The Effect of House Price Risk on Homeowners' Portfolio Choice

Stockholm School of Economics

Master's Thesis in Finance

Yuhuang Sun*

Spring 2020

Abstract

Using the 2017 wave of China Household Finance Survey (CHFS), this paper studies how house price risk affects homeowners' stock market participation and share of liquid financial wealth invested in stocks conditional on not moving. Exploiting the subsample of homeowners whose tenure choices are exogenous due to the institutional changes during the Chinese housing market privatization, this study finds that the correlation between housing return and stock return has a crowding-out effect on both stock market participation and stock shares among participants. However, the general volatility of housing return has no significant effect on homeowners' portfolio choices. This paper also reconciles conflicting findings in previous studies. The effect of increased home equity on homeowners' stock share decisions is found to be insignificant among participants, and education attainment has no significant effect on stock share decisions among participants after risk aversion is explicitly controlled for.

Acknowledgements: I would like to thank Professor Paolo Sodini at Stockholm School of Economics for his valuable input, guidance, and support through this thesis writing process. I would also like to thank Southeastern University of Finance and Economics for granting me access to the valuable data of the CHFS.

*E-mail: 41480@student.hhs.se

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1 Introduction

Housing is the dominant asset on the balance sheet for most households, but the effects of house price risk on households' financial risk-taking decisions remain unclear. Some models predict that house price risk can crowd out households' demand for risky assets due to house price fluctuations and bad hedge against background risk (Cocco, 2005; Yao & Zhang, 2005). Some find that house price risk has limited impact on the demand for risky assets as homeowners do not face this risk until the time to move (Sinai & Souleles, 2005; Chetty, Sándor, & Szeidl, 2017)

Using the 2017 wave of China Household Finance Survey (CHFS), this paper investigates empirically the effect of house price risk on homeowners' portfolio choice. The effects of house price risk on household financial risk-taking are decomposed in this study into extensive margin risky financial asset market participation decision (whether to invest in risky financial assets) and intensive margin portfolio allocation decision (proportion of liquid financial wealth invested in risky financial assets conditional on participation)[1]. Following previous research, house price risk is measured with two variables in this paper: the general volatility of housing return and the correlation between housing return and stock return.

The study begins with the whole sample of urban homeowners who have no plan to move at the time of survey (i.e. year 2017). The sample consists of 17,761 households in the cross-sectional data from the 2017 wave of CHFS. It is found that the correlation between housing return and stock return has a crowding-out effect along both margins. However, contrary to theoretical implications, the general housing return volatility is found to encourage homeowners to participate in risky financial asset market, while its effect on risky shares conditional on participation is not significantly different from zero. These results are similar after clustering on the city level.

The results imply two potential concerns that could bias estimates in the first research

[1]The terms "stock market" and "risky financial asset market" are used interchangeably in this study, as national stock market return is used to proxy for the characteristics of households' holding of risky financial assets.

design. Firstly, for homeowners, both financial portfolio and housing are endogenous choices that can be affected by unobserved factors such as future labor income and preferences (e.g. Cocco, 2005; Vestman, 2019), one cannot identify the causal effect of housing on financial portfolio using cross-sectional variation across households. Secondly, location fixed effects are not explicitly controlled in this cross-sectional study, as house price risk variables are constructed at the province level, adding location fixed effects would eliminate the variation in these risk variables.

To address the first concern of endogenous housing choice, this study exploits the regulatory discontinuities during the housing privatization reform in China. By studying the subsample of homeowners whose housing choice (e.g. timing and location) were beyond family control and thus can be reasonably viewed as exogenous, it is found that the effect from the correlation between housing return and stock market return stays similar on both extensive and intensive margin. The coefficient on the general housing return volatility decreases approximately by half and becomes insignificant but remains positive. This indicates the bias in the estimates is alleviated as household-level confounding factors (e.g. future labor income) in the error terms are not correlated with variables of interest. However, city- or province-level omitted variables can still introduce bias in the estimation as differences across geographical markets can be correlated with both dependent variables (i.e. financial risk-taking decisions) and independent variables of interest (e.g. general volatility of housing return), potentially generating a spurious correlation.

To address the second concern of an omitted location effect variable, this study constructs a regional dummy variable based on the average labor income level in each province. After the inclusion of the regional dummy, the coefficient of general housing return volatility on participation is further reduced, and the estimates of the correlation between housing return and stock return remain similar. The estimates are robust after households' real exposure to house price risk (i.e. interaction with housing wealth), different definitions of regional effect, and the correlation between housing return and labor income growth are taken into account.

Although the interpretation of the coefficient on the regional dummy remains unclear, which can be mixed effects from, for example, regional disparities and future labor income, the finding that the estimates of house price risk are robust across different identifications shows that the outcome is probably not driven by confounders. Using the subsample with exogenous tenure choice, one standard deviation increase in the correlation between housing return and stock return on average reduces the propensity of homeowners to participate in the stock market by 5.47% and reduces their risky share by 2.1% conditional on participation.

This empirical study complements the comparative research of international household finance and contributes to the literature along several dimensions. Firstly, using the subsample of homeowners with exogenous tenure choice, most of the estimated effects are consistent with the previous studies, supporting that these microeconomic factors hold true broadly across different markets instead of specific to the countries with similar characteristics. Secondly, this study reconciles some controversial findings in previous cross-sectional studies and provides new evidence based on the natural experiment provided by the institutional changes. Especially, using the subsample of homeowners with exogenous tenure choice, residential real estate value is found to have no positive effect on participants' risky share decisions in absence of moving, consistent with the findings by Calvet and Sodini (2014) and Chetty et al. (2017). Further, consistent with Calvet and Sodini (2014), educational attainment is found to have no significant impact on risky share decisions among participants after risk aversion is explicitly controlled for.

Regulatory discontinuities in the Chinese housing market provide a natural experiment to facilitate identification in this study and allow more precise measurement of the effects from house price risk. The estimates of the effect of house price risk on homeowners' portfolio decisions are more robust than previous estimates. Using the second wave of the Eurosystem Household Finance and Consumption Survey (HFCS), Aliyev (2019) finds that the correlation between housing return and stock return encourages stock market participation but crowds out investments in risky assets conditional on participating, an outcome potentially coming from the endogeneity of housing choice.

The link between house price risk and homeowners' portfolio decisions documented in this study has implications for practical issues. For example, from the prescriptions of finance theory, house price risk will not realize until it is time to move. The crowding-out effect from house price risk on homeowners' financial risk-taking implies that households may own suboptimal portfolios. As governments across the world have gradually transferred more portfolio construction responsibilities to individuals (e.g. pension savings), it is important to encourage households to consider their risk profiles since welfare losses can otherwise be large.

The reminder of the paper is organized as follows. Section 2 reviews literature of the main theoretical and empirical findings in the line of research. Section 3 describes the data used in the study and the construction of variables. Section 4 presents the empirical results and robustness check. Section 5 discusses limitations in this study. Section 6 concludes.

2 Literature Review and Hypotheses

Markowitz (1952) shows in a single-period model how an investor should optimally construct a portfolio when he only cares about mean and variance of financial returns. However, households with a long horizon care about living standards, which are supported by the portfolio composition rather than financial returns standalone. Therefore, the effect of housing, a dominant asset on households' balance sheets, and its interaction with financial assets become important in addition to the risk-return trade-off of financial assets and the general risk preferences of households.

In Section 2.1, I review the literature of house price risk on household financial risk-taking decisions and present the hypotheses. In Section 2.2, I review the literature of non-housing factors whose effects are found to be controversial in previous research and are also explored in this study.

2.1 House Price Risk

In conventional wisdom, investment in housing is quite risky, as it exposes households to fluctuations in house prices and the correlation with stock market makes it a bad hedge, thus crowding out investments in financial markets among homeowners.

Cocco (2005) studies how housing investment, especially house price risk, affects the composition of a homeowner's portfolio using simulation. Using the Panel Study of Income Dynamics (PSID) data from 1970 to 1992, the author finds that housing investment plays an important role in explaining the observed low level of stock market participation and stockholding in the data, due to house price risk and the illiquid nature of housing investment. The author finds that annual housing return volatility is 6.2% in the data, and it has a crowding-out effect on both market participation and stockholding conditional on participation, and this effect is larger among low financial net-worth investors.

By incorporating the rental market, Yao and Zhang (2005) study the tenure choice of

renting versus owning in the life-cycle model and analyze how households' investment decisions interact with their housing choices facing stochastic labor income and substantial housing risks. The authors find that when households are indifferent between owning and renting, owners and renters choose substantially different portfolios. Homeowners have a lower equity proportion in their net worth (sum of bonds, stocks, and home equity), reflecting the substitution effect of home equity for risky assets. Meanwhile, homeowners hold a higher equity proportion in their liquid financial portfolio (sum of bonds and stocks), reflecting the diversification effect provided by home equity as a buffer to labor income risk and stock market risk.

Another finding of Yao and Zhang (2005) is that increasing the correlation between housing return and risky asset return makes homeowners decrease their risky shares and makes the renters increase risky shares. This reflects a hedging motive, as homeowners are effectively long in housing assets while renters have a short position.

Different from previous studies, Sinai and Souleles (2005) argue that homeownership is not as risky as in the conventional view given that everyone is in effect born "short" of housing and has to live somewhere. Households who do not own a home have to obtain housing service from the spot market and are thus subjected to fluctuations in rent. By contrast, homeownership provides a hedge against rent fluctuations while in turn introduces asset price risk.

Although volatile housing prices can have a large impact on households' balance sheets, the housing asset risk will not materialize until the time households need to sell their houses (e.g. when they move or die). Household can still face house price risk when the hedge provided by homeownership is longer than households' expected length of stay (horizon). However, this asset price risk is further mitigated when the horizon is longer, the spatial correlations in house prices across markets are higher, or the autocorrelation of housing sale prices is greater.

The view is further supported by the finding of Chetty et al. (2017), who separate the effects of mortgage and home equity on households' stock share decisions. Using a portfolio choice model that incorporates both the illiquidity and house price risk, they find that when the house is never sold, house price risk does not affect households' stock share decisions. Their finding is robust when labor income risk and the correlation between labor income and housing

prices are taken into account. They conclude that the result is an indication that house price risk itself has small effects in absence of moving. Even in the event of moving, households can sell their current home and use the money for future housing purchase, so it provides a natural hedge against house price risk when the house price correlation between current place and future place is positively correlated.

Different from angles analyzed above, Kuchler and Zafar (2019) study how house price volatility affects household investment behavior through an individual expectation formation mechanism. Using a sample of 1,200 U.S. household heads from the Survey of Consumer Expectations (SCE) since 2012, the authors study how individuals form expectations about aggregate economic outcomes. They find that past house prices experienced locally play a crucial role in individuals' expectation formation about future national house prices, and that more recently experienced house prices have a substantially larger impact than earlier ones. The authors also find that respondents who have experienced more volatile local house prices report a wider distribution of the expectation about future national house price changes (i.e. second moment of house prices).

Among the individual characteristics that can affect the extent of extrapolation, they find that less sophisticated respondents (household heads with low numeracy skills or without a college degree) extrapolate more from locally experienced house price changes than more sophisticated respondents. Furthermore, the authors do not find any significant effect of locally experienced house price movements on expectations about other aggregate outcomes, such as stock prices and interest rates. This implies that individuals rely on their personal experiences in one domain when forming expectation about that particular domain, but not when forming expectations about other domains (i.e. domain-specific).

Hypothesis 1: House price risk (i.e. housing return volatility, the correlation between housing return and stock return) has no significant effect on homeowners' stock market participation decisions when homeowners have no plan to move.

Hypothesis 2: House price risk has no significant effect on homeowners' stock share decisions conditional on participation when homeowners have no plan to move.

2.2 Other Factors

Home equity

Previous research estimates the effect of home equity on household stock shares with various control variables and obtains mixed results. On the one hand, appreciation in housing value can encourage household financial risk-taking through "wealth effect" (Fougère & Poulhes, 2012) and hedging benefit (Sinai & Souleles, 2005). On the other hand, concentrated wealth in the housing asset (e.g. house-to-net worth ratio) exposes homeowners to large house price fluctuation and liquidity risk (e.g. Cocco, 2005; Yamashita, 2003), thus crowding out homeowners' demand for risky financial assets.

However, as housing choice is endogenous, household, with higher future labor income (i.e. human capital) can essentially select themselves into larger properties and benefit more from rising house prices, and these unobserved factors can contribute to higher stockholding as well. To draw causal effect of home equity on household stockholding, exogenous variation in home equity is required.

Using high-quality panel data of Swedish twins, Calvet and Sodini (2014) study the financial wealth elasticity of risky share with various explanatory variables. The twin dataset naturally controls for time, cohort, and age effects together with latent upbringing characteristics, which is difficult in empirical analysis of portfolio choice over the life cycle. The authors are able to estimate directly the labor income process which requires strong additional assumptions in previous studies. With the subsample of identical twins, the authors find that residential real estate wealth has no significant impact on risky share, as the housing represents both a speculative investment and a hedge against future rent costs, which can be large for households with long horizons.

Similar results are found by Chetty et al. (2017). To generate exogenous variation in home equity, the authors use national house prices interacted with the local housing supply elasticity,

which accounts for potential omitted variable bias from local economic shocks. They find that an increase in home equity, holding the mortgage amount fixed, does not have a significant effect on household risky share, as the wealth effect from increased home equity is canceled out by the effect of having a more expensive house, which implies a higher liability for future housing services (Sinai & Souleles, 2005).

Education

In previous cross-sectional studies, education is found to have a significant positive effect on household financial risk-taking decisions, given that risk aversion is often not controlled for due to the availability of data. Using the 1995 Bank of Italy Survey of Household Income and Wealth, Guiso and Paiella (2004) construct a direct measure of individual absolute risk aversion based on the maximum price she is willing to pay for a risky asset. The authors find that risk aversion plays a crucial role in individual behavior, and it has a direct impact on both portfolio choice and education choice. More precisely, risk-tolerant individuals generally invest more in education (i.e. more years of education) and also invest more in the risky asset market than risk-averse individuals. It indicates that education may capture the impact from risk aversion when the latter is not observable in cross-sectional studies. Using Swedish twin data, Calvet and Sodini (2014) find that education attainment does not have a significant effect on risky share decisions among participants controlling for yearly twin pair fixed effects, which capture potential impact from latent heterogeneity, such as risk aversion.

3 Data and Methodology

In this part, I discuss the datasets used in the study in Section 3.1, definitions and construction of required variables in Section 3.2, and present the sample selection criteria together with descriptive summary statistics in Section 3.3.

3.1 Sources of Data

The data used in this study consist of two parts. The household data is provided by the CHFS, a Chinese household finance survey conducted by Southeastern University of Finance and Economics (Gan et al., 2014). Time series data related to the housing market, the stock market, and the labor market are used to measure the house price risk that households are facing when making financial decisions.

3.1.1 Household Data

This study is based on the CHFS, which is modelled on the Federal Reserve's Survey of Consumer Finances (SCF) in the U.S. The survey has been conducted every two years from 2011 to 2017. The 2017 wave of the CHFS covers 29 provinces and 172 cities in China, with a refusal rate of approximately 12%, which is relatively low compared to the SCF (Chen & Ji, 2016)[2]. The survey is conducted on the household level, with a part of the questions designed for each individual within the household. It covers 4,752 (16,148), 16,836 (56,140), 26,824 (88,144), and 40,011(127,012) households (individuals) in year 2011, 2013, 2015, and 2017 respectively. The survey tracks the households interviewed in previous waves and expands to include more observations in following waves, and it uses the method of three stages Probability Proportionate to Size Sampling to ensure national representative longitudinal data of Chinese households (Zhao & Li, 2017).

Each household and individual are uniquely identified, and household head has been identified for each family in the dataset. The CHFS provides rich data on households' demographic

[2]Tibet, Xinjiang, Hong Kong, Taiwan, and Macau are not included.

characteristics, assets and liabilities, income and other. The currency used in the survey is Chinese Yuan. To facilitate international comparison, all financial quantities are converted into U.S. dollars in the summary statistics, with an average exchange rate of 6.51 Chinese Yuan per U.S. dollar at the end of 2017. This fixed conversion rate is used throughout this paper.

3.1.2 Time Series Data

To assess household risk profile, annual time series data of labor income, house prices, stock market returns, risk-free rates, and inflation rates are used. Labor income, house prices, and risk-free rates are from the National Bureau of Statistics of China (NBSC), and stock market returns and inflation rates data are from Thomson Reuters DataStream.

Labor income data is collected annually on province level from year 2006 to 2018 for each employment sector. The NBSC classifies the employment sectors into 19 categories, and the classification is in line with that in the CHFS, except for the sector International Organization, which covers zero household head in the 2017 wave. As a result, there are 551 province-sector pairs (i.e. 19 sectors in each of the 29 provinces) in the analysis. The description of employment sectors is provided in Table 11 in Appendix.

House price data are collected annually on the province level ranging from the year 2000 to 2018. This is the longest time period available, as China started to have a commercial and privatized housing market from 1998. Before 1994, the start of housing privatization reform, approximate 40 percent of urban households in China resided in state-owned housing (Wang, 2012), and they were provided with the opportunity to buy their current residence from their state employers at a subsidized price during the reform. The reform ended in 1998, and China started to have a commercialized housing market, and commercial banks started to offer mortgage services for private housing purchase.

Following Bonaparte, Korniotis, and Kumar (2014), the national stock market (i.e. the Shanghai Stock Exchange) return is used to proxy for households' financial portfolio performance, since the real value is not observable. In this study, the annual total return, including

dividends, of the Shanghai Stock Exchange All Share Index is used, since it is compatible with the most recent data. The risk-free rate is defined in this study as the period average of returns on three-month treasury bills. It is used in the computation of stock market excess return.

3.2 Construction of Variables

Financial theory suggests that investment decisions should be studied at the family level. This paper is based on the household level following previous studies, while some individual-specific characteristics of interest (e.g. gender, education, and age) are based on the information of the household head, which is uniquely identified for every household in the CHFS. According to the definition in the survey, household head refers to the person who is the main financial source or who makes critical decisions for family affairs. Section 3.2.1 describes the set of variables constructed from individual-level information. Section 3.2.2 describes the set of variables constructed from household-level information. Section 3.2.3 describes the set of variables that are not directly observable in the data and are estimated accordingly. Names in parentheses are abbreviations for related variables, and the summary of definitions is provided in Appendix Table 10.

3.2.1 First Category of Variables

Demographic Characteristics

The age variable (age) is the age of household head at the time of survey (i.e. 2017), and it is divided into 10 brackets. The gender dummy (gender) is equal to one if household head is male and zero otherwise. The education attainment (edu) variable ranges from 1 to 9 from lowest to highest education participated by household head[3]. The married status dummy variable (marry) is equal to one if the household head is married and zero otherwise. The rural dummy (rural) is equal to one if the household resides in a rural area at the time of the survey in 2017

and zero if the household resides in an urban area.

Household composition and habit

Family size (famsize) is constructed to control for family composition, and it is the total number of individuals in each household at the time of the survey, including newly born kids.

In some previous studies, household composition is used as a proxy for habit, while in the 2017 CHFS, households' monthly or yearly consumption of different categories is provided so that households' subsistence consumption level can be directly controlled for. I construct a habit variable (habit), which is the total amount of household monthly consumption of different items, including transportation, food, healthcare etc.

Employment status and labor income

In the 2017 CHFS, when an individual is employed, his or her labor income is recorded as well as the employment sector. The individual labor income is the total amount of regular salary, overtime payments, bonuses etc. Total family labor income (faminc) is the sum of labor income across all household members.

The entrepreneur dummy variable (entred) is equal to one if any member of the household is self-employed or owns a business. The unemployment dummy (unempd) takes value of one if the household head is unemployed, excluding those who are on temporary leave and those who are retired. The retirement dummy variable (retired) is equal to one if the household head is retired and 0 otherwise.

Other assets

The pension asset variable is the sum of self-reported balance in individual social pension account and supplementary pension account, if any. Commercial pension insurance is not

[3]The common definition of education used in household study is the highest level of education attained by household head, while the education information provided in the 2017 wave of CHFS is the highest level of education that household head has participated. It includes the situations that the household head is still studying for the degree or dropped out of the degree.

included in this item. The whole life insurance asset variable is the insured value of individual commercial life insurance. Both pension asset and whole life insurance asset are summed over members in each household for further analysis, and they are only for summary purposes.

3.2.2 Second Category of Variables

Housing-related variables

In the 2017 CHFS, households are asked about detailed information for up to six houses they own at the time of survey as well as the information about any land or store held by the family.

I define households who own their primary residence (i.e. the house they are living in at the time of survey) as homeowners. For homeowners, the homeownership dummy (ownd) is equal to one. In this study, households' primary and secondary residence (if any) are treated as residential real estate. Correspondingly, the outstanding mortgage related to the first two houses are treated as residential mortgage. According to Chetty et al. (2017), it is important to separate effects from home equity and mortgage when analyzing the impact of housing on household financial decision. However, in the 2017 CHFS, only 8% of urban homeowners have outstanding mortgage, a relatively low proportion compared with 75% of homeowners in the Survey of Income and Program Participation (SIPP) data of American households used in Chetty et al. (2017). To avoid potential collinearity problem, home equity (homeeq), which is the difference between self-reported market value of residential real estate and outstanding residential mortgage, is used in the analysis. The potential effect from mortgage is considered together with other forms of debt in the regressor leverage ratio described later.

Commercial real estate value is the total market value of all remaining real estate (e.g. rental, industrial, and agricultural property), held by the household, excluding those classified as residential real estate, and the related mortgage is defined as commercial real estate mortgage, whose impact will be considered with leverage ratio described in the next section. Commercial real estate equity (comrehe) is the difference between the commercial real estate value and the commercial real estate mortgage.

Among all the homeowners, some have plan to purchase a new house at the time of survey. These homeowners are identified with the purchase plan dummy (purd) as they have foreseeable different sources of risk compared with homeowners without a purchase plan.

Non-housing assets

Following previous studies, risk-free wealth is the total value of cash, current account, time deposit, government bonds, gold and money market funds. Risky wealth is the total market value of stockholdings, corporate bonds, derivatives and funds, excluding those invested in the money market. Financial wealth (fa) is the total value of risk-free wealth, risky wealth, private loans owed to the household, pension assets, whole life insurance, value of additional assets in managed accounts, and any other financial assets.

Other valuables (othval) is the total value of cars, other vehicles, and valuables, such as antiques, jewelry, etc. The private equity (pe) variable is defined as the net asset value of households' share in non-publicly listed firms. Businesses that any member of the household is self-employed in or taking an active role in managing are included.

Total wealth is the sum of household financial wealth, residential real estate, commercial real estate, other valuables, agricultural assets, and private equity. Total debt is the sum of mortgages related to residential and commercial real estate, loan values related to agriculture, education, healthcare, stocks, and other forms of liabilities. Leverage ratio (leveratio) is the total debt divided by the total asset.

Risky asset market participation

Following Calvet and Sodini (2014), risky share (w) is defined as the risky wealth divided by the sum of risk-free wealth and risky wealth, a measure of household liquid financial wealth. A household is identified as participant and the participation dummy variable (part) takes value of one if the risky share is positive. The participation dummy and the risky share are used as dependent variables in this paper.

As pointed out by previous studies (e.g. Vestman, 2019), risk aversion plays a crucial role

in household financial risk-taking decisions. In the 2017 CHFS, one question is designed to elicit general risk preference of the household head[4]. The answer to this question as well as the risk aversion (ra) variable takes an integer value between 1 and 5 from least to most risk averse investment attitudes.

3.2.3 Third Category of Variables

Labor income risk

Previous research finds that labor income risk can reduce household stockholdings, as shocks to labor income increase background risk, which mainly consists of income risk, unemployment risk, and real estate risk, and thus reduce the risk appetite of households.

Since the labor income process of each household cannot be directly observed, annual time series data of province-sector average income from year 2006 to 2018 are used. To assess the impact of labor income risk on household portfolios, I measure risk related to labor income with two variables, general volatility of labor income (i.e. log growth of annual labor income, abbreviated as li_std) and the correlation between labor income log growth and stock market excess return (corr_li_st).

The labor income-related risk is estimated according to the employment sector of the household head, and for household heads who are not employed, the employment sector is not identified, and neither are labor income risk variables. For these households, I use state variables (i.e. retired, unempd or entred) to identify potential impact on financial risk-taking.

Using time series data from the NBSC, I compute labor income risk variables for each of 551 province-sector pairs (i.e. 29 provinces and 19 employment sectors). Table 1 presents the summary information on sector level, and the definition of sectors is provided in Appendix Table 11.

[4]The question "which investment would you choose if you have capital at hand?" 1 - high risk, high return, 2 - risk and return a bit more than average, 3 - average risk and return, 4- risk and return a bit lower than average, 5 – no risk, is incorporated in the survey to elicit the risk preferences of household heads.

Table 1: Summary of Labor Income Risk Variables on Employment Sector Level

This table summaries labor income risk variables across urban homeowners in 29 provinces. Appendix Table 10 describes the construction of variables, and Appendix Table 11 describes the definition of employment sectors. Time series data of labor income and stock market return are on an annual basis, ranging from 2006 to 2018.

Employment Sector	AFF	Min	Manu	EGW	Cons
N	184	120	1,171	350	875
li_std	0.068	0.077	0.033	0.046	0.054
corr_li_st	-0.044	0.039	-0.019	0.206	-0.125
Employment Sector	Tra	Infor	WR	H&C	FI
N	721	205	428	230	250
li_std	0.036	0.062	0.044	0.052	0.064
corr_li_st	-0.02	-0.177	-0.082	-0.153	0.336
Employment Sector	RE	Le	RTG	WEP	HS
N	144	68	53	157	967
li_std	0.071	0.08	0.051	0.043	0.103
corr_li_st	0.052	-0.071	0.152	0.079	-0.054
Employment Sector	E	HSS	CSE	PM&SO	Total
N	582	424	135	740	7,804
li_std	0.056	0.041	0.047	0.056	0.055
corr_li_st	0.195	0.081	-0.005	0.251	0.026

Among 21,195 urban homeowners in the sample, 7,804 households are reported to be employed (i.e. the household head's employment sector is identified). As shown in Table 1, manufacturing (Manu), household service (HS), and construction (Cons) sectors are the biggest employment sectors in the sample, and scientific research (RTG), leasing (Le), and mining (Min) sectors are the smallest ones.

The general volatility of labor income is 0.055 on average across different sectors, among which household service (HS) sector has the highest 0.103, and manufacturing (Manu) and transportation (Tra) sectors have the lowest, 0.033 and 0.036 respectively. To compare, annual standard deviation for log labor income used in Yao and Zhang (2005) and Chetty et al. (2017) is 0.13, more than double of the average in the 2017 CHFS data.

The correlation between labor income and the stock market differs substantially in different sectors, from the lowest value of -0.177 for the information transmission, computer service and software (Infor) sector to the highest value of 0.336 for the financial intermediation (FI) sector. The result can be compared with Aliyev (2019) who uses quarterly time series data from 1995

to 2019 for countries covered in the second wave of the HFCS and finds that the correlation of labor income growth with stock market return is relatively low for all of sectors across 20 European countries covered in the survey, ranging from -0.042 in the public sector to 0.068 in the manufacturing sector. Using the PSID data from 1970 to 1992, Cocco (2005) finds the correlation to be insignificantly different from zero.

One disadvantage of the annual aggregated province-sector level labor income data used in this study is that seasonal variation is not captured, while it can be an important risk that households face when making financial decisions. The measurement of related variables can also be improved if longer time series or higher frequency data (i.e. quarterly or monthly) can be acquired, as the estimation of volatility can generally be improved by improving data frequency.

House price risk

To assess the impact of house price risk on households' portfolios, two variables are constructed on the province level, general volatility of real housing market return (i.e. the standard deviation of annual real housing return, abbreviated as hp_std) and the correlation between real housing return and stock market excess return (corr_hp_sto)[5].

The average real housing return volatility across provinces is 9.0% annually during the study period, while exhibiting substantial cross-province variation, ranging from a lowest value of 4.1% in Liaoning to a highest value of 14.9% in Shanghai. Using the European household data, Aliyev (2019) finds that the volatility in log growth of house prices is 2.3% on average across countries, ranging from 1.0% in Italy to 5.9% in Latvia[6].

The average correlation between housing return and stock return across provinces is -0.057, ranging from -0.432 in Hubei to 0.345 in Beijing. Aliyev (2019) also finds large cross-country variation in the correlation between the housing market and the stock market, with mean value of 0.147 in the whole sample, varying from -0.312 in Italy to 0.493 in Latvia.

[5]As the changes in annual housing prices are large during the study period, simple annual real returns are used instead of log real returns to compute variables related to house price risk.

[6]Aliyev (2019) uses log quarterly real housing returns for computation

Table 2: Summary of Labor Income Risk and House Prices Risk Variables on Province Level

This table summaries labor income risk and house price risk variables for urban homeowners in 29 provinces. Appendix Table 10 describes the construction of the variables. Time series data of labor income, house prices, and stock market returns are on an annual basis. The data range from 2006 to 2018 for labor income, and from 2000 to 2018 for house prices and stock market returns.

Province	Anhui	Beijing	Chongqing	Fujian	Gansu	Guangdong
N	367	915	776	786	404	1,508
li_std	0.058	0.046	0.052	0.045	0.078	0.032
corr_li_st	0.193	0.185	0.019	-0.001	-0.06	-0.225
hp_std	0.081	0.137	0.101	0.099	0.126	0.077
corr_hp_sto	-0.143	0.345	-0.159	-0.312	-0.134	0.03
Province	Guangxi	Guizhou	Hainan	Hebei	Heilongjiang	Henan
N	421	230	386	809	771	511
li_std	0.053	0.078	0.085	0.061	0.054	0.047
corr_li_st	0.137	-0.018	0.09	0.077	-0.066	0.083
hp_std	0.062	0.092	0.136	0.061	0.065	0.053
corr_hp_sto	0.055	-0.1	0.295	-0.099	0.051	-0.348
Province	Hubei	Hunan	Jiangsu	Jiangxi	Jilin	Liaoning
N	809	757	1,229	385	667	1,425
li_std	0.066	0.048	0.046	0.064	0.065	0.047
corr_li_st	-0.014	-0.012	-0.07	-0.032	-0.023	0.092
hp_std	0.089	0.076	0.092	0.087	0.091	0.041
corr_hp_sto	-0.432	-0.059	-0.357	-0.278	0.232	0.078
Province	Neimenggu	Ningxia	Qinghai	Shaanxi	Shandong	Shanghai
N	222	243	381	684	1,311	1,447
li_std	0.06	0.068	0.079	0.088	0.048	0.082
corr_li_st	-0.034	0.082	0.087	0.329	0.085	0.01
hp_std	0.072	0.087	0.064	0.093	0.068	0.149
corr_hp_sto	0.091	-0.253	-0.045	-0.046	-0.343	-0.244
Province	Shanxi	Sichuan	Tianjin	Yunnan	Zhejiang	Total
N	600	782	702	392	1,275	21,195
li_std	0.059	0.052	0.071	0.059	0.035	0.055
corr_li_st	0.143	0.042	0.397	-0.136	-0.113	0.026
hp_std	0.104	0.085	0.114	0.078	0.114	0.09
corr_hp_sto	0.218	0.087	-0.09	-0.264	-0.23	-0.057

One limitation of the house price data used in this study is that it may not be a good proxy for the real house price movements experienced by the households. As pointed out by Guiso, Paiella, Visco, et al. (2006), house price volatility can differ across locations and types of real estate within a province, and the extent to which households are exposed to house price risk can also depend on their housing wealth. This concern is investigated in Section 4.4.

3.3 Sample Selection Process

There are 40,011 households in the dataset, and six restrictions are imposed to limit the obvious sources of heterogeneity before the empirical analysis.

1. Household head is between 16 and 90 years old.

2. Household data are not reported to have poor quality due to proportional of unknown objectively answers, high refusal rate, or poor active reporting quality of the interviewers. There are 2.5% households reported to have poor-quality data, and these households on average have lower education, bigger family, higher unemployment rate, and lower stock market participation rate. Dropping these observations may cause the households with lower socioeconomic status to be underrepresented in the data.

3. Households live in urban areas. There are approximately 32% households in the data living in rural areas. As the majority of rural households live in self-built houses and these houses are not as commonly traded on the housing market as those located in urban areas, the measurement of house price risk is not much relevant in their financial decisions (Zhao & Li, 2017).

4. Households own their primary residence (i.e. homeowners).

5. Homeowners' risky asset variables are not missing.

6. Homeowners do not have a plan to buy another property at the time of the survey.

17,761 out of 40,011 households fulfill these requirements. To facilitate comparison, Table 3 and Table 4 present summary statistics for step 4 and 6 respectively. Appendix C presents summary statistics of other subsamples dropped. To avoid outliers affecting the results, risky share, leverage ratio, and all nominal variables have been winsorized at the 1st and 99th percentile before computing summary statistics. All nominal variables are transformed into U.S. dollars with the exchange rate of 6.51 Chinese Yuan per dollar at the end of 2017.

Table 3: Summary Statistics for Homeowners and Renters in CHFS Sample

This table includes all urban households in the 2017 wave of CHFS with household head between 16 and 90 years old and having normal-quality responses during the interview. Household is defined as homeowner if it owns its primary residence. All variables are described in Appendix Table 10. All nominal variables are transformed into U.S. dollars with the exchange rate of 6.51 Chinese Yuan per dollar at the end of 2017. Home equity share, leverage ratio, risky share, and all nominal values are winsorized at the 1st and 99th percentile before computing summary statistics. Sample means for total financial wealth, leverage ratio, risky share are computed among households with non-zero values in these items. Other mean values are computed among all households.

	Homeowners				Renters			
	Mean	SD	N	N of Zero	Mean	SD	N	N of Zero
Demographic characteristics								
Age (years)	56.386	14.010	21,195	0	50.776	16.790	5,271	0
High school dummy	0.469	0.499	21,174	11,249	0.452	0.498	5,265	2,884
Number of household members	3.097	1.420	21,195	0	2.610	1.287	5,271	0
Number of children	0.427	0.689	21,195	14,252	0.391	0.670	5,271	3,707
Employment and income								
Unemployment dummy	0.107	0.309	21,195	18,936	0.110	0.313	5,271	4,692
Income ($)	11,585	8,254	21,195	8,519	10,879	7,932	5,271	2,190
Wealth								
Total wealth ($)	201,150	303,135	26,483	0	73,326	170,593	5,271	0
Financial wealth ($)	23,616	46,034	21,195	472	18,826	42,102	5,271	163
Leverage ratio	0.535	1.499	21,172	18,027	2.366	3.509	5,187	4,443
Annual habit ($)	11,558	9,652	21,195	0	10,136	8,865	5,271	0
Risky asset market participation								
Participation dummy	0.222	0.416	20,390	15,859	0.226	0.418	5,041	3,903
Risky share	0.471	0.314	20,390	15,859	0.423	0.314	5,041	3,903
Risk Aversion	4.2	1.277	21,189	0	4.104	1.326	5,268	0
Number of observations	21,195				5,271			

As housing price risks are only identified for households who own their primary residence, the analysis is limited to the homeowners in the sample. From Table 3, homeowners on average are older and wealthier than renters. However, the difference in participation rates is only 0.4% between homeowners and renters, much smaller than the 40% gap between Swedish homeowners and renters (Vestman, 2019). Using a life-cycle portfolio choice model with endogenous housing tenure choice, the author finds that homeownership does not cause nonparticipation in stock market to any greater extent, nor the gap in participation rates between homeowners and renters, instead, time-invariant unobservable characteristics (e.g. preference heterogeneity) induce household's self-selection along both extensive and intensive margins. In a model with heterogeneity in preference and participation cost, a small fraction of households has low-risk aversion and small saving motive. They save less for housing purchase and financial wealth and

find it less worthwhile to participate in the equity market[7]. However, this group of households has a slightly higher equity share conditional on participation as they are relatively less risk averse. Using the CHFS data, risk aversion is directly observable, and it can be seen that the gaps of risk aversion, participation rates, and risky shares conditional on participation are all small between renters and homeowners, which in is line with the theoretical prediction of Vestman (2019).

Urban homeowners with plans to buy another property are excluded from the analysis as their risk profiles can be different. As mentioned in Sinai and Souleles (2013) and Chetty et al. (2017), when homeowners need to move, their cost to buy a new house is partially hedged by their current house. As a result, the correlation between prices of current and future house, which is not measurable in this study, can be another factor affecting household financial risk-taking decisions.

From Table 4, homeowners with purchase plan are on average wealthier than those without a purchase plan, and the former group also have higher education and risky asset market participation rate, while slightly lower risky share among participants. Eliminating the former group can cause the wealthier population to be underrepresented in the dataset. However, as the risk profile of two groups can be quite different, this study will focus on the latter group and assess how homeowners choose their portfolio facing house price risk.

Compared with similar studies using household data from other countries or regions, for example Vestman (2019) using Swedish data, Chinese households on average have a higher home ownership rate, 80% versus 75%, and a lower participation rate among homeowners, 22.2% versus 61.9%[8]. Meanwhile, there are only 8% urban homeowners have outstanding mortgage in the sample, compared with 75% in the SIPP data for the U.S. households (Chetty et al., 2017).

[7]The result that the average risk aversions are almost the same among renters and homeowners appears contrary to Vestman (2019). It may come from the identity restriction in Chinese market that prevents households with high-risk aversion from purchasing real estate. See Chan and Zhang (1999) for an introduction of the household registration system or 'Hukou' in China.

[8]Vestman (2019) defines a household as stock market participant if it holds either stocks directly or equity mutual funds.

Table 4: Summary Statistics for Homeowners in CHFS Sample

This table includes all urban homeowners in the 2017 CHFS wave with household head between 16 and 90 years old and having normal-quality responses during the interview. All variables are described in Appendix Table 10. All nominal variables are transformed into U.S. dollars with the exchange rate of 6.51 Chinese Yuan per dollar at the end of 2017. Home equity share, leverage ratio, risky share, and all nominal values are winsorized at the 1st and 99th percentile before computing summary statistics. Sample means for home equity share, leverage ratio, risky share, and nominal values are computed among households with non-zero values in these items. Other mean values are computed among all households. The sample of homeowners without purchase plan is used in this cross-sectional study.

	Homeowners without purchase plan				Homeowners with purchase plan			
	Mean	SD	N	N of Zero	Mean	SD	N	N of Zero
Demographic characteristics								
Age (years)	57.494	13.799	17,761	0	47.786	12.285	2,629	0
High school dummy	0.453	0.498	17,742	9,699	0.627	0.484	2,628	979
Family size	3.049	1.429	17,761	0	3.432	1.236	2,629	0
Number of children	0.285	0.451	17,761	12,302	0.589	0.699	2,629	1,382
Employment and income								
Retirement dummy	0.285	0.451	17,761	12,699	0.113	0.317	2,629	2,332
Entrepreneurial dummy	0.239	0.427	17,761	13,509	0.317	0.465	2,629	1,796
Unemployment dummy	0.111	0.314	17,761	15,785	0.041	0.199	2,629	2,521
Income ($)	11,211	8,070	17,761	7,593	13,910	8,977	2,629	519
Housing								
Home equity ($)	181,828	257,753	16,770	0	198,248	259,719	2,500	0
Home equity share	0.817	0.265	16,770	0	0.725	0.260	2,500	0
Commerical real estate equity ($)	224,571	270,392	922	0	218,312	262,825	161	0
Housing return volatility	0.091	0.029	17,761	0	0.087	0.027	2,629	0
Corr. between housing and stock market	-0.072	0.209	17,761	0	-0.082	0.206	2,629	0
Wealth								
Total wealth ($)	214,440	299,200	17,761	0	271,756	324,745	2,629	0
Financial wealth ($)	21,594	43,121	17,761	0	43,594	62,418	2,629	0
Risk-free wealth ($)	9,786	19,979	17,761	0	17,592	27,978	2,629	0
Risky wealth ($)	21,387	29,175	17,761	14,259	22,077	30,781	2,629	1,600
Other valuables ($)	12,466	17,179	17,761	8,887	18,800	21,546	2,629	678
Private equity ($)	7,176	22,267	17,761	16,985	15,658	24,676	2,629	2,377
Total pension assets ($)	2,923	5,549	17,761	8,822	4,269	6,595	2,629	1,392
Whole life insurance ($)	25,322	32,258	17,761	16,181	35,151	37,136	2,629	2,180
Leverage ratio	0.536	1.488	17,761	15,305	0.281	0.919	2,629	2,134
Annual habit ($)	11,169	9,381	17,761	0	15,224	11,102	2,629	0
Risky asset market participation								
Participation dummy	0.197	0.398	17,761	14,259	0.391	0.488	2,629	1,600
Risky share	0.484	0.312	17,761	14,259	0.427	0.316	2,629	1,600
Risk Aversion	4.263	1.246	17,755	0	3.668	1.351	2,629	0
Number of observations	17,761				2,629			

4 Results

For hypothesis 1, I estimate the effects of house price risk on homeowners' participation decisions using the probit regression presented in specification (1). For hypothesis 2, I estimate the effects of house price risk on risky share (i.e. share of liquid financial wealth invested in risky financial market) using the OLS regression presented in specification (2):

$$Participation_i = const + \alpha_1 * hp\_std_i + \alpha_2 * corr\_hp\_sto_i + \gamma * X_i + \varepsilon_i, \quad (1)$$

$$RiskShare_i = const + \beta_1 * hp\_std_i + \beta_2 * corr\_hp\_sto_i + \delta * X_i + \epsilon_i, \quad (2)$$

where X_i denotes other covariates found to be important in previous studies, such as demographic characteristics and wealth measures. I take log of variables with nominal values due to the skewness towards large values, and the nominal values are winsorized at the 1st and 99th percentile before log transformation to reduce the effect of the outliers. Housing return volatility (hp_std) and the correlation between housing return and stock return (corr_hp_sto) measure the house price risk for homeowners when making portfolio decisions. If house price risk has no effect on households' financial risk-taking decisions along either margin, it is expected that the estimated α_1, α_2, β_1, and β_2 are not significantly different from zero. The error terms ε and ϵ capture unobserved factors in households' portfolio decisions. These factors may include future labor income (Cocco, 2005), investment mistakes (Calvet, Campbell, & Sodini, 2007), regional disparities (Chetty et al., 2017), and measurement error in habit (Badarinza,

Campbell, & Ramadorai, 2016).

Some omitted variables in the error terms can be correlated with the variables of interest, introducing bias in the estimates of house price risk. For example, future labor income is an important factor in both housing and financial portfolio decisions. Based on the theoretical literature on portfolio composition in the presence of non-tradable income, human capital, although risky, resembles Treasury bills more closely than stocks (Cocco, 2005). When households have big amount of human capital, they implicitly hold large proportion of risk-free assets in their portfolios. This would shift the portfolio allocation towards risky assets. Meanwhile, aggregate demand shocks for housing have larger impacts on house prices in locations with low housing supply elasticity, generating differential variation in house prices across states (e.g. Chetty et al., 2017). From Table 2, we can see that housing return volatility in larger provinces with an inelastic housing supply, like Beijing and Shanghai, is more than double of that in some other smaller provinces with an elastic housing supply. If households with higher expected labor income can select themselves into neighborhoods with an inelastic housing supply, housing return volatility is also positively correlated with human capital in ε, generating an upward bias in the estimate of α_1. The estimate of β_1 can be affected by similar mechanism. Such endogeneity problems make it crucial to use exogenous variation in the variables of interest in order to identify α_1, α_2, β_1, and β_2.

The empirical analysis is divided into four sections. First, I use the whole sample of homeowners and compare the results with prior studies. I then identify the causal effects of house price risk on financial risk-taking decisions using the natural experiment provided by the housing privatization in Chinese market, taking into account regional disparities. I discuss estimates of robustness test and other covariates at the end.

4.1 Whole Sample Results

Table 5 presents results using the whole sample of urban homeowners without a purchase plan. Column 1 reports estimates of probit regression of the market participation on house price risk

without any other controls. The estimated coefficient of α_2 is insignificant either economically or statistically on the 5% level. However, the estimate of α_1 is contrary to expectation and indicate that housing return volatility is positively correlated with stock market participation. This is potentially because households having household head employed (i.e. labor income is defined), and/or having undergone large housing price volatility tend to be richer, and these omitted variables induce them to participate in the risky asset market.

Column 2 accounts for other covariates X_i. The inclusion of these variables reduces the magnitude of α_1 by more than 50%, but it remains significantly positive. One standard deviation increase in housing return volatility on average makes a homeowner 6.76% (= 2.332* 0.029 * 100) more likely to participate, relative to a mean of 19.7%. Meanwhile, the estimate of α_2 becomes significant both statistically and economically after controlling for these covariates. One standard deviation increase in the correlation between housing return and stock return makes a household 4.72% (= 0.226 * 0.209 * 100) less likely to participate in stock market, and the estimate is significant on the 1% level while the magnitude is only approximately one tenth of that of housing return volatility.

For the risky share decision, column 4 presents the results without any other controls. The positive coefficient on housing market return volatility is presumably driven by omitted variables as analyzed regarding the participation decision above.

Column 5 includes other covariates X_i, and the estimate of β_1 becomes insignificant while the estimate of β_2 remains significant. One standard deviation increase in the correlation between housing return and stock return decreases risky share by approximately 1.76% (=0.084*0.209*100), relative to a mean of 48.4% among participants in the whole sample.

Column 3 and 6 include X_i and are clustered on the city level. Recent studies (Bailey, Dávila, Kuchler, & Stroebel, 2019) find that experiences of investors' friends can directly affect investment behavior in the housing market. Similarly, households living in the same city may share similar latent characteristics and their attitudes towards house price risk and financial risk-taking decisions may be affected by other people in the same city. It can be seen that clustering standard errors on the city level does not cause much change in the estimated results

Table 5: House Price Risk Estimates for Homeowners without a Purchase Plan

Specification (1) to (3) report probit estimates of the effect of house price risk on propensity to participate in the market for risky assets. Specification (4) to (6) report OLS estimates of the effect of house price risk on risky share. Standard errors are clustered at the city level for specification (3) and (6). R-sq is the McFadden pseudo R squared for probit regressions, and is the adjusted R squared for OLS regressions. Risky share, debt ratio, and all nominal values are winsorized at the 1st and 99th percentile to reduce the influence of outliers. All variables are described in Appendix Table 10.

Dependent variable:	Participation			Risky share		
	(1)	(2)	(3)	(4)	(5)	(6)
House price risk						
Housing return volatility	7.031***	2.332***	2.332***	0.591***	-0.136	-0.136
	(18.76)	(4.52)	(3.85)	(3.48)	(-0.70)	(-0.68)
Corr. with stock market return	-0.078	-0.226***	-0.226***	-0.068***	-0.084***	-0.084***
	(-1.52)	(-3.48)	(-2.84)	(-2.83)	(-3.44)	(-3.71)
Demographic characteristics						
Age		-0.047***	-0.047***		0.015***	0.015***
		(-6.16)	(-6.37)		(4.73)	(5.13)
Gender dummy		-0.073**	-0.073**		-0.024*	-0.024**
		(-2.14)	(-2.32)		(-1.87)	(-2.01)
Education		0.086***	0.086***		0.007**	0.007**
		(9.32)	(8.04)		(2.07)	(2.22)
Married dummy		-0.003	-0.003		0.035*	0.035
		(-0.07)	(-0.08)		(1.81)	(1.57)
Family size		-0.063***	-0.063***		-0.023***	-0.023***
		(-4.61)	(-4.35)		(-3.98)	(-4.68)
Financial characteristics						
Log financial wealth		0.402***	0.402***		0.012***	0.012**
		(38.69)	(23.25)		(2.78)	(2.31)
Log residential home equity		0.061***	0.061***		0.019***	0.019***
		(4.90)	(4.56)		(3.74)	(3.34)
Log commercial real estate		-0.003	-0.003		0.000	0.000
		(-0.79)	(-0.63)		(0.17)	(0.12)
Leverage ratio		0.077	0.077*		0.063*	0.063
		(1.53)	(1.73)		(1.89)	(1.37)
Risk aversion		-0.197***	-0.197***		-0.023***	-0.023***
		(-17.23)	(-15.65)		(-5.16)	(-6.06)
Labor income and related risk						
Log household income		0.033***	0.033***		-0.002	-0.002
		(6.84)	(6.80)		(-0.86)	(-0.91)
Labor income volatility		-0.432	-0.432		-0.109	-0.109
		(-0.86)	(-0.82)		(-0.59)	(-0.71)
Corr. with stock market return		0.017	0.017		-0.007	-0.007
		(0.24)	(0.21)		(-0.30)	(-0.32)
Entrepreneur dummy		-0.012	-0.012		-0.074***	-0.074***
		(-0.28)	(-0.26)		(-4.26)	(-4.63)
Unemployment dummy		0.013	0.013		-0.003	-0.003
		(0.19)	(0.21)		(-0.10)	(-0.09)
Retirement dummy		0.268***	0.268***		-0.025	-0.025
		(5.05)	(4.66)		(-1.18)	(-1.19)
Habit						
Log habit		0.166***	0.166***		0.006	0.006
		(6.77)	(6.73)		(0.65)	(0.72)
Clustered on city level	×	×		×	×	
N	17761	16730	16730	3502	3306	3306
R-sq	0.020	0.358	0.358	0.005	0.063	0.063
t statistics in parentheses				* p<.10	** p<.05	*** p<.01

of independent variables along either extensive or intensive margin.

However, the positive effect of housing return volatility on the participation decision is contrary to theoretical implications, either from the view of "crowding-out effect" or from the view of "no house price risk until moving". Using the second wave of the HFCS between 2013 and the first half of 2015, Aliyev (2019) finds that one standard deviation increase in housing return volatility makes a household 4.1% less likely to participate in risky financial asset market conditional on being a homeowner.

This contrary estimation indicates that the endogeneity of housing choice can potentially introduce an upward bias in the estimated effect of housing return volatility. To further investigate how households react to house price risk, I utilize the institutional changes during the housing privatization reform in China and explore the subsample of households whose housing choice is beyond family control and is plausibly orthogonal to other household-level unobserved factors of financial risk-taking decisions.

4.2 Homeowners with Exogenous Tenure Choice

In the 2017 CHFS, respondents provide the way they acquired real estate assets as one of: (1) direct purchase of new property from commercial housing markets; (2) direct purchase of second-hand property from commercial housing market; (3) purchase of policy housing (i.e. property purchased from the government at subsidized prices); (4) from inheritance or endowments; (5) discount purchase from the employer as welfare housing distribution; (6) cooperative-constructed property from the employer (i.e. the employers raise funds and sell the property to their employees at the cost of construction); (7) self-built property; (8) property acquired through relocation and compensation from collective land expropriation of local governments; (9) purchase with limited property rights (usually located in rural areas).

As (4), (5), (6), and (8) are not directly from the housing market and the time of acquisition is beyond family control, the tenure choice can be reasonably viewed as exogenous and is not jointly decided with financial portfolio choice (Zhao & Li, 2017). This subsample consists

Table 6: Summary Statistics for Homeowners with Exogenous Tenure Choice

This table provides summary statistics of urban homeowners whose residential real estate purchase decision is beyond family control. All variables are described in Appendix Table 10. All nominal variables are transformed into 2017 U.S. dollars with an exchange rate of 6.51 Chinese Yuan per dollar at the end of 2017. Leverage ratio, risky share, and all nominal values are winsorized at the 1st and 99th percentile before computing summary statistics. Sample means for leverage ratio, risky share, and nominal values are computed among households with non-zero values in these items. Other mean values are computed among all households.

	Exogenous Subsample				Remaining Sample			
	Mean	SD	N	N of Zero	Mean	SD	N	N of Zero
Age (years)	62.022	13.261	5,432	0	55.499	13.558	12,329	0
High school dummy	0.484	0.5	5,429	2,802	0.440	0.496	12,313	6,897
Number of household members	2.689	1.231	5,432	0	3.207	1.480	12,329	0
Income ($)	10,312	7,515	5,432	2,748	11,534	8,236	12,329	4,845
Home equity ($)	205,020	267,016	5,274	0	171,188	252,691	11,496	0
Total wealth ($)	237,627	302,751	5,432	0	204,225	297,060	12,329	0
Financial wealth ($)	22,813	41,888	5,432	0	21,056	43,643	12,329	0
Leverage ratio	0.658	1.777	5,432	5,060	0.514	1.430	12,329	10,245
Participation dummy	0.213	0.410	5,432	4,273	0.190	0.392	12,329	9,986
Risky share	0.504	0.302	5,432	4,273	0.474	0.316	12,329	9,986
Risk Aversion	4.346	1.203	5,430	0	4.227	1.264	12,325	0
Housing return volatility	0.093	0.031	5,432	0	0.090	0.027	12,329	0
Corr. between housing and stock market	-0.056	0.226	5,432	0	-0.079	0.201	12,329	0
Number of observations	5,432				12,329			

of 5,432 households, among which 1,159 are participants.

From Table 6, we can see that households in the subsample of exogenous tenure choice are on average older and richer than the remaining, and participation rate and risky share are also higher in the former group. However, as the acquisition timing and location of housing assets are not decided by the household, house price risk variables are not the outcome of households' self-selection and thus are not correlated with unobserved factors on household level (e.g. human capital) in the error term.

Column 1 reports estimates of probit regression of market participation on house price risk variables without any other controls. The estimated coefficients are similar to those estimated from the whole sample, and the positive estimate are presumably driven by omitted variables.

Column 2 includes other covariates X_i and uses the subsample of households with exogenous tenure choice. The estimate of α_1 is less than half of that in column 3 from the whole sample, and it is insignificant on the 10% level. The estimate of α_2 remains significant on the 5% level and similar in magnitude.

Column 4 to 6 report the OLS estimates of risky share on house price risk. Column 5

Table 7: House Price Risk Estimates for Homeowners with Exogenous Tenure Choice

Specification (1) to (3) report probit estimates of the effect of house price risk on propensity to participate in risky asset market. Specification (4) to (6) report OLS estimates of the effect of house price risk on risky share. All variables are described in Appendix Table 10. Specification (1), (2), (4), and (5) use the subsample of homeowners with exogenous tenure choice and having no real estate purchase plan, and specification (3) and (6) use the whole sample of homeowners without a purchase plan. Standard errors are clustered at city level for specification (2), (3), (5), and (6). R-sq is the McFadden pseudo R squared for probit regressions, and is the adjusted R squared for OLS regressions. Risky share, debt ratio, and all nominal values are winsorized at 1st and 99th percentile to reduce the influence of outliers.

Dependent variable:	Participation			Risky share		
	(1)	(2)	(3)	(4)	(5)	(6)
House price risk						
Housing return volatility	6.126***	1.122	2.332***	0.742***	0.086	-0.136
	(9.77)	(1.10)	(3.85)	(2.61)	(0.36)	(-0.68)
Corr. with stock market return	-0.053	-0.225**	-0.226***	-0.083**	-0.093***	-0.084***
	(-0.63)	(-2.23)	(-2.84)	(-2.25)	(-3.32)	(-3.71)
Demographic characteristics						
Age		-0.040***	-0.047***		0.022***	0.015***
		(-3.30)	(-6.37)		(4.09)	(5.13)
Gender dummy		-0.096*	-0.073**		-0.042**	-0.024**
		(-1.73)	(-2.32)		(-2.47)	(-2.01)
Education		0.079***	0.086***		0.006	0.007**
		(4.69)	(8.04)		(1.27)	(2.22)
Married dummy		0.015	-0.003		0.069***	0.035
		(0.25)	(-0.08)		(3.40)	(1.57)
Family size		-0.079***	-0.063***		-0.023**	-0.023***
		(-2.92)	(-4.35)		(-2.39)	(-4.68)
Financial characteristics						
Log financial wealth		0.454***	0.402***		0.013**	0.012**
		(16.19)	(23.25)		(2.03)	(2.31)
Log residential home equity		0.041**	0.061***		0.011	0.019***
		(2.06)	(4.56)		(1.56)	(3.34)
Log commercial real estate		0.006	-0.003		0.002	0.000
		(0.67)	(-0.63)		(0.77)	(0.12)
Leverage ratio		-0.375	0.077*		-0.287	0.063
		(-0.78)	(1.73)		(-1.58)	(1.37)
Risk aversion		-0.230***	-0.197***		-0.017**	-0.023***
		(-9.20)	(-15.65)		(-2.39)	(-6.06)
Labor income and related risk						
Log household income		0.032***	0.033***		-0.000	-0.002
		(3.82)	(6.80)		(-0.07)	(-0.91)
Labor income volatility		-0.477	-0.432		-0.690**	-0.109
		(-0.52)	(-0.82)		(-2.58)	(-0.71)
Corr. with stock market return		0.237*	0.017		0.018	-0.007
		(1.96)	(0.21)		(0.49)	(-0.32)
Entrepreneur dummy		0.184**	-0.012		-0.119***	-0.074***
		(2.23)	(-0.26)		(-4.00)	(-4.63)
Unemployment dummy		-0.012	0.013		-0.046	-0.003
		(-0.10)	(0.21)		(-1.03)	(-0.09)
Retirement dummy		0.265**	0.268***		-0.076**	-0.025
		(2.31)	(4.66)		(-2.21)	(-1.19)
Habit						
Log habit		0.158***	0.166***		0.024	0.006
		(3.73)	(6.73)		(1.50)	(0.72)
Clustered on city level	×					×
N	5432	5265	16730	1159	1130	3306
R-sq	0.017	0.353	0.358	0.007	0.072	0.063
t statistics in parentheses				* p<.10	** p<.05	*** p<.01

includes other covariates X_i and uses the subsample of households. The estimate of β_1 remains insignificant, and the estimate of β_2 is similar in both magnitude and significance level compared with that in column 6 from the whole sample.

The estimated results from the subsample indicate that eliminating household-level omitted variables improves the identification of the effect from house price risk. Although smaller in magnitude, however, the estimated coefficient of α_1 using the "exogenous" subsample is still positive and contrary to theoretical implications. This can come from the fact that location fixed effects are omitted in the design. Since house price risk variables are defined on the provincial level in this cross-sectional study, province- or city-level fixed effects will capture the impact from these risks. It can be seen in Table 2 that house price volatility is higher in larger provinces like Shanghai which tend to have better financial services and thus higher stock market participation, generating a spurious positive correlation between two variables. Motivated by this potential channel, I refine the research design with regional effect in Section 4.3.

For estimates on other variables, several interesting things are found using the subsample of homeowners with exogenous tenure choice: (1) the effect of education on risky share becomes insignificant. (2) the effect of residential home equity on risky share decision becomes insignificant. (3) the coefficients of leverage ratio on participation decision and risky share become negative. (4) the estimate of entrepreneurial dummy on participation decision becomes significantly positive. Further analysis on this is carried out in Section 4.5.

4.3 Inclusion of Location Effects

For regional effects, it can be reasonably expected that more developed regions tend to have, for example, a better environment for household to access financial services and thus encourage equity market participation. Using province-sector pairs of labor income in the year 2018, I compute the average income level across sectors for different provinces and find substantial variation in this variable. The regional dummy takes value of 1 if a province has an average income

level over 15,000 dollars per year, and there are 5 out of 29 provinces meet this requirement , namely, Beijing, Shanghai, Guangdong, Zhejiang, Tianjin[9].

Using the "exogenous" subsample, column 2 includes the regional dummy and other covariates X_i included in column 1. The estimate of α_1 is further reduced by approximately half and is not significant at any conventional level. The coefficient on α_2 becomes slightly more negative after controlling for the regional effects, and the estimations for other covariates remain similar. However, the estimate of the regional dummy itself is not significantly different from zero.

Regarding the risky share, the estimates of β_1 , β_2, and other covariates all remain similar after the inclusion of the regional dummy, and the estimate of the regional dummy itself is not significant.

The change in the estimates of α_1 indicates that a regional effect may be a reason that housing return volatility appears to encourage risky financial market participation in previous identifications. One may doubt that this regional dummy is simply another measure of housing return volatility as several provinces in the high-income group also have high housing return volatility. However, as shown in Table 2, there is large within variation in housing return volatility in the two groups (i.e. the base group with regional dummy equal to zero and the group with regional dummy equal to one) and dividing provinces into two groups with the regional dummy will eliminate this variation. For example, the range of housing return volatility in the base group is from 0.041 in Liaoning to 0.136 in Hainan, and the range in the other group is from 0.077 in Guangdong to 0.149 in Shanghai. As a result, the regional dummy does not work simply as another measure of house price volatility. The insignificant estimate of α_1 also supports the finding of Kuchler and Zafar (2019) that although personally experienced local housing price and its volatility can affect households' beliefs about aggregate economic outcomes through expectation formation, this mechanism tends to affect expectation about that particular domain but not about other domains (e.g. stock market).

Due to the way the regional dummy is defined, it is possible that this variable reflects the

[9]Using average labor income in each province gives the same result.

Table 8: House Price Risk Estimates with Regional Effect

Specification (1) to (2) report probit estimates of the effect of house price risk on propensity to participate in risky financial asset market. Specification (3) to (4) report OLS estimates of the effect of house price risk on risky share. Specification (2) and (4) include regional dummy for the households living in provinces with average annual labor income over 15,000 dollars, using an exchange rate of 6.51 Yuan per US dollar at the end of 2017. All variables are described in Appendix Table 10. All standard errors are clustered at city level. R-sq is the McFadden pseudo R squared for probit regressions, and is the adjusted R squared for OLS regressions. Risky share, debt ratio, and all nominal values are winsorized at 1st and 99th percentile to reduce the influence of outliers.

Dependent variable:	Participation				Risky share			
	(1)		(2)		(3)		(4)	
	Estimates	t-stat	Estimates	t-stat	Estimates	t-stat	Estimates	t-stat
Regional effect								
Regional dummy			0.046	(0.45)			0.000	(0.01)
House price risk								
Housing return volatility	1.122	(1.10)	0.725	(0.59)	0.086	(0.36)	0.085	(0.24)
Corr. with stock market return	-0.225**	(-2.23)	-0.242**	(-2.16)	-0.093***	(-3.32)	-0.093***	(-3.20)
Demographic characteristics								
Age	-0.040***	(-3.30)	-0.040***	(-3.29)	0.022***	(4.09)	0.022***	(4.09)
Gender dummy	-0.096*	(-1.73)	-0.097*	(-1.73)	-0.042**	(-2.47)	-0.042**	(-2.47)
Education	0.079***	(4.69)	0.081***	(4.77)	0.006	(1.27)	0.006	(1.25)
Married dummy	0.015	(0.25)	0.015	(0.24)	0.069***	(3.40)	0.069***	(3.36)
Family size	-0.079***	(-2.92)	-0.078***	(-2.87)	-0.023**	(-2.39)	-0.023**	(-2.40)
Financial characteristics								
Log financial wealth	0.454***	(16.19)	0.454***	(16.21)	0.013**	(2.03)	0.013**	(2.02)
Log residential home equity	0.041**	(2.06)	0.037*	(1.71)	0.011	(1.56)	0.010	(1.58)
Log commercial real estate	0.006	(0.67)	0.006	(0.68)	0.002	(0.77)	0.002	(0.77)
Leverage ratio	-0.375	(-0.78)	-0.380	(-0.79)	-0.287	(-1.58)	-0.287	(-1.58)
Risk aversion	-0.230***	(-9.20)	-0.230***	(-9.21)	-0.017**	(-2.39)	-0.017**	(-2.39)
Labor income and related risk								
Log household income	0.032***	(3.82)	0.032***	(3.80)	-0.000	(-0.07)	-0.000	(-0.07)
Labor income volatility	-0.477	(-0.52)	-0.435	(-0.48)	-0.690**	(-2.58)	-0.690**	(-2.58)
Corr. with stock market return	0.237*	(1.96)	0.242*	(1.92)	0.018	(0.49)	0.018	(0.48)
Entrepreneur dummy	0.184**	(2.23)	0.186**	(2.27)	-0.119***	(-4.00)	-0.119***	(-4.00)
Unemployment dummy	-0.012	(-0.10)	-0.013	(-0.11)	-0.046	(-1.03)	-0.046	(-1.03)
Retirement dummy	0.265**	(2.31)	0.265**	(2.31)	-0.076**	(-2.21)	-0.076**	(-2.22)
Habit								
Log habit	0.158***	(3.73)	0.157***	(3.74)	0.024	(1.50)	0.024	(1.49)
N	5265		5265		1130		1130	
adj. R-sq	0.353		0.353		0.072		0.072	
t statistics in parentheses						* p<.10	** p<.05	*** p<.01

mixed effects of regional disparities and human capital. As human capital is the discounted value of future labor income, it can be reasonably expected that households with higher current labor income will have higher future labor income and thus have higher human capital.

Even though the role of the regional dummy remains unclear, the hypotheses that house price risk has no effect on homeowners' financial risk-taking decisions in absence of moving can be reasonably rejected on the 5% level. Using the results from column 2 and column 4 in Table 8, a one standard deviation increase in the correlation between the housing return and the stock return, on average, makes households less likely to participate in the risky asset market by 5.47% (=0.242*0.226*100), and reduces the risky share by 2.1% (=0.093*0.226*100) among participants. It can be compared with a recent study by Aliyev (2019). Using European household data, the author finds that among homeowners, a one standard deviation increase in the correlation between housing and stock market, on average, makes household 3.3% more likely to be participant and decreases the risky share by 3.7% conditional on participation. Although, as pointed out by the author, this does not necessarily support the causal link, the fact that such empirical regularities are present suggests that households have suboptimal portfolios given their hedging motive. Results under different definitions of regional effects are presented in Appendix B.

4.4 Robustness Check

As mentioned in Guiso et al. (2006), households with larger housing wealth are more exposed to house price variation. To check whether the results obtained above are driven by households with low housing wealth, I interact each component of house price risk with household current home equity, which is divided into 10 brackets.

From Table 9, the estimate for α_1 remain insignificant after considering how much of household wealth is exposed to house price risk. Using coefficients from column 2 and 4, a one standard deviation increase in the correlation between housing return and stock return, on

average, makes a household 5.01% (=0.030*1.694*100) less likely to participate in risky asset market and decreases the risky share by 1.5% (=0.009*1.694*100) conditional on participation[10], compared with 5.47% (=0.242*0.226*100) and 2.1% (=0.093*0.226*100) from column 1 and column 3, which do not take households' wealth exposure to housing market into consideration.

The crowding-out effect of the correlation between housing return and stock return on financial risk taking is slightly attenuated after taking household actual exposure into account, while still remaining statistically significant on the 1% level and economically important. The estimates of other covariates remain similar.

Robustness check with different definitions of regional effects and extensions with labor income risk is presented with details in Appendix B. The estimates of variables of interest remain similar across different definitions and specifications.

4.5 Other Numerical Results

Using the subsample of homeowners with exogenous tenure choice, this study provides evidence consistent with previous findings of age and labor income risk (Cocco, Gomes, & Maenhout, 2005), entrepreneurship (Heaton & Lucas, 2000), financial wealth (Calvet & Sodini, 2014), risk aversion (Guiso & Paiella, 2004), and retirement (Viceira, 2001) on risk share decisions. Meanwhile, three variables give interesting coefficients worth further analysis.

Firstly, using the subsample of homeowners with exogenous tenure choice, home equity has no significant effect on households' risky share decisions conditional on participation. This is consistent with the empirical finding of Chetty et al. (2017) and Calvet and Sodini (2014). As pointed out by Sinai and Souleles (2005), the increase in house prices indicates a commensurate increase in the present value of expected future rents, when discount rate remains unchanged. For homeowners with an infinite horizon (e.g. no plan to move), the increase in house prices will be offset by the increase in household's implicit cost for housing services. As a result, rising

[10]The mean value of the interaction term between housing wealth and the correlation between housing return and stock return is 1.694 in the sample of homeowners with exogenous tenure choices.

Table 9: Robustness Check with Housing Wealth Exposure

Specification (1) and (2) report probit estimates of the effect of house price risk on propensity to participate in risky asset market. Specification (3) to (4) report OLS estimates of the effect of house price risk on risky share. Variables of house price risk in specification (2) and (4) are interacted with home equity. Home equity is divided into ten brackets before interacting with house price risk. All specifications use the subsample of homeowners with exogenous tenure choice, and all standard errors are clustered at the city level. R-sq is the McFadden pseudo R squared for probit regressions, and is the adjusted R squared for OLS regressions. Risky share, debt ratio, and all nominal values are winsorized at the 1st and 99th percentile to reduce the influence of outliers. Variables are summarized in Table 10.

Dependent variable:	Participation				Risky share			
	(1)		(2)		(3)		(4)	
	Estimates	t-stat	Estimates	t-stat	Estimates	t-stat	Estimates	t-stat
Regional effect								
Regional dummy	0.046	(0.45)	0.031	(0.29)	0.000	(0.01)	0.000	(0.01)
House price risk								
Housing return volatility	0.725	(0.59)	0.139	(0.84)	0.085	(0.24)	0.003	(0.07)
Corr. with stock market return	-0.242**	(-2.16)	-0.030***	(-2.59)	-0.093***	(-3.20)	-0.009***	(-2.90)
Demographic characteristics								
Age	-0.040***	(-3.29)	-0.039***	(-3.27)	0.022***	(4.09)	0.022***	(4.10)
Gender dummy	-0.097*	(-1.73)	-0.098*	(-1.76)	-0.042**	(-2.47)	-0.043**	(-2.49)
Education	0.081***	(4.77)	0.081***	(4.79)	0.006	(1.25)	0.006	(1.16)
Married dummy	0.015	(0.24)	0.016	(0.26)	0.069***	(3.36)	0.070***	(3.38)
Family size	-0.078***	(-2.87)	-0.077***	(-2.84)	-0.023**	(-2.40)	-0.022**	(-2.37)
Financial characteristics								
Log financial wealth	0.454***	(16.21)	0.454***	(16.09)	0.013**	(2.02)	0.014**	(2.05)
Log residential home equity	0.037*	(1.71)	0.009	(0.29)	0.010	(1.58)	0.010	(0.90)
Log commercial real estate	0.006	(0.68)	0.006	(0.67)	0.002	(0.77)	0.002	(0.74)
Leverage ratio	-0.380	(-0.79)	-0.397	(-0.83)	-0.287	(-1.58)	-0.284	(-1.54)
Risk aversion	-0.230***	(-9.21)	-0.230***	(-9.20)	-0.017**	(-2.39)	-0.017**	(-2.37)
Labor income and related risk								
Log household income	0.032***	(3.80)	0.032***	(3.82)	-0.000	(-0.07)	-0.000	(-0.09)
Labor income volatility	-0.435	(-0.48)	-0.486	(-0.54)	-0.690**	(-2.58)	-0.683**	(-2.55)
Corr. with stock market return	0.242*	(1.92)	0.243*	(1.91)	0.018	(0.48)	0.018	(0.48)
Entrepreneur dummy	0.186**	(2.27)	0.186**	(2.28)	-0.119***	(-4.00)	-0.119***	(-4.02)
Unemployment dummy	-0.013	(-0.11)	-0.014	(-0.11)	-0.046	(-1.03)	-0.046	(-1.03)
Retirement dummy	0.265**	(2.31)	0.260**	(2.26)	-0.076**	(-2.22)	-0.076**	(-2.20)
Habit								
Log habit	0.157***	(3.74)	0.156***	(3.66)	0.024	(1.49)	0.023	(1.46)
Interacted with housing wealth		×				×		
N	5265		5265		1130		1130	
adj. R-sq	0.353		0.353		0.072		0.070	
t statistics in parentheses						* p<.10	** p<.05	*** p<.01

house prices raise measured household wealth but it corresponds to more expensive housing services instead of a higher standard of living (Badarinza et al., 2016).

Secondly, while education attainment is found to have a positive effect on the participation decision as in Cocco et al. (2005), it is not found to be a significant factor in the risky share decision conditional on participation in this study. As pointed out by Guiso and Paiella (2004), individual risk aversion plays a crucial role in both portfolio choice and education choice. Risk-tolerant individuals on average invest more in risky assets and education (e.g. more years of education). In previous cross-sectional studies, risk aversion is usually not explicitly controlled for as it is not available in the dataset, and education, which may capture the impact from risk aversion, is found to have a significant positive effect on household stockholdings. In this study, risk aversion is directly obtained from the data and controlled for, and the effect of education on stockholdings is not significantly different from zero among participants. This finding is consistent with Calvet and Sodini (2014).

Thirdly, it can be seen in Table 6 that, after using the "exogenous" subsample and including the regional effect, the impact of the leverage ratio on participation and risky share decisions becomes negative and economically important, while remaining statistically insignificant at conventional level. As Cocco (2005) points out, human capital can presumably be the reason that investments in risky financial assets and leverage appears to be positively correlated in the cross-sectional analysis. As housing has a dual dimension, both as an asset in households' portfolios and as a consumption good providing housing services, households with more human capital tend to purchase more expensive housing and take on more leverage. Meanwhile, although human capital is risky, it resembles bonds closer than stocks, which induces a tilt toward risky assets in households' portfolios. The decrease in the estimates of leverage ratio indicates that the potential bias of unobserved human capital is alleviated by accounting for the endogeneity of tenure choice with the "exogenous" subsample and potential regional effects.

One noticeable difference in the estimates is that habit has a positive effect on household financial risk taking in all specifications, though decreasing along the refined identifications. In this study, habit or subsistence is estimated directly from the questions about household

consumption of different items. The summary statistics are given in Table 4, and it can be seen that average household consumption is only slightly lower than average household labor income for homeowners without a purchase plan, a finding that is inconsistent with the previous research that Chinese households generally have a high saving rate (Kraay, 2000).

Given the design of this study, the contradicting estimated effect of habit may come from two origins. Firstly, human capital is not explicitly controlled for across specifications, and this can cause the estimates of the habit variable to be upward biased as both habit and financial risk taking are positively correlated with human capital (Cocco, 2005).

Secondly, the construction of the habit variable may suffer from measurement error if households' self-reported consumption is not the real amount spent. This would cause attenuation bias in the estimation of the habit effect. More precisely, if habit has a negative effect on household financial risk-taking decisions, measurement error in habit would cause the estimation to be less negative, and this can contribute to a positive effect acquired in this study together with the omitted variable bias from human capital analyzed above.

However, omitted variables can only affect the estimation of variables of interest when they are correlated. In this case, if human capital is correlated with housing risk variables and financial risk-taking decisions at the same time, the estimates of variables of interest can be biased. This concern is addressed in Section 4.2 with the subsample of homeowners with exogenous tenure choice.

5 Discussion of the Limitations

Utilizing rich data from the CHFS and institutional changes during the Chinese housing market reform, this paper studies the effects of house price risk on homeowners' portfolio decisions and is able to reconcile some findings of previous studies. However, it has several limitations that need to be acknowledged and discussed.

Firstly, province-level time series data used in this study may not fully represent house

price risk faced by homeowners. As pointed out by King and Leape (1998), most stock market participants hold a small number of stocks and their portfolio returns can vary substantially more than the stock market return. Thus using index return as a proxy for individual stock returns may introduce measurement error and lead to attenuation bias in the estimated effect on financial risk-taking decisions. Regarding labor income, seasonal variation is not captured in the annual time series used in this study. However, it can be an important risk that households face when making financial decisions. For house prices, though household exposure (i.e. housing wealth) has been considered in Section 4.4, house prices also vary across different locations and types of estate which are not directly observable from the data.

Secondly, the estimated effect of housing return volatility on the participation decision may be different as the whole set of regional fixed effects can be controlled. Appendix B provides outcomes from specifications defining regional effects in different ways. The estimates of housing return volatility vary across specifications, but all remain insignificant on the 10% level. The estimates of other covariates all remain similar.

Thirdly, human capital as an omitted variable could pose risks at the identification of variables of interest. For the subsample of homeowners with exogenous tenure choice, though the choices of time, location, and often size are beyond household control, it could be the case that households with higher ability and future labor income select themselves into employers located in large cities from the beginning, which may later on have higher housing return volatilities. Though this potential risk can be viewed as minor given the barriers to labor force mobility before the housing reform[11], it would be interesting to see the results after the inclusion of human capital.

Fourthly, wealthy households may be underrepresented in the sample used for this cross-sectional study. To eliminate an obvious source of heterogeneity, homeowners with a plan to buy new real estate are excluded from this study, and these homeowners on average have larger wealth in all different items for summary statistics. Though this group represents only 10% of the whole sample of homeowners, their portfolio decisions may be more relevant for financial

[11]See Chan and Zhang (1999) for an introduction of the household registration system or 'Hukou' in China.

market aggregates (Chetty et al., 2017).

Another limitation, as always in household finance studies, is inaccurate measurement of statistics. Household surveys provides a top-down view, while the nonresponse to important individual questions, responses influenced by imperfect recall, and illiquidity of assets leading to inaccurate valuations (e.g. real estate value) can be concerning (Badarinza et al., 2016).

6 Conclusion

This paper studies homeowners' financial risk-taking decisions in the presence of house price risk when they have no plan to move. It is found that housing return volatility has no significant effect on either participation or the share of liquid wealth invested in risky assets conditional on participation, while the correlation between housing return and stock return is found to have a negative effect on both participation and risky share decisions.

The crowding-out effect of the correlation between housing return and stock return holds in the research design that uses the whole sample as well as refined designs that (1) exploit the subsample of homeowners whose tenure choice is exogenous from institutional changes during the Chinese housing market reform and (2) consider potential regional disparities and (3) take into account homeowners' actual exposure to house price risk depending on household housing wealth. Though each of these designs is not necessarily definitive in itself, the stability of the results across different identifications indicates that the estimated results are probably not driven by confounding variables.

Using the subsample of homeowners with exogenous tenure choice, this paper is able to overcome the endogeneity problem of housing decision which is a highlighted difficulty in empirical analyses of portfolio choice over the life cycle. With this setting, this study is also able to reconcile some findings from previous research that (1) the wealth effect from rising house prices on homeowners' risky share decisions is insignificant and (2) education is positively correlated with risky asset market participation while its effect on risky share conditional on participation is insignificant after risk aversion is explicitly controlled for.

The sample period used in this study is the period after the housing market privatization and urbanization of China, during which the house prices in most cities have undergone one-way growth. As macroeconomic conditions change over time and a longer time series of house prices is available, it will be interesting to study how house price risk affects household financial risk-taking. Meanwhile, as more micro data becomes available, what role house price risk plays in the financial risk-taking decisions of renters will be another topic to explore to gain a full picture of household hedging motives.

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A Definitions of Variables

Table 10: Definitions of Variables

This table summarizes the variables used in this study. The first panel summarizes the variables used for identifications, and the second panel summarizes the ones for summary statistics purposes. Nominal variables used in identifications are in Chinese Yuan amounts and are winsorized at the 1st and 99th percentile before taking log values. Nominal variables used for summary purposes are converted into U.S. dollar amounts with an average exchange rate of 6.51 Chinese Yuan per dollar at the end of 2017.

Variable for identifications	Abbreviation	Description
Dependent variable		
Participation dummy	part	One if the household's risky share is positive.
Risky share	w	Risky wealth divided by the sum of risk-free wealth and risky wealth.
Independent Variable		
House price risk		
Housing return volatility	hp_std	Volatility of housing market real return.
Corr. between housing and stock	corr_hp_sto	Correlation between housing market real return and stock market excess return.
Corr. between housing and labor income	corr_li_hp	Correlation between housing market real return and labor income log growth.
Regional effects		
Regional dummy	reginc	One if a province has average annual labor income more than $15,000.
City size dummy	citysize	One if the city has a population more than the 75th percentile of that in the dataset.
East dummy	east	One if a province is located in eastern China according to definition of the NBSC, including guangdong, shanghai, zhejiang, beijing, tianjin, hebei, jiangsu, fujian, shandong, and hainan.
Demographic characteristics		
Age (years)	age	Age of the household head in year 2017. The variable is divided into 10 brackets.
Gender (Male=1, Female=0)	gender	One if the household head is male and zero otherwise.
Education	edu	Highest education household head participated in, taking integer value from 1 to 9 from lowest to highest.
Married dummy	marry	One if household head is married.
Number of household members	famsize	Number of individuals present in the survey, including newly born kids.
Financial characteristics		
Financial wealth	fa	The total value of risk-free wealth, risky wealth, private loans owed to the household, pension asset, whole life insurance, value of additional asset in managed account, and any other financial asset.
(Residential) home equity	homeeq	Value of primary and secondary residences, if present, subtracted by related mortgage.
Commercial real estate equity	comrehe	Value of other real estate (e.g. rental, industrial, and agricultural property) subtracted by related mortgage.
Leverage ratio	leveratio	Total debt devided by total asset. Total debt is the sum of mortgage related to residential and commercial real estate, loan value related to agriculture, education, health, stocks, and other forms of liabilities.
Risk aversion	ra	Taking integer value between 1 and 5 from least to most risk averse investment attitudes.
Labor income and related risk		
Household income	faminc	Sum of annual labor income of all household members. Labor income is the total amount of regular salary, overtime payments, bonuses etc.
Labor income volatility	li_std	Volatility of log growth of annual labor income.
Corr. between labor income and stock	corr_li_st	Correlation between labor income log growth and stock market excess return.
Retirement dummy	retired	One if the household head is retired.
Entrepreneur dummy	entred	One if any member of the household is self-employed or own any family business.
Unemployment dummy	unempd	One if the household head is unemployed.
Habit		
Habit	habit	Household monthly consumption of different items, including transportation, food etc.

Variable for summary statistics	Abbreviation	Description
High school dummy	highschool	One if household head attained a high school degree.
Rural dummy	rural	One if the household resides in rural area and zero if resides in urban area.
Homeowner dummy	ownd	One if the household owns its primary residence.
Home equity share	he_share	Home equity divided by net asset value (i.e. total asset minus total debt).
Total wealth ($)	tot_asset	The sum of financial wealth, residential real estate, commercial real estate, other valuables, agricultural asset, and private equity.
Risk-free wealth ($)	riskfree	Value of cash, current account, time deposit, government bonds, gold and money market funds.
Risky wealth ($)	risky	Value of stockholding, corporate bonds, derivatives and funds, excluding those invested in money market.
Other valuables ($)	othval	Value of cars, other vehicles, and valuables, such as antiques, jewelry, etc.
Private equity ($)	pe	Net asset value of household's share in non-publicly listed business.
Total pension assets ($)	tot_pension	The balance of individual social pension account and supplementary pension account. It sums across all household members.
Whole life insurance ($)	tot_ins	The insured value of individual commercial life insurance. It sums across all household members.

Table 11: Description of Employment Sectors

This table lists the abbreviations and corresponding description of employment sectors used in this study. The classification of employment sectors is from the NBSC, and it is the same with that in the 2017 CHFS to classify employment of individuals. Time series of aggregate labor income in each province and labor income risks are based on this classification.

Sector Code	Sector Description
AFF	Agriculture, Forestry, Animal Husbandry and Fishery
Min	Mining
Manu	Manufacturing
EGW	Production and Distribution of Electricity, Gas and Water
Cons	Construction
Tra	Transport, Storage and Post
Infor	Information Transmission, Computer Service and Software
WR	Wholesale and Retail Trades
H&C	Hotels and Catering Services
FI	Financial Intermediation
RE	Real Estate
Le	Leasing and Business Services
RTG	Scientific Research, Technical Services, and Geological Prospecting
WEP	Management of Water Conservancy, Environment and Public Facilities
HS	Services to Households and Other Services
E	Education
HSS	Health, Social Securities and Social Welfare
CSE	Culture, Sports and Entertainment
PM&SO	Public Management and Social Organization

B Robustness of Results with Extensions

Location effects: To check whether the outcomes obtained in Section 4.3 are dependent on the way that regional effects are defined, another two definitions are used in this section: (1) a city dummy that takes value of one if the city has a population more than the 75th percentile of that in the dataset and (2) a province dummy that takes value of one if a province is located in eastern China according to the definition of the NBSC[12].

From Table 12, the estimates of α_2, β_1, and β_2 remain similar across different specifications in both magnitude and significance level. The estimate of α_1 changes in magnitude across specifications while remain insignificant on the 10% level. The estimates of other covariates remain similar under different specifications.

Income Risk: Next, I consider the effect of the correlation between labor income growth and housing return. This variable is constructed for every province-sector pair, and it varies substantially across sectors in the data, ranging from -0.064 for the hotels and catering services (H&C) sector to 0.311 for the education (E) sector. This can be compared to Cocco (2005) who constructs an equally weighted house price index with the PSID data from 1970 to 1992 and finds that cyclical fluctuation in house prices is strongly positively correlated with aggregate labor income with a coefficient of 0.553. Column 3 and 6 in Table 12 show that the correlation between housing return and labor income log growth has no significant effect along either margin, consistent with Chetty et al. (2017). The estimates of α_2 and β_2 remain similar in both magnitude and significance level.

[12]The information on city level (e.g. name) is masked in the dataset due to confidentiality, while the households living in the same city are marked with unique city labels. This enables me to identify the relative size of the city in terms of population as the dataset is nationally representative.

Table 12: Robustness Check

This table reports probit estimates and OLS estimates of house price risk on stock market participation and stock shares respectively, with different definitions of regional effects. Specification (3) and (6) include the correlation between housing return and labor income log growth. Variables are summarized in Table 10. All specifications use the subsample of homeowners with exogenous tenure choice. All standard errors are clustered at the city level. R-sq is the McFadden pseudo R squared for probit regressions, and is the adjusted R squared for OLS regressions. Risky share, debt ratio, and all nominal values are winsorized at the 1st and 99th percentile.

Dependent variable:	Participation			Risky share		
	(1)	(2)	(3)	(4)	(5)	(6)
Regional effect						
Regional dummy	0.001	0.023	0.045	-0.002	-0.017	0.001
	(0.01)	(0.32)	(0.44)	(-0.10)	(-0.90)	(0.03)
House price risk						
Housing return volatility	1.118	0.968	0.720	0.096	0.191	0.103
	(0.91)	(1.00)	(0.58)	(0.39)	(0.69)	(0.29)
Corr. with stock market retur	-0.225**	-0.219**	-0.243**	-0.093***	-0.097***	-0.093***
	(-2.34)	(-2.29)	(-2.15)	(-3.25)	(-3.21)	(-3.11)
Corr. with labor income			-0.037			0.044
			(-0.28)			(1.00)
Definition of regional dummy	citysize	east	reginc	citysize	east	reginc
N	5265	5265	5265	1130	1130	1130
R-sq	0.353	0.353	0.353	0.072	0.072	0.071
t statistics in parentheses				* p<.10	** p<.05	*** p<.01

C Sample Summary Statistics

Table 13: Summary Statistics for Poor and Normal-Quality Records in CHFS Sample

This table includes all households in the 2017 wave of CHFS with household head between 16 and 90 years old. All variables are described in Appendix Table 10. All nominal variables are transformed into U.S. dollar with an exchange rate of 6.51 Chinese Yuan per dollar at the end of 2017 and are winsorized at the 1st and 99th percentile before computing summary statistics. Sample mean for income is computed among households with non-zero income value. Other mean values are computed among all households.

	Low-Quality Records				Normal-Quality Records			
	Mean	SD	N	N of Zeros	Mean	SD	N	N of Zeros
Demographic characteristics								
Age (years)	55.957	15.61	1,004	0	56.09	14.042	38,855	0
Gender (Male=1, Female=0)	0.743	0.437	1,004	258	0.795	0.404	38,855	7,955
High school dummy	0.338	0.473	994	658	0.355	0.479	38,855	25,040
Number of household members	3.404	1.705	1,004	0	3.171	1.546	38,855	0
Number of children	0.481	0.762	1,004	652	0.468	0.756	38,855	25,766
Rural (Rural=1, Urban=0)	0.323	0.468	1,004	680	0.318	0.466	38,855	26,483
Employment and wealth								
Retirement dummy	0.126	0.333	1,004	877	0.174	0.379	38,855	32,089
Unemployment dummy	0.188	0.391	1,004	815	0.123	0.329	38,855	34,066
Entreprenrial dummy	0.377	0.485	1,004	625	0.379	0.485	38,855	24,147
Income ($)	11,886	8,863	1,004	405	10,640	7,759	38,855	17,210
Total wealth ($)	136,311	268,643	1,004	0	141,815	250,214	38,855	0
Risky asset market participation								
Participation dummy	0.123	0.329	886	935	0.163	0.369	38,855	35,055
Number of observations	1,004				38,855			

Table 14: Summary Statistics for Urban and Rural Households in CHFS Sample

This table includes all households in the 2017 wave of CHFS with household head between 16 and 90 years old, with normal-quality responses during the interview. All variables are described in Appendix Table 10. All nominal variables are transformed into U.S. dollars with the exchange rate of 6.51 Chinese Yuan per dollar at the end of year 2017. Home equity share, leverage ratio, risky share, and all nominal values are winsorized at the 1st and 99th percentile before computing summary statistics. Sample means for household income, home equity, home equity share, total financial wealth, leverage ratio, and risky share are computed among households with non-zero values in these items. Other mean values are computed among all households.

	Urban Households				Rural Households			
	Mean	SD	N	N of Zero	Mean	SD	N	N of Zero
Demographic characteristics								
Age (years)	55.273	14.776	26,483	0	57.839	12.141	12,372	0
Gender (Male=1, Female=0)	0.751	0.433	26,483	6,602	0.891	0.312	12,372	1,353
High school dummy	0.465	0.499	26,456	14,141	0.118	0.323	12,362	10,899
Number of household members	2.999	1.408	26,483	0	3.539	1.751	12,372	0
Number of children	0.420	0.685	26,483	17,973	0.572	0.879	12,372	7,793
Employment and income								
Retirement dummy	0.247	0.431	26,483	19,939	0.018	0.133	12,372	12,150
Unemployment dummy	0.107	0.309	26,483	23,642	0.157	0.364	12,372	10,424
Income ($)	6,222	4,447	26,483	10,811	4,567	3,195	12,372	6,489
Housing:								
Homeowner dummy	0.8	0.4	26,483	5,288	0.935	0.247	12,372	809
Home equity ($)	174,306	251,325	22,077	0	34,053	71,509	10,742	0
Home equity share	0.801	0.279	22,070	26	0.726	0.431	10,737	0
Wealth								
Total wealth ($)	190,026	286,372	26,483	0	40,785	84,430	12,372	0
Financial wealth ($)	23,115	45,666	26,483	637	5,443	16,296	12,372	580
Leverage ratio	0.885	2.165	26,483	22,575	1.269	2.431	12,322	8,772
Annual habit ($)	11,274	9,515	26,483	22,593	6,000	6,011	12,372	0
Risky asset market participation								
Participation dummy	0.223	0.416	25,446	19,773	0.027	0.161	11,216	10,918
Risky share	0.461	0.314	22,070	16,397	0.297	0.295	11,216	10,918
Risk Aversion	4.181	1.287	26,474	0	4.546	1.234	12,371	0
Number of observations	26,483				12,372			