be FAR, $Alpha$, $c - Alpha$, $RFAR$, $c - RFAR$, or SMP.

$$PF_{it} = \beta_J Jeonse_{it} + \beta_O Owner_{it} + RegionTime_{it} + \epsilon_{it} \tag{11}$$

Figure 18 shows the estimated parameters and confidence intervals of β_J and β_O.[12] It clearly summarizes the relationship between housing tenure status and households' portfolio choices, while controlling for year and region fixed effects. We can clearly see the substitution effect in FAR. Jeonse tenants show a -21% lower FAR compared with renters, while homeowners show a -29% lower FAR. Jeonse and homeownership seem to predict positive relationships with $Alpha$ and to have some small negative effects on $c - Alpha$. Moving to $RFAR$, it is negatively correlated with jeonse and homeownership, while being a jeonse tenant predicts 20% lower $RFAS$ conditional on participation and homeownership predicts 26% lower $RFAS$ conditional on participation. Though I do not include other control variables,

[12] Standard errors are clustered at region-time level.

these patterns seem to be fairly consistent with the model's predictions. Interestingly, jeonse tenant status and homeownership seem to have crowding-out effects on the intensive margin but not on the extensive margin, which shows actually positive relationships. Jeonse and ownership are positively correlated with stock market participation, where being a jeonse tenant predicts 2.13% higher stock market participation and homeownership predicts 1.31% higher stock market participation. These results are similar to those of Vestman (2019) for the extensive margin. The regression in Vestman (2019) uses moving to homeownership as a treatment in DID set-up with household fixed effect, and thus it is slightly different from the regression specification here. However, the two regressions are similar in the sense that they do not control for the household's wealth or income, and show the positive relationship between stock market participation and homeownership (also jeonse tenant status.) Though this positive relationship likely stems from the endogeneity caused by confounders, including $\frac{W}{Y}$, it still describes the overall data patterns well.

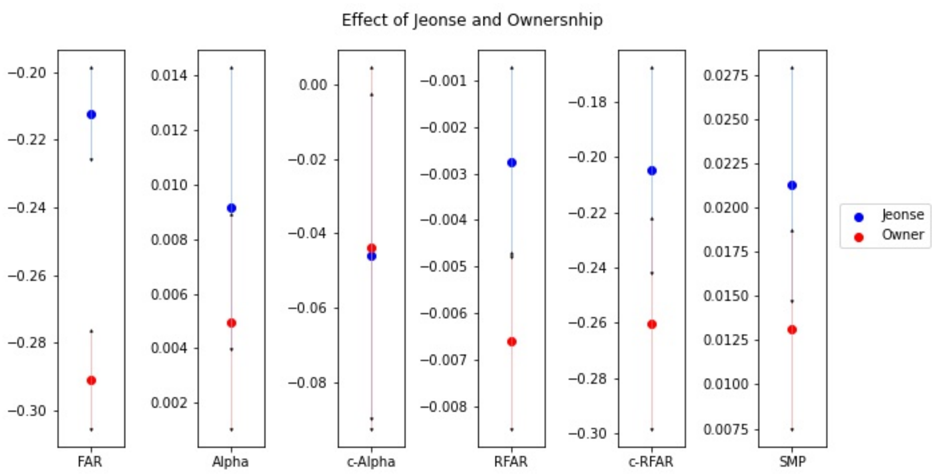


Figure 11: Housing Tenure and Portfolio Choice

7.4 The Crowding-out Effect Across $\frac{W}{Y}$

In this subsection, with full control for household characteristics, I capture the crowding-out effect pattern of each tenure type across $\frac{W}{Y}$ in more detail. I will state the definitions of crowding-out effects to estimate again in terms of the variables defined in this empirical section. Because the housing tenure variables are highly correlated with $\frac{W}{Y}$ and Age variables, which also substantially affect portfolio choice variables—which is predicted by my model—controlling for $\frac{W_{data}}{Y_{data}}$ and Age_{data} in the regression is important. This is equivalent to controlling for $\frac{X_{model}}{Y_{model}}$ and Age_{model} in the model.

$$E(PF|\frac{W}{Y}, Age, Renter(\tau), Z) - E(PF|\frac{W}{Y}, Age, Homeowner(\Phi), Z) \quad (12)$$

$$E(PF|\frac{W}{Y}, Age, Renter(\tau), Z) - E(PF|\frac{W}{Y}, Age, Jeonse(\Phi_J), Z) \quad (13)$$

$$PF \in (FAR, RFAR, c - RFAR, SMP, Alpha, c - Alpha)$$

Also, there are two ways we can view the effect of housing tenure. We can either use dummy variables for jeonse tenure and homeownership, as Brandsaas (2018) does, or we can use $\frac{Jeonse\ Deposit}{Net\ Wealth}$ ($\frac{JD}{W}$) and $\frac{House\ Price}{Net\ Wealth}$ ($\frac{HP}{W}$), as Cocco (2005) and Yao and Zhang (2005) do. To facilitate comparison across the research, I perform both of the specifications below.

$$PF_{it} = \beta U_{it} + \sum_{Q=1}^{5} \gamma_{1Q} Jeonse_{it} [\frac{W}{Y}]_{it}^{Q} + \sum_{Q=1}^{5} \sigma_{1Q} Owner_{it} [\frac{W}{Y}]_{it}^{Q} + \epsilon_{it} \quad (14)$$

$$PF_{it} = \beta U_{it} + \sum_{Q=1}^{5} \gamma_{2Q} \frac{JD}{W}_{it} [\frac{W}{Y}]_{it}^{Q} + \sum_{Q=1}^{5} \sigma_{2Q} \frac{HP}{W}_{it} [\frac{W}{Y}]_{it}^{Q} + \epsilon_{it} \quad (15)$$

$$PF_{it} \in (FAR_{it}, RFAR_{it}, c - RFAR_{it}, SMP_{it}, Alpha_{it}, c - Alpha_{it})$$

I include the interaction terms with housing-related variables and $[\frac{W}{Y}]^{Q}$, which is a dummy variable for being in each $\frac{W}{Y}$ quantile group. I divide all households into 5 groups, depending on their quantile group of $\frac{W}{Y}$. This is in order to see whether there is a heterogeneous crowding-out effect that depends on households' wealth-to-income ratio, as predicted by the model. U_{it} includes $Log(\frac{W}{Y})$, education level, $Log(Age)$, number of members in the household, year fixed effects, and household fixed effects. These variables are all controlled for by Cocco (2005) and Yao and Zhang (2005). What I do not control for here is whether the household is operating their own business or not and the amount of mortgage debt, as I have no corresponding information.

These regressions effectively exploit two within-household variations of portfolio choices. The first variation is the variation in portfolio changes that occurs when the household changes their housing tenures, and the second variation is the variation that occurs when the household experiences changes in their wealth-to-income ratio. If an individual changes their housing tenure from renting to jeonse, if something occurs in their portfolio choices, that will be captured by my regression. At the same time, even when households stay in same housing tenure,—let's say jeonse—, if they experience changes in their wealth-to-income ratio, and if their portfolio choices also change, the variation will be captured by the regression.

These regressions may be subject to endogeneity concerns, since housing tenure choice and portfolio choice can be simultaneously affected by numerous confounders such as the household's risk preference, the household's belief about future income, and their current income or wealth. I strive to control for such factors using individual fixed effects and detailed household demographics and balance sheet information.

As another concern, Beaubrun-Diant and Maury (2016) argue that there are strong simultaneity and cross-causality effects between homeownership and stock market participation. Here I do not try to control for such confounding relationships, because I have no proper instrumental variables. I proceed under the assumptions that all the confounding effects are controlled by controlling Age and $\frac{W}{Y}$. Also I assume that all dynamics can be controlled for by their wealth variables and age variables. At the least, the empirical analysis below can be interpreted as summarizing the correlations that represents how the data compare with the model's predictions.

	FAR	$Alpha$	$c-Alpha$	$RFAR$	$c-RFAR$	SMP
$Education1$	0.4108***	0.1922	-0.3144	0.0584***	-0.0117	0.3951***
	(3.0984)	(1.4493)	(-0.5233)	(2.5818)	(-0.2262)	(4.0079)
$Education2$	0.4078***	0.1939	-0.3071	0.0572***	-0.0093	0.3940***
	(3.1888)	(1.5323)	(-0.5415)	(2.6802)	(-0.1871)	(4.1747)
$Education3$	0.3982***	0.1668	-0.2720	0.0596***	-0.0017	0.3593***
	(3.1936)	(1.3711)	(-0.5122)	(2.7721)	(-0.0339)	(3.7797)
$Number\ of\ Members$	-0.0117***	-0.0032*	-0.0022	-0.0015**	-0.0031	-0.0060**
	(-3.7816)	(-1.6782)	(-0.3820)	(-2.3245)	(-0.9111)	(-2.5073)
$Log(Age)$	0.0177	-0.0371	0.0864	-0.0100*	0.0096	-0.0797***
	(0.5345)	(-1.1400)	(0.6200)	(-1.8180)	(0.7726)	(-3.2685)
$Log(\frac{W}{Y})$	-0.0185***	0.0055**	0.0030	0.0017	0.0057	0.0086***
	(-2.9040)	(2.5559)	(0.4490)	(1.3073)	(0.9271)	(3.7985)
$Owner \times [\frac{W}{Y}]^Q_1$	-0.2985***	-0.0024	-0.0027	-0.0096***	-0.0056	-0.0189***
	(-17.186)	(-0.4052)	(-0.0958)	(-3.9377)	(-0.3953)	(-2.9461)
$Owner \times [\frac{W}{Y}]^Q_2$	-0.3197***	-0.0058	-0.0302*	-0.0110***	-0.0256*	-0.0190***
	(-24.125)	(-1.0591)	(-1.8988)	(-3.6546)	(-1.8158)	(-2.8609)
$Owner \times [\frac{W}{Y}]^Q_3$	-0.3126***	-0.0116*	-0.0257	-0.0140***	-0.0296*	-0.0257***
	(-22.348)	(-1.9127)	(-1.4591)	(-3.7786)	(-1.6826)	(-3.5689)
$Owner \times [\frac{W}{Y}]^Q_4$	-0.3119***	-0.0189***	-0.0272	-0.0153***	-0.0334	-0.0345***
	(-20.579)	(-2.8703)	(-1.5783)	(-3.6464)	(-1.6340)	(-4.4235)
$Owner \times [\frac{W}{Y}]^Q_5$	-0.3041***	-0.0160**	-0.0195	-0.0155***	-0.0343	-0.0327***
	(-16.463)	(-2.0542)	(-0.9226)	(-3.1197)	(-1.3945)	(-3.5877)
$Jeonse \times [\frac{W}{Y}]^Q_1$	-0.1976***	0.0024	0.0070	-0.0027	0.0011	-0.0052
	(-14.213)	(0.4458)	(0.3510)	(-1.1066)	(0.0899)	(-0.9058)
$Jeonse \times [\frac{W}{Y}]^Q_2$	-0.2331***	-0.0004	0.0088	-0.0088***	-0.0155	-0.0022
	(-20.325)	(-0.0698)	(0.5059)	(-2.8967)	(-0.8874)	(-0.2986)
$Jeonse \times [\frac{W}{Y}]^Q_3$	-0.2210***	-0.0023	-0.0127	-0.0089**	-0.0213	-0.0041
	(-17.139)	(-0.3647)	(-0.6592)	(-2.3762)	(-1.0297)	(-0.4704)
$Jeonse \times [\frac{W}{Y}]^Q_4$	-0.2054***	-0.0054	-0.0042	-0.0087*	-0.0222	-0.0113
	(-13.062)	(-0.6107)	(-0.2031)	(-1.8975)	(-1.1578)	(-1.0366)
$Jeonse \times [\frac{W}{Y}]^Q_5$	-0.1759***	0.0105	0.0223	-0.0039	-0.0184	-0.0006
	(-8.5335)	(0.8658)	(0.7312)	(-0.6904)	(-0.7676)	(-0.0468)
No. Observations	60220	43478	4462	60220	6642	60220
R-squared	0.0869	0.0019	0.0049	0.0049	0.0181	0.0026
P-value (F-stat)	0.0000	0.0000	0.2442	0.0000	0.0000	0.0000
Effects	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE

T-statistics are in the parentheses. Standard errors are clustered in household levels. $[\frac{W}{Y}]^Q_1$ means household's $\frac{W}{Y}$ is between 0-20 percents quantile in overall distributions.

Table 3: Regression Specification 1 - $\frac{W}{Y}$ Cross-section

Table 3 reports the results for the specification in equation 14. I find that $Log(Age)$ has a negative relationship with all portfolio choice variables. This is consistent with the finding of Brandsaas (2018) for stock market participation. In addition, the $Number\ of\ Members$ has a negative sign as, as is also the case for Brandsaas (2018). As an important state variable,

$Log(\frac{W}{Y})$ is estimated to have positive effects on most portfolio choice variables other than FAR, which is again consistent with the concave relationship implied by the model and the results in Brandsaas (2018). In particular, it shows that high $Log(\frac{W}{Y})$ implies higher SMP. A model with a certain level of participation cost predicts such a relationship.

Shifting to the crowding-out effects of interest, I find consistent crowding-out effects of housing from homeowners (σ_{1Q}) on FAR, $RFAR$, $c - RFAR$, and SMP, in contrast the crowding-out effects of jeonse tenure (γ_{1Q}) seem to have an effect only on FAR and $RFAR$.

First, for FAR, we see jeonse tenure and homeownership have strong negative effects on FAR, which is also predicted by the model as the substitution effect. Interestingly, the effect of jeonse is much smaller than that of homeownership. In addition, crowding-out effect from jeonse (γ_{1Q}) decreases as households move into higher $\frac{W}{Y}$ quantile groups, while the crowding-out effect from homeownership (σ_{1Q}) somewhat decreases or persists, which is also predicted by my model. This should stem from the fact that homeownership not only requires larger down payment (more of the liquidity constraint channel) but also incurs the house price risk channel.

Second, moving to $Alpha$, we see that the coefficients on jeonse (γ_{1Q}) are not significant. The model predicted higher $Alpha$ for jeonse tenants compared with the renters, and it seems the regression does not capture that channel fully. For the effect of homeownership on $Alpha$, we see that in the model, this heavily depends on the correlation structure between housing returns and stock returns. Because households in our data set should have different houses in different locations (which means different correlation structures between the housing returns and stock returns they face), it is natural that we cannot capture strong patterns of diversification effects. However, it seems that it implies, on average, high correlation between housing return and stock return based on my model's predictions, so they are negatively estimated. In total, the crowding-out effect on α is heavily affected by individual stock market participation costs and correlation structures between its housing price process and stock return process, and thus it is natural that the effect is not captured in this regression. It would require more detailed data to clearly see the effect on α such as the detailed locations of households.

Most importantly, we see the total crowding-out effect from the regressions on $RFAR$ and $c - RFAR$. The most interesting pattern is that, in the regression for $RFAR$, the crowding-out effect from homeownership (σ_{1Q}) increases as $\frac{W}{Y}$ increases, while the crowding-out effect from jeonse (γ_{1Q}) decreases and becomes insignificant as $\frac{W}{Y}$ increases. In the case of the crowding-out effect from homeownership on $RFAR$, if households have $\frac{W}{Y}$ corresponding to the lowest 20th percentile group of $\frac{W}{Y}$, which is from 0.156 to 1.497 in our sample, the crowding-out effect is -0.96%. On the other hand, if households have $\frac{W}{Y}$ corresponding to the highest 20th percentile group of $\frac{W}{Y}$, which is from 8.51 to 90.923, homeownership is estimated to crowd out the $RFAR$ by -1.55%, which is much larger than the effect on the lowest 20th percentile group. Quantitatively, this is a little different from the model's prediction for this effect for the age of 50 households with high $\frac{X}{Y}$, which was about 4%. I believe that the crowding-out effect for households in the lowest quantile of $\frac{W}{Y}$ is eliminated due to the stock market participation cost, as we saw in Figure 9, while the latter sustained crowding-out effect is as the model predicted due to the house price risk channel. Considering the sample mean of $RFAR$ for renters in the 2010 survey, which is 0.87%, its size is economically significant.

On the other hand, for the crowding-out effect stemming from jeonse , we find that the crowding-out effect for households with $\frac{W}{Y}$ in the 40th to 60th quantiles is estimated to be -0.89%, while that of households with $\frac{W}{Y}$ in the 80th to 100th quantile is estimated as having no significant effect. This is also as predicted by the model. A higher $\frac{W}{Y}$ effectively eliminates the liquidity constraint channel, which causes the crowding-out effect of jeonse to be zero. One interesting feature is that the jeonse crowding-out effect for the lowest $\frac{W}{Y}$ quantile is estimated to be insignificant, as in the case of homeownership. As I elaborated on above, a high stock market participation cost can effectively eliminates much of the crowding-out effect for households with low $\frac{W}{Y}$, since even renters do not participate in stock market. For $c - RFAR$, though we lose all significance due to the small number of observations, we see the same patterns for signs and the sizes of estimates.

Lastly, for stock market participation, we see that homeownership crowds out stock market participation, while jeonse has no significant effect. In Figure 9, we saw that with some level of stock market participation costs, homeowners and jeonse tenants participate in the stock market only with higher $\frac{X_{model}}{Y_{model}}$ compared with renters, due to the low level of financial assets A_{model} in hand. The Regressions seem to also capture those effects.

Table 4 reports results for the specification in equation 15. It shows patterns similar to those we found in specification 1. Both homeownership and jeonse tenure show substantial crowding-out effects on FAR but have less significant effects on $Alpha$ and $c - Alpha$. We also see the increasing crowding-out effect on $RFAR$ and $c - RFAR$ with higher $\frac{W}{Y}$ from homeownership and decreasing crowding-out effects on $RFAR$ and $c - RFAR$ with higher $\frac{W}{Y}$ from jeonse. Lastly, I find that the crowding-out effect on SMP stems not only from homeownership but also from jeonse, which is different from specification 1. Comparing the result with Yao and Zhang (2005) and Cocco (2005), we see similar patterns in general, especially for the stronger significance of the effect on $RFAR$ than that on $Alpha$. Overall, we find evidence of a crowding-out effect of housing among for Korean households, as the literature has shown in other countries. Though the endogeneity concerns could not be fully resolved, the data pattern seems fairly consistent with the structural model's prediction. In particular, the presence of the crowding-out effect of jeonse on FAR, the stronger crowding-out effect of homeownership compared with that of jeonse on FAR, and the increasing pattern of the housing crowding-out effect of homeowners on $RFAR$ with higher $\frac{W}{Y}$ and opposite patterns for jeonse tenants yields better understanding of how each channel of the crowding-out effect works.

	FAR	$Alpha$	$c-Alpha$	$RFAR$	$c-RFAR$	SMP
$Education1$	0.4304***	0.2009	-0.3116	0.0612***	-0.0165	0.3958***
	(3.2779)	(1.5181)	(-0.5214)	(2.7202)	(-0.3420)	(4.0361)
$Education2$	0.4201***	0.2022	-0.3006	0.0596***	-0.0137	0.3941***
	(3.3060)	(1.6013)	(-0.5332)	(2.8075)	(-0.2953)	(4.1978)
$Education3$	0.3984***	0.1750	-0.2646	0.0615***	-0.0060	0.3595***
	(3.2378)	(1.4430)	(-0.5017)	(2.8790)	(-0.1293)	(3.8050)
$Number\ of\ Members$	-0.0230***	-0.0035*	-0.0033	-0.0020***	-0.0042	-0.0066***
	(-6.8950)	(-1.8594)	(-0.5901)	(-3.0063)	(-1.1100)	(-2.7607)
$Log(Age)$	-0.0188	-0.0394	0.0849	-0.0117**	0.0088	-0.0800***
	(-0.5759)	(-1.2116)	(0.6121)	(-2.1243)	(0.7578)	(-3.2991)
$Log(\frac{W}{Y})$	-0.0222***	0.0050***	0.0026	0.0008	0.0017	0.0087***
	(-3.5647)	(3.2060)	(0.4851)	(1.1596)	(0.5428)	(5.0337)
$\frac{HP}{W} \times [\frac{W}{Y}]^Q_1$	0.0111	0.0007	-0.0020	2.659e-05	0.0007	-0.0021**
	(0.8192)	(0.6328)	(-1.0912)	(0.0517)	(0.6870)	(-2.0933)
$\frac{HP}{W} \times [\frac{W}{Y}]^Q_2$	-0.0780***	-0.0011	-0.0106	-0.0015	-0.0041***	-0.0114***
	(-8.7990)	(-0.3175)	(-1.3860)	(-0.7941)	(-3.3328)	(-3.5347)
$\frac{HP}{W} \times [\frac{W}{Y}]^Q_3$	-0.1078***	-0.0086**	-0.0138	-0.0053***	-0.0064***	-0.0217***
	(-11.645)	(-2.4887)	(-1.6341)	(-4.5195)	(-2.6324)	(-6.1812)
$\frac{HP}{W} \times [\frac{W}{Y}]^Q_4$	-0.1308***	-0.0186***	-0.0221***	-0.0071***	-0.0091**	-0.0338***
	(-11.574)	(-4.9443)	(-2.6817)	(-5.6611)	(-2.4979)	(-7.9756)
$\frac{HP}{W} \times [\frac{W}{Y}]^Q_5$	-0.1406***	-0.0163***	-0.0185	-0.0078***	-0.0110*	-0.0349***
	(-7.4822)	(-3.4173)	(-1.5651)	(-4.8216)	(-1.8187)	(-6.3566)
$\frac{JD}{W} \times [\frac{W}{Y}]^Q_1$	0.0135	-0.0003	0.0024	0.0015	0.0033	-0.0022
	(1.0227)	(-0.1716)	(0.5271)	(1.1829)	(0.9680)	(-1.1666)
$\frac{JD}{W} \times [\frac{W}{Y}]^Q_2$	-0.0933***	-0.0033	0.0130	-0.0050***	-0.0065	-0.0084*
	(-5.0732)	(-0.7844)	(0.7186)	(-3.2054)	(-0.8450)	(-1.6516)
$\frac{JD}{W} \times [\frac{W}{Y}]^Q_3$	-0.1132***	-0.0074	-0.0158	-0.0065***	-0.0123	-0.0128*
	(-8.6323)	(-1.3638)	(-1.0341)	(-3.1673)	(-1.2569)	(-1.6947)
$\frac{JD}{W} \times [\frac{W}{Y}]^Q_4$	-0.1187***	-0.0085	0.0041	-0.0058**	-0.0079	-0.0201**
	(-8.3772)	(-0.9658)	(0.1806)	(-2.2915)	(-1.1760)	(-2.2984)
$\frac{JD}{W} \times [\frac{W}{Y}]^Q_5$	-0.1122***	0.0048	0.0299	-0.0051	-0.0110	-0.0146
	(-5.9606)	(0.4257)	(1.0277)	(-1.6076)	(-0.9158)	(-1.3909)
No. Observations	60220	43478	4462	60220	6642	60220
R-squared	0.0649	0.0022	0.0057	0.0044	0.0113	0.0037
P-value (F-stat)	0.0000	0.0000	0.1265	0.0000	0.0000	0.0000
Effects	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE

T-statistics are in the parentheses. Standard errors are clustered in household levels. $[\frac{W}{Y}]^Q_1$ means household's $\frac{W}{Y}$ is between 0-20 percents quantile in overall distributions.

Table 4: Regression Specification 2 - $\frac{W}{Y}$ Cross-section

7.5 The Crowding-out Effect Across *Age*

In this subsection, I examine how the crowding-out effect changes across age groups. While other controls are same, I use the following regression formulas to reveal the pattern of crowding-out effects.

$$PF_{it} = \beta U_{it} + \sum_{Q=1}^{5} \gamma_{1Q} Jeonse_{it}[Age]^Q_{it} + \sum_{Q=1}^{5} \sigma_{1Q} Owner_{it}[Age]^Q_{it} + \epsilon_{it} \tag{16}$$

$$PF_{it} = \beta U_{it} + \sum_{Q=1}^{5} \gamma_{2Q} \frac{JD}{W}_{it}[Age]^Q_{it} + \sum_{Q=1}^{5} \sigma_{2Q} \frac{HP}{W}_{it}[Age]^Q_{it} + \epsilon_{it} \tag{17}$$

$$PF_{it} \in (FAR_{it}, RFAR_{it}, c-RFAR_{it}, SMP_{it}, Alpha_{it}, c-Alpha_{it})$$

Overall, the estimates of control variables are similar, which allows me to directly jump into crowding-out effect estimates across age group. First, regressions on *FAR* show that the crowding-out effect on *FAR* is fairly similar across ages groups for both homeownership and jeonse, which is not as the model predicts; the model predicted that older households are expected to show a lower crowding-out effect on FAR. For $Alpha$, jeonse tenants and homeowners should show higher values than renters based on the model's predictions, which means that positive estimates get bigger for the higher age groups. However, again we cannot find any significant effect on α. This seems coming from the heterogeneous correlation structure likely faced by different households. For $RFAR$, we can see that the crowding-out effects are estimated as decreasing as households get older, which seems to be consistent with the model's predictions for both homeowners and jeonse tenants. In particular, the crowding-out effect of jeonse completely goes away when households get old enough, while the crowding-out effect of homeownership persists even though households get older with decreasing sizes. Similar to the previous regressions, homeownership and jeonse tenure seem to prevent households from participating in the stock market, though it is difficult to find any specific patterns across ages.

	FAR	$Alpha$	$c-Alpha$	$RFAR$	$c-RFAR$	SMP
$Education1$	0.4432***	0.1408	-0.4287	0.0670**	-0.0509	0.3231***
	(2.9588)	(1.0767)	(-0.7426)	(2.5595)	(-0.6904)	(3.2528)
$Education2$	0.4320***	0.1474	-0.4154	0.0665***	-0.0487	0.3277***
	(2.9553)	(1.1840)	(-0.7662)	(2.6630)	(-0.6843)	(3.4457)
$Education3$	0.4212***	0.1204	-0.3801	0.0691***	-0.0404	0.2922***
	(2.9355)	(1.0040)	(-0.7505)	(2.7411)	(-0.5616)	(3.0446)
$Number\ of\ Members$	-0.0133***	-0.0029	-0.0028	-0.0013**	-0.0037	-0.0055**
	(-4.2100)	(-1.5470)	(-0.5344)	(-1.9805)	(-1.0347)	(-2.3045)
$Log(Age)$	0.0121	-0.0245	0.1137	-0.0126*	0.0197	-0.0621**
	(0.3159)	(-0.7651)	(0.8539)	(-1.9444)	(1.0051)	(-2.5281)
$Log(\frac{W}{Y})$	-0.0173***	0.0025*	0.0038	0.0003	0.0016	0.0054***
	(-4.1099)	(1.7420)	(0.7239)	(0.3870)	(0.4773)	(3.5948)
$Owner \times [AGE]_1^Q$	-0.3149***	0.0026	0.0355	-0.0125***	-0.0121	-0.0066
	(-25.078)	(0.3917)	(0.8595)	(-4.2543)	(-1.4094)	(-0.7719)
$Owner \times [AGE]_2^Q$	-0.3108***	-0.0125*	-0.0208	-0.0120***	-0.0213*	-0.0269***
	(-24.003)	(-1.8953)	(-1.0639)	(-3.7498)	(-1.9539)	(-3.4756)
$Owner \times [AGE]_3^Q$	-0.2948***	-0.0228***	-0.0264	-0.0116***	-0.0214	-0.0407***
	(-18.582)	(-3.7023)	(-1.5565)	(-3.7965)	(-1.5322)	(-5.6589)
$Owner \times [AGE]_4^Q$	-0.3069***	-0.0195***	-0.0347*	-0.0105***	-0.0284	-0.0384***
	(-16.055)	(-3.1568)	(-1.9517)	(-3.1843)	(-1.5633)	(-5.4960)
$Owner \times [AGE]_5^Q$	-0.3388***	-0.0004	-0.0131	-0.0062*	-0.0226	-0.0142*
	(-15.431)	(-0.0534)	(-0.6062)	(-1.8795)	(-1.1729)	(-1.9331)
$Jeonse \times [AGE]_1^Q$	-0.2334***	0.0065	0.0853	-0.0059*	-0.0005	0.0096
	(-18.248)	(1.0323)	(1.4716)	(-1.8633)	(-0.0428)	(1.1561)
$Jeonse \times [AGE]_2^Q$	-0.2083***	0.0033	-0.0102	-0.0048*	-0.0053	-0.0013
	(-14.313)	(0.4992)	(-0.4808)	(-1.7708)	(-0.5577)	(-0.1496)
$Jeonse \times [AGE]_3^Q$	-0.1944***	-0.0086	0.0031	-0.0066*	-0.0092	-0.0189**
	(-13.091)	(-1.2396)	(0.2108)	(-1.9258)	(-0.6194)	(-2.1538)
$Jeonse \times [AGE]_4^Q$	-0.1810***	-0.0087	-0.0037	-0.0078	-0.0193	-0.0203**
	(-8.4354)	(-1.1493)	(-0.2227)	(-1.4683)	(-0.8083)	(-1.9876)
$Jeonse \times [AGE]_5^Q$	-0.2013***	0.0098	0.0155	-0.0024	-0.0119	-0.0029
	(-8.8016)	(1.1824)	(0.5587)	(-0.7901)	(-0.7186)	(-0.4514)
No. Observations	60220	43478	4462	60220	6642	60220
R-squared	0.0871	0.0028	0.0086	0.0043	0.0137	0.0036
P-value (F-stat)	0.0000	0.0000	0.0058	0.0000	0.0000	0.0000
Effects	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE

T-statistics are in the parentheses. Standard errors are clustered in household levels. $[Age]_1^Q$ means household's Age is between 0-20 percents quantile in overall distributions.

Table 5: Regression Specification 1 - Age Cross-section

Table 6 also shows similar patterns. Interestingly, some of the crowding-out effects for $Alpha$

and $c - Alpha$ are estimated as positive, which seems consistent with the model. Since the crowding-out effect on FAR gets larger as they get older, households increase their α_a in the model. This specification gives some support for the model's prediction. However, again, the effect on α should be difficult to measure since it depends largely on individual housing characteristics. We can see a decreasing pattern of the crowding-out effect from homeownership on $RFAR$ but no significant effect from jeonse tenure on $RFAR$ among the oldest households. Again, this corroborates my argument regarding the nature of the liquidity constraint channel. In the end, as households get older, they are free from the incomplete-market nature of their life-cycle.

	FAR	$Alpha$	$c - Alpha$	$RFAR$	$c - RFAR$	SMP
$Education1$	0.4632***	0.2121	-0.4356	0.0706***	-0.0578	0.4149***
	(3.2523)	(1.6095)	(-0.7283)	(2.9310)	(-1.0164)	(4.1932)
$Education2$	0.4358***	0.2146*	-0.4245	0.0690***	-0.0542	0.4146***
	(3.1548)	(1.7094)	(-0.7533)	(3.0330)	(-1.0004)	(4.3815)
$Education3$	0.4130***	0.1877	-0.3879	0.0710***	-0.0471	0.3798***
	(3.0708)	(1.5537)	(-0.7352)	(3.0950)	(-0.8720)	(3.9846)
$Number\ of\ Members$	-0.0271***	-0.0034*	-0.0038	-0.0019***	-0.0043	-0.0067***
	(-7.5246)	(-1.7942)	(-0.7149)	(-2.7832)	(-1.1397)	(-2.7856)
$Log(Age)$	-0.0284	-0.0433	0.1141	-0.0146**	0.0179	-0.0866***
	(-0.7981)	(-1.3412)	(0.8256)	(-2.4693)	(1.3092)	(-3.5407)
$Log(\frac{W}{Y})$	-0.0516***	0.0014	0.0012	-0.0009*	-0.0005	0.0020
	(-12.654)	(1.0996)	(0.2945)	(-1.8518)	(-0.2732)	(1.4654)
$\frac{PH}{W} \times [AGE]_1^Q$	-0.0338***	0.0018	0.0146	-0.0020**	0.0067**	-0.0042
	(-4.9659)	(0.6677)	(0.7602)	(-2.2276)	(2.3416)	(-1.3406)
$\frac{PH}{W} \times [AGE]_2^Q$	-0.0131**	-0.0027	-0.0028	-0.0013***	-0.0001	-0.0072***
	(-2.0845)	(-1.5287)	(-1.1315)	(-3.2479)	(-0.2988)	(-3.5249)
$\frac{PH}{W} \times [AGE]_3^Q$	0.0290	-0.0026*	0.0003	-0.0003	0.0015	-0.0055***
	(1.1486)	(-1.6885)	(0.0935)	(-0.7128)	(0.8111)	(-3.2125)
$\frac{PH}{W} \times [AGE]_4^Q$	-0.0146	0.0006	-0.0135	0.0016	-0.0030*	-0.0053*
	(-1.3474)	(0.1466)	(-1.4445)	(0.7758)	(-1.6961)	(-1.9364)
$\frac{PH}{W} \times [AGE]_5^Q$	-0.0737***	0.0113***	-0.0097	0.0019*	-0.0019	0.0063**
	(-6.5479)	(2.6803)	(-0.8122)	(1.6493)	(-1.0963)	(2.3761)
$\frac{JD}{W} \times [AGE]_1^Q$	-0.0162	-0.0015	0.0741	9.658e-05	0.0011	-0.0027
	(-1.3451)	(-0.6139)	(1.1153)	(0.0427)	(0.3560)	(-0.7815)
$\frac{JD}{W} \times [AGE]_2^Q$	0.0192	0.0027	0.0095	0.0017	0.0070	0.0020
	(1.4248)	(0.9871)	(0.4858)	(1.1370)	(1.0747)	(0.5065)
$\frac{JD}{W} \times [AGE]_3^Q$	0.0002	0.0001	0.0146	0.0019	0.0109	-0.0041
	(0.0162)	(0.0287)	(1.1980)	(0.5748)	(0.9040)	(-0.9143)
$\frac{JD}{W} \times [AGE]_4^Q$	0.0619	-3.736e-05	0.0026	3.614e-05	0.0022	-0.0055
	(1.1850)	(-0.0113)	(0.2816)	(0.0185)	(0.2921)	(-1.4856)
$\frac{JD}{W} \times [AGE]_5^Q$	-0.0143	0.0033	-0.0004	0.0004	-0.0002	0.0015
	(-1.4444)	(1.2145)	(-0.2214)	(1.1040)	(-0.4967)	(1.1865)
No. Observations	60220	43478	4462	60220	6642	60220
R-squared	0.0454	0.0013	0.0063	0.0022	0.0095	0.0022
P-value (F-stat)	0.0000	0.0000	0.0722	0.0000	0.0000	0.0000
Effects	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE	HH/Year FE

T-statistics are in the parentheses. Standard errors are clustered in household levels. $[Age]_1^Q$ means household's Age is between 0-20 percents quantile in overall distributions.

Table 6: Regression Specification 2 - Age Cross-section

8 Conclusion

In this study, by using a calibrated life-cycle model with endogenous housing tenure choice and stock market participation, I show how the crowding-out effect from jeonse, which only occurs with the liquidity constraint channel, differs from the crowding-out effect from ownership, which incurs both the liquidity constraint channel and house price risk channel.

The model tells us that the crowding-out effect from jeonse (the liquidity constraint channel) affects only young and low wealth (or liquidity-constrained) households, but does not affect not liquidity-constrained or old households. However, the crowding-out effect coming from the homeownership (the liquidity constraint channel + house price risk channel) affects all types of households, and the crowding-out effect persists even though households accumulate much more wealth. If households get older, the crowding-out effect gets smaller but never goes to zero.

We see that stock market participation cost and the covariance structure between stock return and housing return can nonlinearly affect the size and nature of the crowding-out effect of housing. In particular, these dramatically affect the risky financial asset ratio over financial asset non-linearly. This causes us to expect that in regression, it should be difficult to observe such channels.

Regressions from KLIPS household panel data show that the crowding-out effect of jeonse gets smaller as households have a higher net wealth-to-income ratio, while the crowding-out effect of homeownership does not decrease (or even increase in some cases) even though households have a higher net wealth-to-income ratio. In addition, as households get older, the crowding-out effect from jeonse disappears while the crowding-out effect from homeownership persists, though it decreases quantitatively. This empirical pattern confirms the different natures of the crowding-out effect from the liquidity constraint channel and the house price risk channel, as predicted by the model.

Future work may reveal clearer identification of each channel using other novel instrumental variables and suggest a more accurate quantitative nature of crowding-out effects. More detailed data on a granular level may also more clearly show us the crowding-out effect of the risky financial asset over financial asset ratio.

A Life-Cycle Non-Capital Income Profile

Through following procedure, I calculate the life-cycle labor income profile. First, I use the almost the same sample from KLIPS which I use for fixed effect regressions in the paper. One difference is that I additionally include households who are renters or *Jeonse* tenants and have other real estate assets twice higher than their *Jeonse* deposit or rent deposit. These households were removed from the empirical analysis as they do not represent the renters and *Jeonse* tenants properly, I include them here as I want more information to consistently estimate the life-cycle profile of labor income.

With this sample, I regress the logged non-capital income (Y) on age dummy variables for each year (2009-2019). Then, I averaged out all the estimates across the years. Finally, I regress the averaged estimates on age from 30 to 64 dummy variables on the fifth order age polynomial, while averaging out the estimates on ages after 64 for estimating retirement income. Then, I calculate the fitted values which are represented below in Figure 12.

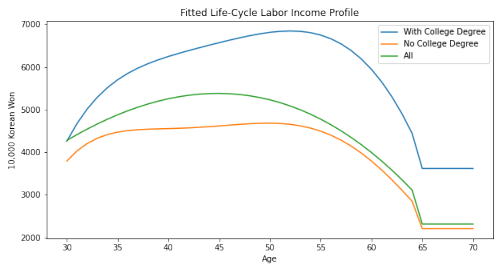


Figure 12: Calibrated Life-Cycle Income

Here, by averaging out, I controlled each year's fixed effect. In addition, I assume that households' individual characteristics are averaged out. With following calibrated labor income profile, I calculate the growth rate $[g_i]_{i=1}^{i=35}$ (log difference), and use them to solve the model in the main paper.

B Calibration for Exogenous Processes

B.1 First Moments

For housing return process and stock return process, I use national stock index and national housing price index from KOSPI and Korea Real Estate Board. I calculate the log of yearly mean return for them, and I calculate the μ, μ_h, σ_ϵ, and σ_h.

B.2 Correlations across Return Processes

To calculate out the correlation between labor income process, stock return process, and housing return process, we need each component's aggregate shocks. For housing return and stock return, following Vestman (2019), I use aggregate indices for both, and calculate the log of yearly mean return. For the labor income process, following Vestman (2019), I calculate the following component.

$$resid1_{it+1} = log(Y_{it+1}) - log(Y_{it}) + g_{it+1} \tag{18}$$

$$AggLab1_t = \frac{\sum_{i=1}^{i=N_I} resid1_{it} * SW_{it}}{\sum_{i=1}^{i=N_I} SW_{it}} \tag{19}$$

Here, $AggLab1$ represent the aggregate shock as idiosyncratic shocks goes away by averaging out for each year. As the second method, similar to that of Cocco (2005), I regress following regression.

$$\begin{aligned} log(Y_{it}) =& \alpha_i + \gamma_t \beta_1 Age + \beta_2 Age^2 + \beta_3 Age^3 + \beta_4 Age^4 + \beta_5 Age^5 \\ &+ \beta_6 Education + \beta_7 NumOfMember + \epsilon_{it} \end{aligned} \tag{20}$$

After that, by calculating the fitted value $log(\hat{Y}_{it})$, I calculate following residuals.

$$resid2_{it+1} = log(Y_{it+1}) - log(Y_{it}) + log(\hat{Y}_{it+1}) - log(\hat{Y}_{it}) \tag{21}$$

$$AggLab2_t = \frac{\sum_{i=1}^{i=N_I} resid2_{it} * SW_{it}}{\sum_{i=1}^{i=N_I} SW_{it}} \tag{22}$$

Then, I calculate the weighted mean according to the survey weight (SW_{it}) for each year. Following Figure 13 is the plot for $AggLab1$, $AggLab2$, $log(R)$, and $log(R^H)$.

It is interesting that $AggLab1$ and $AggLab2$ share very similar trajectories throughout the years. If I calculate the Pearson correlations between these processes, none of them are statistically significant as noted in Table 7.

	AggLab1 & Stock	AggLab1 & Housing	AggLab2 & Stock	AggLab2 & Housing	Stock & Housing
Correlation	0.114546	-0.222892	0.179976	0.021417	0.22599
P-Value	0.752693	0.535934	0.618808	0.953171	0.53013

Table 7: Exogenous Process Correlation Structures

Consequently, I set all the correlations as zero as in Fagereng et al. (2017) and Brandsaas (2018).

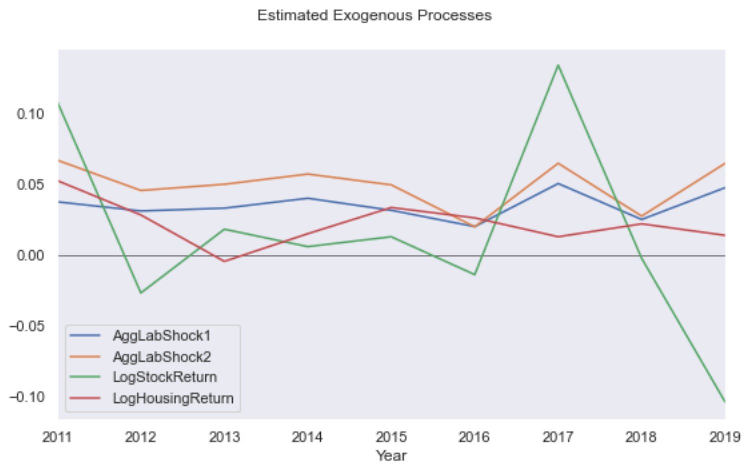


Figure 13: Estimated Exogenous Processes

C Downpayment Constraint for the Normalized Model

According to Korea Real Estate Board, the median price of all types of apartments in 2015 is estimated as 25,194.5, while the median *Jeonse* deposit size of all types of apartments in 2015 is estimated as 17,953.4. [13] On the other hand, median household yearly income with 3 household members after tax is 3507.5. As one period is 2 years in the model, it corresponds to 7,015. With calibrated downpayment ratio for *Jeonse* and purchase in the main paper (0.416, 0.482), we can calculate as following for *Jeonse* tenant.

$$X_a \geq \delta_J \bar{J} P^H \underline{H} \tag{23}$$

$$\frac{X_a}{Y_a} \geq \frac{\delta_J \bar{J} P^H \underline{H}}{Y_a} \tag{24}$$

$$\frac{X_a}{Y_a} \geq 0.416 * 17,953.4/7,015 = 1.064 \tag{25}$$

Also, with the same method, for home purchaser, we calculate following.

$$X_a \geq \delta P^H \underline{H} \tag{26}$$

$$\frac{X_a}{Y_a} \geq \frac{\delta P^H \underline{H}}{Y_a} \tag{27}$$

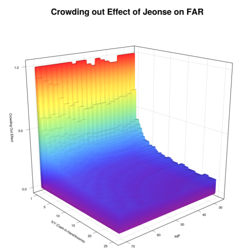
$$\frac{X_a}{Y_a} \geq 0.482 * 25,194.5/7,015 = 1.7304 \tag{28}$$

[13] Here, 1 means 10,000 Korean Won which is $8.52 in 2015 average exchange rate.

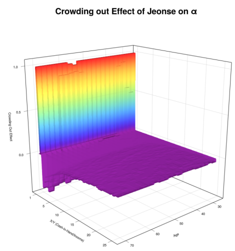
D Crowding Out Effect Graphs

D.1 High Correlation between Stock Return and Housing Return

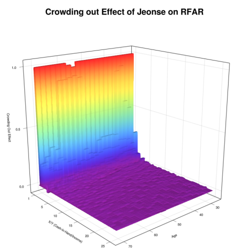
Here I use the baseline calibration with only ρ_{hs} set as 0.3 which is higher than that of original value.



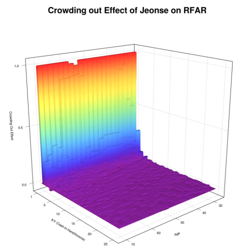
((a)) *Jeonse* on $\frac{A_a}{NW_a}$



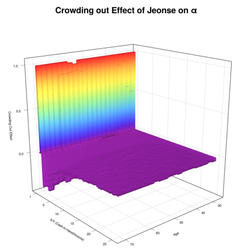
((b)) *Jeonse* on α_a



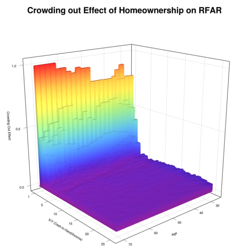
((c)) *Jeonse* on $\frac{\alpha_a A_a}{NW_a}$



((d)) Homeowner on $\frac{A_a}{NW_a}$



((e)) Homeowner on α_a



((f)) Homeowner on $\frac{\alpha_a A_a}{NW_a}$

Figure 14: Crowding out Effect With $\rho_{hs} = 0.3$

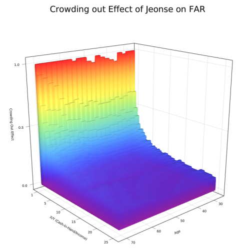
D.2 High Stock Market Pariticpation Costs

Here I use the baseline calibration with only γ set as 0.05 which is higher than that of original value.

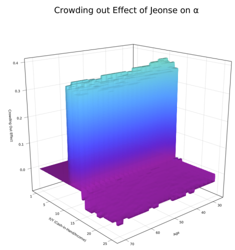
E Additional Empirical Analysis

E.1 Data Source

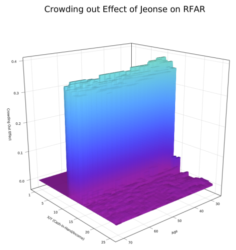
In this appendix, I use another well-known household panel data called as Survey of Household Finances and Living Conditions (SHFLC hereafter) from South Korea, an annual panel survey starting from 2012 to 2019. This panel survey tracks about 20,000 households which represent the entire Korean population. In this survey, a household is defined as an economic units where people live together and are financially connected. It has a detailed data on non-durable goods expenditures, housing expenditures, income, wealth, debt, asset allocation, human capital, and household characteristics.



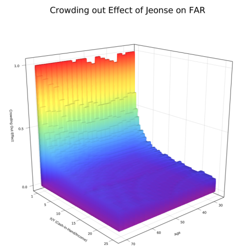
((a)) *Jeonse* on $\frac{A_a}{NW_a}$



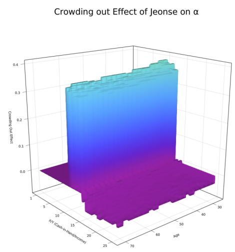
((b)) *Jeonse* on α_a



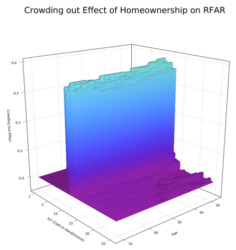
((c)) *Jeonse* on $\frac{\alpha_a A_a}{NW_a}$



((d)) Homeowner on $\frac{A_a}{NW_a}$



((e)) Homeowner on α_a



((f)) Homeowner on $\frac{\alpha_a A_a}{NW_a}$

Figure 15: Crowding out Effect With $\gamma = 0.05$

E.2 Definitions

Before I proceed, I define some variables. *Disposable Income* means all the regular income that households expect for a year other than capital income, and *Capital Income* is about the capital gain from stock investment or house price increase. So *Non-capital Income* (Y) is defined as *Disposable Income* minus *Capital Income*. Then, *Cash-in-Hand* (X) is defined as sum of net wealth (W) and Y. X/Y refers the ratio between two, and it is a data counterpart of important state variable of the structural model developed in this paper. As the most important variable of interest, I define Stock over Net worth (SW) as the sum of risky financial asset (αA) over net wealth (W). This will be a variable for measuring the crowding out effect.

$$\begin{aligned}
Y &= Disposable\ Income - Capital\ Income \\
X &= NetWealth + Y \\
X/Y &= X/Y \\
SW &= \frac{Stock + Future + Bond + Option + Mutual\ Fund}{Net\ Wealth}
\end{aligned}$$

E.3 Sample Selection

Throughout this section, I use a selected sample by several criterion rather than using the whole data set. First, I remove bottom 3% and top 3% in terms of X/Y to remove abnormal observations such as huge negative net wealth. Additionally, I use observations of renters and

Jeonse renters who do not own any other housing assets. It is common in South Korea that some people live in rented house or *Jeonse* rented house though they have their own houses for various job-related or investment-related reasons. If I also include those observations of renters or *Jeonse* renters who have their own houses, that would be misleading. So I exclude data of households whose housing tenure types are "rent" or "*Jeonse*" but have other housing asset worth more than rent deposit or *Jeonse* deposit. Lastly, I use observations of households who are older than 30. Due to Korean specific law, a person becomes independent household either if he/she get married or become older than 30. Under this condition, if I use data of households younger than 20, that will be selected sample, which do not represent the true data pattern of people of age 20.

E.4 Descriptive Statistics

Table 8 summarizes the survey-weighted sample averages of important variables of each housing tenure group in 2015. We can see that, while ownership accounts for the most share of housing tenure, *Jeonse* also accounts for 12.6 % which is economically significant. We can clearly see the increasing pattern of X/Y, *Net Wealth*, *Assets*, and *Disposable Income* as we move from Rent to *Jeonse* and to Ownership. Importantly, while stock market participation rate of owners is the highest, the conditional risky asset share of renter (average SW of stock market participants) is the highest.

	Total	**Renter**	**Jeonse**	**Owner**
Ratio	1.000	0.154	0.126	0.597
Age	52.77	50.26	47.61	54.33
X/Y	8.675	2.951	6.391	10.916
Net Wealth	26169.00	4957.26	15856.46	34405.06
Financial Asset	8664.99	4871.96	15643.17	7650.85
Risky Financial Asset	667.64	158.40	605.60	794.94
Other Real Asset	10812.01	1160.13	2828.34	12992.45
Rent Deposit	-	2398.155	0.00	0.00
Jeonse Deposit	-	0.00	10722.633	0.00
House Living	-	0.00	0.00	20834.604
Disposable Income	4164.35	2850.04	3716.41	4685.44
Stock Market Participation	0.180	0.064	0.169	0.213
SW	0.006	0.012	0.018	0.012
Conditional SW	0.034	0.185	0.108	0.060

Table 8: Descriptive Statistics

E.5 Life-Cycle Pattern

In this subsection, I show the life-cycle pattern of X/Y, X, Y, housing asset over net wealth ratio, housing tenure, stock market participation rate, SW, and SW conditional on participation across age groups and housing tenures. These are all important variables affecting aggregate stock investment. For these moments, I simply calculated average reflecting the sampling weights. As mentioned in Ameriks and Zeldes (2004), controlling cohort effect and year effect is important to capture the pure age effect which is of interest. I ran pooled regressions to control the cohort effects and year effects by cohort-dummy variable and each year's macroeconomic variables such as GDP growth rate, house price growth rate, unemployment rate and stock market return. However, though some of them are statistically significant, they are not economically significant and estimates are similar to weighted sample mean. In addition, age profiles were not statistically significant for renters. Consequently, here I just present the weighted average of variables of interest.

E.5.1 X,Y, and X/Y over Life-Cycle

Some of the most important variables in the model are Y, X, and the ratio X/Y. Figure 16 shows the average of X, Y, and X/Y by age and housing tenure status. This figure is an average conditional on age and housing tenure. These are not showing causality, rather it is an equilibrium outcome from households' endogenous choices. For X, we can see that concave life-cycle wealth profile which can be observed from other countries' data. As they get closer to the middle ages (50-55), they accumulate the wealth, and it decreases later, as households use their accumulated wealth. We can see the similar pattern for non-capital income Y. Interestingly, we can see that the homeowners usually accumulate the multiple times of the wealth while the renters keep having only 2-3 times of their yearly income as a net wealth. For homeowners, this should be driven by bequest motives or uncertainty about their timing of death.

Figure 16: Net Wealth and Non-Capital Income

E.5.2 Housing Expenditure and Housing Tenure by Age

This section is about households' decisions regarding housing. In Figure 17, left plot shows the housing asset over net wealth ratio. Housing asset is defined as rent deposit for renters, *Jeonse* deposit for *Jeonse* renters, and as the value of house of living for homeowners. For housing asset ratio, we can see that it is really high when they are young while as they get older it decreases, which reflects the fact that households pay back the debt and accumulate other types of asset as they get older. On the other hand, the ratio of *Jeonse* deposit increases as we move to older age groups, which implies that *Jeonse* deposit is one of the most important asset to some of old households. Right plot shows how the housing tenure distribution evolves as time goes. When the households are young, half of households use rent or *Jeonse* contract, while, as they get older, they are more likely to be homeowners. This should be driven by the liquidity constraint that households experience when they are young.

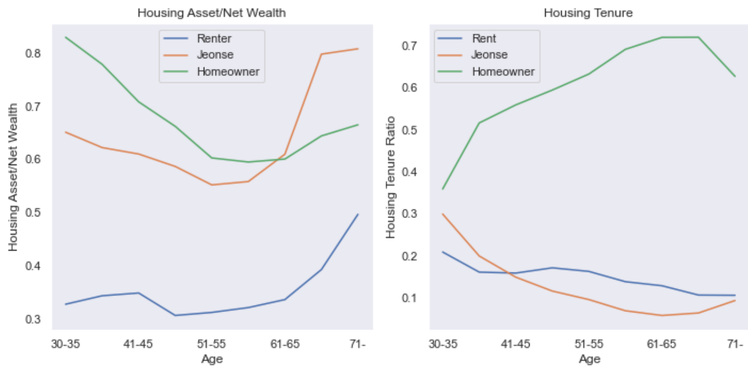


Figure 17: Housing Asset and Housing Tenure Choice

E.5.3 Stock Market Participation Rate and Share of Equity by Age

The last and most important data patterns are stock market participation rate and ratio of risky financial asset *SW*. We can see that homeowners and *Jeonse* renters participate in stock market more than renters. As pointed out in Vestman (2019), this should be driven by the fact that renters have lower assets or they are different in the sense that they have more present oriented preference or higher stock market participation costs compared to the homeowners. In the second graph, we can show that though the renters show the lower stock market participation rate, they show similar aggregate average of *SW* with *Jeonse* renter or homeowners, which reflects that, conditional on participation, renters invest much more share of their wealth than *Jeonse* renter or homeowners. These endogenous movement will be captured by model developed later.

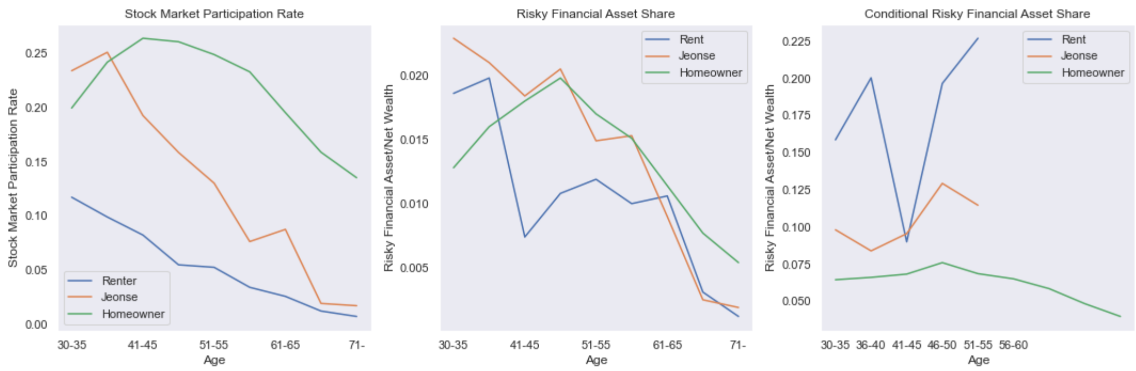


Figure 18: Stock Market Participation Rate and Risky Asset Ratio

E.6 Effect of Transition

Lastly, by exploiting the panel dimension, I document how X, X/Y, stock market participation, and SW change when households transition from one tenure type to another tenure type. Table 9 shows how many households transitioned in data for each possible housing tenure transition. I again calculated weighted averages of these households' corresponding variables. I define 1) rent to *Jeonse* transition, 2) rent to ownership transition, and 3) *Jeonse* to ownership transition as upward transition. As it is common that households transition from rent to *Jeonse* and *Jeonse* to ownership as they get richer, this transition is more likely to be accompanied by positive wealth shock. Below figures are depicting how households' X, X/Y, stock market participation, and SW change as they transition.

	Rent to *Jeonse*	Rent to Ownership	*Jeonse* to Ownership
Upward Transition	765 (0.9%)	516 (0.6%)	977 (1.1%)
	Ownership to *Jeonse*	Ownership to Rent	*Jeonse* to Rent
Downward Transitionax	450 (0.5%)	291 (0.3%)	1085 (1.3%)

Table 9: Transitioning Households

As we conjectured, most of the upward-transitioning households experience the positive wealth shock, which is shown by the increase not only in X but also in X/Y. Interesting patterns appear for Figure 19 (b). Even though they experience the positive wealth shock, they invest less in risky asset in ratio, and some of the households transitioning from *Jeonse* to ownership even exit the stock market. Surely, this does not show the causal effect of housing tenure transition, and housing purchase. However, as this transition usually happen with positive wealth shock which usually incentivizes households to participate in stock market or invest more in stock holdings, I argue that this shows the minimum of the crowding out ef-

((a)) X and X/Y ((b)) Stock Market Participation and SW

Figure 19: Upwardly Transitioning Households

fect. Importantly, we can see the decreasing pattern of SW for households transitioning from rent to *Jeonse* who is likely to experience only liquidity constraint shocks, and these size of decreases are larger for households who are transitioning to ownership, which is presumably experiencing the crowding out effect coming from both of the liquidity constraint and house price risk channel.

Next, I document the data pattern of households transitioning downward. I define 1) ownership to rent, 2) ownership to *Jeonse*, and 3) *Jeonse* to rent as downward transition. Being opposite to the upward transition cases, downward transitioning households experience negative wealth shock or at least their labor income becomes more important compared to their wealth accumulated. This should incentivize the households to have less risky portfolio.

((a)) X and X/Y ((b)) Stock Market Participation and SW

Figure 20: Downwardly Transitioning Households

However, we can see that the stock market participation after the transition increase in all transition cases, and SW also increases except the case of the transition from *Jeonse* to renter case which might be the case where negative wealth shock effect dominates the crowding out effect as described in Figure 20.

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