How do house prices affect household consumption growth over the life cycle?*

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Abstract

We use a rich household panel dataset to study how house price changes affect household consumption decisions over the life cycle. We find that: (i) Young homeowners with greater income volatility have higher consumption sensitivity, supporting a precautionary saving channel; (ii) Older households with a higher housing equity to wealth ratio have higher consumption sensitivity, supporting a housing wealth effect; (iii) Young- and middle-aged homeowners are more likely to use cash-out refinancing after house price increases than old-aged homeowners, supporting a borrowing constraints channel. These results are consistent with a life cycle model with borrowing constraints and risky labor income.

JEL classification: D1, E21, G11, G21.

Keywords: House prices; Housing wealth; Household consumption; Household finance; Life cycle; Borrowing constraints; Precautionary savings; Refinancing; Income risks.

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1. Introduction

Home property is often the most important asset in a household's portfolio. It is usually the most valuable asset a household owns and the most readily available collateral for borrowing.[1] Because house prices are subject to large swings, housing price volatility poses great risk on household welfare (Mian, Rao, and Sufi, 2013). This risk is further amplified by the use of substantial leverage by homeowners. The recent U.S. housing boom and subsequent downturn during the subprime mortgage crisis put a spotlight on these risks. In the aftermath of the Great Recession, one particular concern of policy makers and academics is the dampening effects of falling house prices on household consumption[2] (Mian, Rao, and Sufi, 2013; Kaplan, Mitman, and Violante, 2015; Berger, Guerrieri, Lorenzoni, and Vavra, 2015). In order to design effective policies to influence consumption, an important task for policy makers and academics is to understand how house price changes can influence households' consumption decisions.

Our objective in this paper is to study how three channels—housing wealth, borrowing constraints, and precautionary savings motives—affect consumption sensitivity to house prices, both theoretically and empirically. We present a parsimonious model to illustrate how these effects vary over the life-cycle, and across households with different characteristics such as liquid wealth, borrowing constraints, and income volatility. Various simplifying assumptions in our model enable us to derive a closed-form solution that helps provide a deeper understanding of the economic forces driving household decisions in such a complex setting. Using the lens of this model, we examine how house prices affect consumption decisions of heterogeneous households using a novel dataset: the household, income and labor dynamics in Australia (HILDA) survey data. This dataset follows the same households from 2001 and

[1]In the U.S., for example, housing wealth accounted for about half the total net worth of households in 2008 (Iacoviello, 2011) and home mortgage debt was equal to about half of the market value of houses in 2007 (Greenspan and Kennedy, 2008).

[2]In the U.S., personal consumer expenditure accounted for 70% of gross domestic product in 2008. During and after the great recession, the U.S. economy has seen a deep and persistent drop in household consumption (Parker and Vissing-Jorgensen, 2009; Petev, Pistaferri, and Eksten, 2011).

contains detailed spending records as well as other household characteristics. This allows us to overcome some limitations of the panel datasets applied in previous empirical studies that typically do not have good measures of consumption, income, or housing.

The literature recognizes reasons why housing wealth, borrowing constraints, and precautionary savings motive may influence household consumption sensitivity to house prices (see e.g. Lustig and Van Nieuwerburgh (2005), Campbell and Cocco (2007) and Gan (2010)): (i) Under standard assumptions, the optimal consumption level chosen by a household is determined by their expected present value of life-time wealth (the permanent income hypothesis (PIH)). This gives rise to a housing wealth effect, where optimal consumption increases as housing wealth increases, all else equal.[3] (ii) In the presence of borrowing constraints, the PIH does not hold. If households are unable to borrow enough to consume from their expected future income, then their consumption level will be confined to their current liquid savings plus the amount they are able to borrow. Further, if the amount households are able to borrow depends on the value of their housing collateral, then household consumption exhibits excess sensitivity to house prices compared to the case with no borrowing constraints. (iii) Some households may not currently be borrowing constrained but may increase their savings to forearm themselves against the possibility of being constrained in the future (the precautionary savings motive). These households will also exhibit excess consumption sensitivity to house prices as an increase in the value of housing collateral means they can borrow more in times of need, and hence they need to save less in the current period.

Our parsimonious life-cycle model captures these three sources of housing-consumption sensitivity in a setting where households make consumption-investment decisions over three periods representing young-, middle-, and old-age. We then empirically evaluate which of

[3]Increased house value does not necessarily increase the real wealth of a homeowner, as it may be offset by higher implicit rental costs (Sinai and Souleles, 2005). A household can gain from rising house prices only if it has more housing assets than its future rental liability, such as an elderly household with a large house. In contrast, those who plan to obtain more housing assets in the future, such as young renters, will be adversely affected by rising house prices. This suggests that the housing wealth effect is a redistributive effects and whether a household benefits or loses depends on the characteristics of the household (Campbell and Cocco, 2007; Buiter, 2008).

these three channels dominate in each stage of the life-cycle. In all our tests, the richness of our panel data enables us to control for both unobservable household fixed effects as well as time-varying factors such as household size, income and housing positions, thereby improving identification.

We find that young homeowners have a large positive and significant consumption sensitivity to house prices. This sensitivity is likely to be driven mostly by the precautionary saving motive as young homeowners with higher income volatility tend to have higher consumption sensitivity to house prices. Further, consistent with our model, young homeowners with low and medium levels of liquid wealth tend to have the largest sensitivity. For old homeowners, we find a positive and significant consumption sensitivity to house prices, which supports a housing wealth effect. This sensitivity tends to be higher if they have a large ratio of housing wealth to total net worth, which is consistent with our model prediction. We also find that both young and middle-aged homeowners are more likely to use cash-out refinancing to adjust their consumption when house price changes. This is consistent with our model, which suggests that both young and middle-aged homeowners are more likely to be borrowing constrained.

Our study contributes to the literature in several ways. First, our parsimonious model with closed-form solutions provides a useful framework to fix ideas and understand various empirical arguments in the existing literature. In contrast, related models typically rely on numerical solutions (Yao and Zhang, 2005; Li and Yao, 2007; Yang, 2009).

Second, using our panel data with controls for household and time fixed effects, and time-varying factors such as household size and income, we find evidence that household consumption responds to house price changes. One concern for identification is that omitted variables, such as future productivity growth and financial liberalization, drive both consumption growth and house prices, thus leading to the observed correlation between the two (Attanasio and Weber, 1994; Attanasio, Blow, Hamilton, and Leicester, 2009). To control for such factors, we compare housing-consumption sensitivity between homeowners and renters over the life-cycle (Chaney, Sraer, and Thesmar, 2012; Schmalz, Sraer, and Thesmar, 2015). Although omitted aggregate variables should largely affect owners and renters in the same life cycle stage homogeneously, rising house prices only lead to wealth gains or increased collateral for homeowners. In the data, we find that homeowners have a statistically significant housing-consumption sensitivity of 0.163, while renters have insignificant sensitivity close to 0, inconsistent with the omitted variable argument.[4] Further, we find differences in consumption sensitivity across groups classified by credit constraints, income volatility and expected tenure. These differences are unlikely to be driven by omitted variables.

Third, consistent with our model prediction, we show that income growth volatility is a key dimension that identifies young homeowners who have high sensitivity to house prices. Our evidence highlights the precautionary savings nature of housing investment for young homeowners with substantial income risk. Gan (2010) concludes that among the majority of households who do not refinance, consumption sensitivity appears to be due to a reduction in precautionary savings as it is stronger among less leveraged households, responds to the unpredictable component of housing returns, is stronger for younger households, and is stronger for discretionary spending. We enhance this evidence and document that consumption sensitivity is higher for young homeowners with higher income volatility, providing direct support for the precautionary savings nature of housing investment.

Lastly, we show that higher house prices significantly increase the probability of cash-out mortgage refinancing: a 10% rise in house prices increases the probability of refinancing by 0.76%, which is about 18.5% of the refinancing probability of our sample (4.1% of homeowners each year).[5] Further, refinancing significantly boosts non-durable consumption growth: on average, households increase non-durable spending by nearly 8.5% in the year they refi-

[4] The difference between the two groups is particularly significant among young households. This is inconsistent with the argument that future productivity growth drives the correlation between house prices and consumption growth because both young owners and renters should enjoy the most from future productivity growth compared to the middle and old households, and both should have positive consumption sensitivity to house prices.

[5] About 77% mortgages in our sample are adjustable rate mortgages (ARMs) and 15% are fixed rate mortgages (FRMs). This suggests that refinancing is mainly for cash-out purposes.

nance their mortgage. This indicates that households spend at least part of the withdrawn equity for current consumption. Mian and Sufi (2011) note that if home-equity based borrowing is used for consumption rather than paying down more expensive debts, the real and policy implications are substantial. Because Mian and Sufi (2011) do not have household-level consumption data, they provide indirect evidence that homeowners borrow against their home equity for consumption by showing that homeowners do not refinance to buy real estate or financial assets, or to pay down credit card debt. Mian, Rao, and Sufi (2013) provide evidence that housing wealth shocks impact zip-code level consumption. Adding to this zip-code-level evidence, our household-level analysis supports the conjecture that rising house prices allow constrained households to access increased home equity through refinancing and thereby increase their consumption.

We proceed as follows. We present our theoretical model in Section 2 and discuss our empirical model and the identification strategies in Section 3. Section 4 describe our data and variable construction. Empirical analysis is in Section 5, and Section 6 concludes.

2. Theory

To illustrate how housing prices could affect household consumption over the life cycle, we consider a conceptual (partial equilibrium) model in which a household maximizes lifetime utility by optimizing over nondurable consumption and debt/saving, given a distribution of risky labor income and house prices. The household is endowed with housing and cash.

We study and contrast two versions of the model. In the unconstrained version, homeowners are permitted to borrow by shorting bonds without any constraints. In the constrained version, homeowners are forbidden to borrow more than a fraction of their house value. This is motivated by the role of a house as collateral. Using this model, we describe key elements of the consumption-saving trade-offs faced by a homeowner over the life-cycle.

2.1. Model setup

We model the consumption, and debt/savings choices of homeowners who live for three periods ($t = 0, 1, 2$) as young-, middle-, and old-aged. Three is the minimal number of periods that captures the heterogeneity of homeowners across age groups, which we wish to emphasize: the borrowing-constrained young, the saving middle-aged, and the dissaving old (Constantinidies, Donaldson, and Mehra, 2002). In each period t, the household optimizes nondurable consumption c_t, and their savings b_t in risk-free bonds.[6] Bonds and wages are denominated in units of the consumption good.

The household derives utility from nondurable goods for each period before period T. The time between any two periods in our model corresponds to about 20 years in a household's life. They consume all their wealth w_T in the last period. Each period, the household invests/borrows in bonds. The household's optimal investment in risky assets or timing of house purchase/sale is not considered here.

2.1.1. Preferences

We assume that the utility function is linear-quadratic in consumption, $U(c) = c + \frac{\theta}{2}c^2,\ \theta < 0$. Homeowners maximize their lifetime utility over nondurable consumption:

$$U(c_0, c_1, c_2) = c_0 + \frac{\theta}{2}c_0^2 + \beta E\left[c_1 + \frac{\theta}{2}c_1^2\right] + \beta^2 E\left[c_2 + \frac{\theta}{2}c_2^2\right]; \qquad (1)$$

where $E[]$ represents expectation, and β is a discount factor, which also determines the riskless rate $r_f = \frac{1}{\beta}$. θ is the risk-aversion parameter.

An important advantage of this utility specification is that optimal consumption exhibits the certainty equivalence property in the absence of borrowing constraints. That is, optimal

[6]Because we focus on the consumption sensitivity of homeowners over the life cycle, we implicitly assume that house price expectations are such that owning a home dominates renting, and those that can afford homeownership in the first two periods of their life will purchase a home as soon as their borrowing capacity allows. In the last period, we assume that households will sell their house and consume all their terminal wealth. A household's optimal timing of home sale or purchase is not considered here.

consumption depends only on the expected future income and expected present value of wealth (financial and housing). The variance and higher moments of income and housing wealth do not affect optimal consumption in the absence of borrowing constraints. This feature of linear-quadratic utility helps isolate the housing wealth effect from the effect of borrowing constraints and precautionary savings.

2.1.2. Housing

House prices in our model are exogenously specified and have the following dynamics:[7]

$$h_t = h_{t-1} + (\bar{h} - h_{t-1})v + \epsilon_{h,t}; \tag{2}$$

where $\bar{h}$ is the long-run average level of house prices, $v \in [0, 1]$ and $E[\epsilon_{h,t}] = 0$. When $v = 1$, the house prices have a constant expectation of $\bar{h}$ and current house prices do not affect expectation of future house prices. When $v = 0$, house prices follows a martingale process. When v is in between 0 and 1, house prices follow a mean-reverting process. Empirical evidence suggests that house prices in the long-run tend to have reversal property (Piazzesi and Schneider, 2016) and therefore a realistic calibration for v is likely to be in between 0 and 1. For convenience, we assume that ϵ_h is equally likely to be either $+\delta_h$ or $-\delta_h$, with $0 < \delta_h < \bar{h}$.

2.1.3. Borrowing constraint

The level of borrowing is restricted by the house value such that:

$$b_t \geq -\phi h_t, \tag{3}$$

[7]We could introduce rent in the model as the determinant of house prices. However, as long as the rental yield is constant, there would be a deterministic relation between rent and house prices, and their distinction would not be meaningful for the optimization problem.

where ϕ determines that maximum proportion of house value that households can borrow. We assume that $\frac{1}{2} \leq \phi \leq 1$ to ensure that households can borrow a substantial proportion and are not constrained to sell their house in order to consume their housing wealth. In our model, the borrowing constraint only binds due to low labor income realizations.

2.1.4. Labor income

We assume that households receive deterministic labor income in young-age, and stochastic income at the start and end of the middle-age. Once the labor income level is realized at the end of the middle-age, the old age households face no further labor income uncertainty.[8] We do not consider the labor-leisure decision and assume the income process are exogenous and independent.

More formally, a homeowner earns labor income y_t for $t = 0, 1, 2$. For $t = 0$, we assume the income in the period (y_0) is known at the start of the period. For $t = 1, 2$, we assume the labor income to be either high income, $y_u = \bar{y} + \delta_y$, with probability of p, or low income, $y_d = \bar{y} - \delta_y$, with probability $(1 - p)$. Therefore we have $E_0[y_1] = E_1[y_2] = \bar{y} + (2p - 1)\delta_y$.

These stylized assumptions are meant to capture two key aspects of reality in a parsimonious way. First, the major future income uncertainty is faced by the young and middle-aged households.[9] Second, both the young and middle-aged would like to borrow against future income, and the old will not borrow as they do not have future income.

2.1.5. Budget constraint

We denote the level of savings for future consumption (or borrowing for current consumption) as b_t, where a negative number represents borrowing. The household could save/borrow b_t at the risk-free rate, r_f. We calculate w_t (the liquid cash on hand or short-term debt liability) by adding period t financial (nonhousing) wealth $r_f b_{t-1}$ to period t labor income y_t.

[8] Old households can receive income from both government pension and personal retirement savings, but we assume that this level is known by the end of middle-age.

[9] The simplifying assumption that the income of the young ($t = 0$) is deterministic may be relaxed to allow this income to be stochastic without meaningfully changing the solution of the model.

That is $w_t = r_f b_{t-1} + y_t$. The budget constraints for nondurable consumption in each period are as follow. In period $t = 0$, $b_0 = w_0 - c_0$. In period $t = 1$,

$$b_1 = w_1 - c_1 = r_f b_0 + y_1 - c_1, \tag{4}$$

with $w_0 = y_0$.[10] Final period wealth and consumption are given by

$$w_2 = c_2 = r_f b_1 + y_2 + h_2, \tag{5}$$

where the price of a house at period t is denoted as h_t.

2.1.6. *Optimization problem*

Households maximize lifetime utility (equation 1), subject to the borrowing constraint (equation 3) and the budget constraints listed in section 2.1.5. For simplicity and algebraic convenience, we assume that interest rate is zero so that $r_f = \frac{1}{\beta} = 1$. In Appendix A, we solve the model recursively from the last period and discuss technical details regarding the housing-consumption sensitivity of homeowners in the three periods.

2.2. *Testable predictions*

The model illustrates how house price changes can affect a homeowner' consumption growth through different channels over the life-cycle of a household. Based on the model and the life-cycle characteristics of household wealth, we can generate some predictions of the cross-sectional relationship between house price changes and household consumption growth.

In the old-age period, households consume their wealth, which includes the current value of the house. The higher the house value, the larger the wealth of the household, and thereby the larger their consumption will be: the housing wealth effect. Since they have no

[10] y_0 can also be interpreted as the starting income plus wealth inherited by the young household. As we cannot distinguish initial income and inherited wealth, we simply assume initial wealth equals income.

future labor income to borrow against, old-age households are not influenced by borrowing constraints or precautionary savings motives. For these households, our model makes the following prediction:

Prediction 1: In the old age, a larger share of housing wealth to total wealth is associated with a greater sensitivity of consumption to house prices due to a wealth effect.

In our model, consumption elasticity of old homeowners is given by $E_{h_2} = h_2/w_2$ (see Appendix A, Equation 25). This says that a 1% change in house price implies a greater percentage change in wealth for homeowners who have a larger share of wealth tied to house prices.

At the other end of the life-cycle, our model predicts that the housing wealth effect should be smallest for young homeowners due to their long remaining life horizon. However, both the precautionary savings channel and the borrowing constraint channel are active for young homeowners, who tend to be more liquidity constrained with limited savings. Accordingly, our model makes the following prediction for young homeowners:

Prediction 2: Young homeowners who have high income volatility (but are neither borrowing constrained nor have high liquid savings) should have a larger consumption sensitivity to house prices due to a stronger precautionary saving motive.

In our model, the consumption elasticity of young homeowners increases with higher income volatility for an homeowner with an intermediate level of w_0 (see Appendix A, Equation 27). The housing-consumption sensitivity of young homeowners is linked to income volatility as a higher level of income volatility implies a higher magnitude and probability of an unfavorable income realization (it is a function of δ_y, p). To forearm against this possibility, households consume less (save more) compared to the case with no borrowing constraints. However, when house prices rise, their ability to borrow and consume in these adverse states increases. Consequently, they optimally save less and increase current consumption.

Another implication of our model is that, compared to old homeowners, young and middle-aged homeowners are more likely to have consumption demands greater than their ability to finance them through savings and borrowing. The present value of total wealth of old-aged homeowners is never likely to be more than the amount they can borrow (assuming they are able to borrow against the full value of the house, $\phi = 1$). However, young and middle-aged homeowners are borrowing constrained if $w_1 < E_1[y_2] + E_1[h_2] - 2 * \phi h_1$ or $w_0 < w_d$, where w_d is defined in Equation 22. Young and middle-aged homeowners may be constrained from consuming till their optimal level as they have non-collateralizable future labor income. The maximum amount they can borrow is ϕh, which depends on house prices and can be less than the amount they need to reach their optimal consumption levels. This observation suggests the following:

Prediction 3: For the same level of savings/debt and housing wealth, young and middle-aged homeowners are more likely to be borrowing constrained compared to old homeowners as they are unable to borrow against the expected value of their future labor income.

Prediction 3 can be tested by comparing the propensity of young, middle-aged, and old homeowners to refinance their mortgages and boost consumption growth. Following our prediction, we should expect that compared to the old, the young and middle-aged homeowners are more likely to refinance their mortgages to increase their consumption when house prices rise as their borrowing constraints are relaxed.

Some caveats regarding our model are prudent. We only model the behavior of a household in isolation and abstract away from general equilibrium considerations where house prices are determined by the collective behavior of households. In our model, Predictions 2 and 3 hold as long as the mean-reversion parameter v is not one. Since house prices are autocorrelated, this assumption is likely to be satisfied under most house prices processes. We also abstract away from the choice of housing consumption and when a household should optimally become a homeowner (Agarwal, Hu, and Huang, 2015). Instead, we model the nondurable consumption decisions of households who are already homeowners, and plan to remain homeowners in all three periods. Accordingly, in our empirical work, we focus on the behavior of homeowners. When the costs incurred in buying and selling a house are large, this simplifying assumption is likely to be reasonable modeling approximation.

In an extension of our model in Appendix A.3, we consider the case when middle-aged households incur transaction costs when up-sizing to a larger home. This is motivated by the observation that the number of members in households tends to increase in the middle-age. We find that, when the transaction costs (taxes, agent fees, renovation etc) are large, the housing-consumption sensitivity of middle-aged households reduces considerably.

3. Empirical design

In this section, we first discuss some of the empirical challenges faced by previous empirical studies and then present our identification strategy and empirical model.

3.1. Empirical challenges in previous studies

There is a growing empirical literature that examines the relationship between consumption and house prices. Macro studies generally find significant positive correlations between the aggregate consumption growth and house price changes (Case, Quigley, and Shiller, 2005, 2013; Carroll, Otsuka, and Slacalek, 2011). However, it is not clear what drives the correlation. Campbell and Cocco (2007) point out that such a correlation does not necessarily imply a direct housing wealth effect and there might be several alternative explanations.

First, it is possible that the correlation between house prices and consumption may be driven by unobserved common macroeconomic factors such as future productivity growth. Indeed, Iacoviello and Neri (2008) find that a large portion of the correlation seems to be driven by such common factors. In contrast, Mian et al. (2013) use an instrumental variable approach and estimate a large consumption elasticity of 0.6 to 0.8 with strong heterogeneities across US zip codes.

Second, as shown in our model, increases in house prices can relax borrowing constraints, particularly for the young and middle-aged homeowners. This feature of the housing asset can generate a positive consumption response to an increase in house value through two mechanisms: a) allow liquidity-constrained households to extract home equity for current consumption through for example cash-out refinancing (Hurst and Stafford, 2004), and b) reduce the need for precautionary savings due to a homeowner's increased ability to refinance in the future if they experience negative income shocks (Gan, 2010). Importantly, our model demonstrates that the various channels do not necessarily contradict each other. Instead, they might co-exist among households of different life-cycle stages. Therefore, it is important to control for life-cycle stages in examining the various mechanisms.

Another major challenge for macro studies is to control for household heterogeneities. Accounting for household characteristics is inherently difficult using data at the country-, state-, or zip-code-level but nonetheless important. For example, Calomiris, Longhofer, and Miles (2013) consider age composition, wealth distribution, and housing wealth share at the state level in the U.S. and show that those factors are significant in examining the housing wealth effect.

The difficulty in controlling for household heterogeneities in macro studies can be overcome by using micro datasets of households. Early studies using the PSID data from the U.S., for example Skinner (1996) and Engelhardt (1996), provide indirect evidence that housing wealth affects consumption, as the measures of consumption are inferred from changes in household savings. Similarly, Disney, Gathergood, and Henley (2010) estimate consumption from changes in savings using the British household panel survey (BHPS), and Browning, Gørtz, and Leth-Petersen (2013) do so using a Danish panel dataset. The lack of direct measures of consumption is often a problem in household panel datasets.

An alternative method is to use consumer expenditure surveys. Unfortunately, these surveys typically only follow the same households for a short period of time. Studies using such datasets typically require researchers to construct a pseudo-panel of households (based on cohorts). For example, Campbell and Cocco (2007) construct a pseudo-panel from the British FES data and use county-level house price indexes to analyze the relation. They find that the consumption sensitivity to house prices is largest for older homeowners and smallest for young renters, supporting the wealth effect. However, this conclusion has been later challenged by Attanasio et al. (2009) using the FES data, Disney et al. (2010) using the BHPS, and Browning et al. (2013) using a Danish dataset.

In contrast to survey-based data, Gan (2010) links credit card data from six issuers with mortgage applications from a large bank in Hong Kong. She thereby obtains an impressive panel with consumption growth (based on credit card spending), and household information in mortgage applications such as age and occupation. She finds evidence supporting a wealth effect, a liquidity-driven refinancing effect, as well as a precautionary saving effect. Some challenges in using this approach are the representativeness of the sample, controls for time-varying household characteristics, and the length of sample period. Indeed, Gan (2010) finds that people above age 50 are under-represented in her three-year data sample. She also lacks controls for household-level income growth and volatility that are likely to be important in examining the precautionary saving channel.

3.2. The empirical model

To overcome the challenges in previous empirical studies, we use a new panel data that follows the same Australian households between 2005 and 2013, and provides detailed records of household spending on non-durable goods and services. We will provide a detailed description of the data and the variables in the next section. In our empirical analysis, we not only control for a range of time-varying household characteristics, such as household size and income, but also unobservable time-invariant factors through household fixed effect. Our baseline empirical model examines the impact of house price changes on consumption growth using the following empirical model:

$$\Delta Log(C_{it}) = \beta_0 \Delta Log(HP_t^j)$$
$$+ \beta_2 \Delta Log(Inc_{it}) + \beta_3 \Delta Log(Size_{it}) + \beta_4 \Delta Log(Mtg_{it}) + \beta_5 \Delta Log(Rent_{it})$$
$$+ \beta_6 \Delta UNEMP_{it} + \beta_7 \Delta SP_t^j + \beta_8 \Delta SI_t^j + \alpha_i + \eta_t + u_{it}, \quad (6)$$

where i indexes household, t year, and j state and ΔLog indicates changes in natural log. Our main parameter of interest, the consumption sensitivity to house price changes ΔHP_{jt}, is given by β_0. α_i and η_t are household and year fixed effects, respectively. We also control for time-varying household characteristics, including household income Inc_{it}, household size $Size_{it}$, mortgage payments Mtg_{it}, and rent payments $Rent_{it}$.[11] Time-invariant household characteristics, such as gender and education, are omitted due to the use of household fixed effects. Age and age squared are excluded as their effect is indistinguishable from year fixed effects after taking first difference (Deaton, 1992). As we use state-level house price changes, we control for other state and local economic conditions by including changes in state gross product SP_t^j, income per capita SI_t^j, and changes in local unemployment rates $UNEMP_{it}$. Year fixed effects are included to control for country-level factors, such as changes in interest rates and stock market returns. u_{it} are residuals.

In some of our specifications to test for significant differences in consumption sensitivity across groups of households, we add an interaction between house price changes and dummy (or categorical) variables for whether the household belongs to the group of interest ($GroupDummy_k$). In such specifications, the coefficient of interest is that of the interaction term, which measures the differential consumption elasticity of various household groups compared to the baseline group. If there are significant differences across groups of households, the difference should be due to their group membership. To control for any

[11] Here the mortgage payments control for household leverage. Also, as most households have adjustable rate mortgage in Australia, including mortgage payments partially controls for the impact of interest rate changes (Campbell and Cocco, 2007)

economy-wide shocks and state-level factors that differentially influence groups of households, we interact the time fixed effect η_t and all other state-level factors with the group membership dummy.

To test whether rising house prices increase the probability of refinancing, controlling for other well-documented refinance motives, we use the following random-effect probit model:

$$Refinance_{it} = a + b\Delta Log(HP_{jt}) + \boldsymbol{c * Controls_{it}} + e_{it}, \tag{7}$$

where $Refinance_{it}$ is a dummy variable equal to one if household i refinances its mortgage in year t. The control variables include household demographics, liquidity shocks caused by adverse events, and portfolio diversification motives (Hurst and Stafford, 2004). To evaluate robustness, we also perform this analysis using a linear probability model, a simple probit model, and various logit models.

4. Data and variable construction

We apply the HILDA data for empirical analysis. HILDA is a national representative longitudinal survey data designed to facilitate studies on income, labour market participation, health, and housing issues of Australian households.[12] The survey began in 2001 with 7682 households and has been conducted annually following the same families mainly through face-to-face interviews by professional interviewers. In many aspects, HILDA presents an ideal setting to study the relation between household consumption and house prices. First, starting in 2005, HILDA has collected regular household spending on a wide range of non-durable goods and services, which has often been missing in other panel datasets. Second, HILDA contains detailed housing-related information, such as homeownership, tenure and movements, mortgages, and refinancing, which enables us to conduct tests based on the housing position of a household and better identify specific channels. Third, the variety of

[12] For details of the survey, refer to the User Manual prepared by Summerfield, Freidin, Hahn, Li, Macalalad, Mundy, Watson, Wilkins, and Wooden (2014).

other information collected in HILDA, such as income, wealth, and demographics, permits controls for household heterogeneities. Lastly, the nature of the panel data improves the comparability of consumption behavior over time, and allows for controls of unobservable household characteristics through household fixed effects.

We use wave 5 (2005) to wave 13 (2013) of the HILDA data, the longest range with records of spending at the time of the study. Most questions in the survey, such as income and spending, ask for values of variables covering the prior financial year (July 1 to June 30). Other questions, such as family composition and wealth, give values as of the survey dates.[13] Throughout the paper, when we refer to the value of a variable in year t, we mean the value as reported in the survey taken in the year t. Next, we will describe the sample selection procedure and the main variables used in the analysis.

4.1. Sample selection

Applying the sample selection procedure described in Appendix B, we obtain a balanced panel of 4620 households with both household and individual level information between 2005 and 2013. We classify households based on their homeownership status, which fundamentally determines how they respond to house price changes. Overall, we consider four groups of households: homeowners, renters and those who change between homeowner and renter once during the sample period.[14] The focus of this study will be 1956 homeowners who did not move during the sample period, as this group of homeowners corresponds most closely to the household type in our model. In addition, with non-moving homeowners, we can isolate the impact of house price changes from that of changing housing assets and reduce the potential estimation bias arising from the endogenous choice of homeownership.[15]

[13] The data collection starts in August each year, and the bulk of the families are interviewed between August and October.

[14] We omit households who have frequently changed homeownership status as we believe the frequent housing transactions will add too much noise to provide any reliable estimation. We also exclude households who are not owners nor renters.

[15] Robustness tests including moving homeowners give results that are largely the same qualitatively with reduced levels of significance in some cases, reflecting the noise added by those households. The results are

We further classify non-moving homeowners into three life-cycle age groups. We define homeowners as young if the head of a household is younger than or equal to 40 in 2005, and as old if the head is older than 60, with the rest defined as middle-aged. The age of 40 is a common cut-off point in the literature (Campbell and Cocco, 2007; Gan, 2010) and enables us to compare our results with previous studies. Gourinchas and Parker (2002) also show that households tend to behave as buffer-stock savers before 40. Sixty is about the retirement age for household heads in the sample and is therefore applied.

4.2. Variables used

4.2.1. Measures of consumption

To obtain a measure of consumption, we first aggregate a household's annual spending on non-durable goods and services available in HILDA, excluding three non-discretionary items: groceries, public transport, and utilities (electricity, gas, and other heating fuel).[16] We then deflate the total expenditure to the price level as of June 2005 using the Australian consumer price index (CPI). We exclude the three non-discretionary items as spending on these items is inelastic by nature. We also define an alternative measure of consumption that includes spending on all non-durable goods and services. In one robustness test, we show that using the alternative measure provides highly consistent results but reduces the estimated coefficients in magnitude and statistical significance in some cases. Following Campbell and Cocco (2007) and Gan (2010), we do not consider spending on durable goods, as we cannot measure the consumption flows provided by these goods and the data series is shorter in HILDA.

The curve with triangle marks in Figure 1 plots the discretionary consumption over the life cycle of households in our sample, where we can see the well-documented hump-shape

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available upon request

[16]These include spending on alcohol, cigar, meals eaten outside home, clothing, education, motor vehicle fuel, telephone and Internet, health care, child care, private health insurance, other insurance (home, contents, and motor vehicle), and vehicle repair.

with the spending peaking around the age of 50. The curve with hash marks plots the consumption measure with all spendings, which presents a very similar pattern. Table 1 presents the summary statistics of the main variables for all homeowners and the three age groups. As expected, young households have higher consumption growth than that of both middle- and old-aged households. In addition, the rate of consumption growth and its volatility are both lower when consumption is measured with the non-discretionary items included.

[**Insert Figure 1 near here**]

4.2.2. Measures of house prices

To measure house prices, we use the Residential Property Price Indexes of the eight capital cities of Australia provided by the Australian Bureau of Statistics (ABS).[17] ABS uses a stratification approach (refer to Appendix B) and quarterly sales data to compile these indexes. We similarly deflate house price indexes using CPI to the 2005 price level. Figure 2 plots the house price indexes of the eight states and the weighted average of Australia. Overall, housing markets in Australia have seen strong growth over the sample period with substantial variations across states. Two periods of downturns can be identified: the first one from 2008 to 2009, coinciding with the recent great recession, and the second from 2010 to 2012 during the European debt crisis. The average annual growth in house prices across all states is about 2% with a standard deviation of about 7%.

[**Insert Figure 2 near here**]

[17] Australia has 6 states and 2 territories, and over 64% of its total population resides within the eight capital cities in 2010 according to ABS population statistics. Therefore, the indexes of the capital cities are representative of the state- and territory-level price movements

4.2.3. Income, wealth and housing-related information

To measure income, we use household total disposable income in HILDA and deflate it using CPI to the price level in 2005.[18] The curve with dot marks in Figure 1 plots the life-cycle patterns of the household income in our sample, where we can also see a hump-shaped pattern with income increasing sharply until middle-age and declining afterwards. Table 1 indicates that income growth declines with age among homeowners.

Every four years (2002, 2006, 2010), HILDA conducts a special wave to collect information on household wealth, such as bank savings, bond and stock investments, and debt. We use the wealth information collected in 2006 (the start of our sample for first-differenced variables) to identify households who face potential credit constraints. The key variables we consider are the level of liquid savings, total net worth and the loan to value (LTV) ratio of the home property. The liquid savings is defined as the sum of bank savings, investments in equities, and bonds. Net worth is the value of all assets minus the value of any debt. Table 1 shows that both the mean and median level of liquid savings increase with age. The middle-aged group actually has the highest level of net worth, followed by the old and the young. The average LTV ratio decreases with age: 43%, 20% and 1% for the young, middle- and old-aged homeowners.

A range of housing related information is collected in HILDA, including for example, homeownership, household movements, self assessed value of the house and remaining mortgage, and mortgage and rent payments.[19] The special wealth waves also collect information on refinancing retrospectively; the survey asks when a household most recently refinanced their mortgage and the value of their mortgage after refinancing. We can, therefore, map

[18] Disposable income is calculated as total income minus the income tax, where the tax is estimated by an income tax model in HILDA. Please refer to the User Manual for more details. Other income variables have also been applied as robustness tests, and the results remain unchanged.

[19] We do not use the self-assessed value of the house in our study because it is contaminated with spending on home repair and renovation. We do not have full information of these spending to have a clean measure of house value. In addition, previously literature has shown that households' assessments are biased and systematically correlated with household characteristics (Agarwal, 2007). However, we do conduct robustness tests using this measure.

out whether a household has refinanced their mortgage in a particular year between 2005 and 2010.[20] We define the dummy $Refinance_{it}$ equal to one if a household refinance their mortgage in a particular year, and the dummy *D.Refinanced household* equal to one if a household has ever refinanced their mortgages during the sample period. In Table 1, about 20% homeowners refinanced their mortgages during the sample period, and young (47%) and middle-aged (21%) homeowners have the higher rate of refinancing than the old (1%). On average, about 4.1% of non-moving homeowners refinance their mortgages each year.

One question in HILDA asks households how likely they will move in the next twelve months, and households can choose among five choices, ranging from 1-very unlikely to 5-very likely with 3-neither. We refer to this variable as $Move\ intention_{it}$ and based on it, we construct a dummy variable, *D.Likely to move*, which is equal to one if a household ever responds to this question with 4 or 5 during the sample period. The summary statistics in Table 1 show that the moving intention declines as households age.

[**Insert Table 1 near here**]

5. Empirical analysis

5.1. Baseline results across homeownership groups

We first examine the impact of house price changes on consumption decision of all household types.[21] We estimate Equation 6 for different specifications and present the results in column (1) to (6) of Table 2. The standard errors reported in parentheses are clustered by households and the stars indicate levels of significance at conventional levels. In column (1), we find a positive and significant impact of house price changes on consumption growth

[20] As the question only asks the most recent refinancing during the past four years, it is possible that a household could have refinanced more than once within the period. However, due to the costs of refinancing, there should not be many such cases. Further, the missing cases will work against us in finding any significant results.

[21] The sample includes homeowners, renters, households who change between homeowner and renter once during the sample period.

after controlling for changes in household size, income, rent and mortgage payments, as well as household and year fixed effects. As expected, increases in household size and income both significantly boost household spending and higher housing costs, either through rent or mortgage payments, tend to reduce non-housing spending.

As house prices are measured at the state level, they could be correlated with other state-level economic factors. To alleviate the concern that omitted variables drive consumption and house prices to the same direction, column (2) includes measures of state economic growth: the growth in gross state product and income per capita. Following Campbell and Cocco (2007), we also use changes in the unemployment rate of the local area a household resides to control for local economic conditions. With these control variables, the estimated coefficient of house price changes indeed decreases in magnitude and significance, but remains significant.

Even with all the control variables, there is still the concern that omitted macro variables, such as future productivity growth and financial liberalization, might drive our observed relationship between house prices and consumption (Attanasio and Weber, 1994; Attanasio et al., 2009). Following recent literature such as Chaney et al. (2012) and Schmalz et al. (2015), we compare homeowners with the control group: renters. As only homeowners on average enjoy the benefits of rising house prices (both increased wealth and collateral), they should respond more positively to house price changes than renters, who most likely suffer from rising housing costs (Sinai and Souleles, 2005; Han, 2010). In column (3), we test this argument by including an interaction term between house price changes and a dummy variable "$Renting_{it}$" to indicate when a household is renting. Hence the coefficient on $\Delta Log(HP)$ measures the elasticity of homeowners, and that of the interaction term measures the incremental elasticity of those who are renting. Consistent with our conjecture, we find homeowners do have a large and significant consumption sensitivity of 0.163, and renters have insignificant sensitivity close to zero.

One concern of this test is that homeownership is an endogenous choice, which might bias the estimated consumption sensitivity. For example, if high income households tend to become homeowners and have higher consumption sensitivity to household prices, then omitting income will bias our estimates. Following Chaney et al. (2012); Schmalz et al. (2015), we attempt to reduce the potential bias by including variables that may lead to homeownership, such as household size and income growth. In addition, our household fixed effect controls for time-invariant factors, such as education, gender and ethnicity. We also interact the renting dummy with both other state-level variables and year dummies to make sure macro level variables do not contaminate our results. Lastly, as age is an important determinant of homeownership and affect house-price consumption sensitivity according to our model, we explicitly consider age groups in the following tests.[22]

In columns (4) to (6), we extend the comparison between homeowners and renters to three life-cycle stages: young, middle-aged, and old. We find although the differences are present among all age groups, it is mainly driven by the substantial difference between young homeowners and renters. Note this result is inconsistent with the argument that future productivity growth drives the correlation between house prices and consumption, as argued by (Attanasio et al., 2009; Disney et al., 2010). This argument predicts that both young homeowners and renters have positive consumption sensitivity as both groups will benefit the most from future productivity growth compared to the middle- and old-aged.

To sum up, after controlling for time-varying household and state level variables, year and household fixed effects, and explicitly comparing homeowners and renters across the life cycle, our findings provide evidence that house price changes do affect homeowner consumption growth.

Next in columns (7) to (10), we focus on non-moving homeowners, which enables us to isolate the impact of house price changes from that of the adjustment of housing assets. Also non-moving homeowners most closely resemble the household type studied in our model.

[22]With our household-level panel data, we can clearly identify and control for homeownership and household fixed effect. Therefore we do not suffer the self-selection bias of homeownership typically present in studies using cohort analysis, where owner and renter groups within a cohort change endogenously over time (Campbell and Cocco, 2007).

Column (7) shows these homeowners have a positive and significant consumption sensitivity to house prices, controlling for all the variables we include before. In columns (8) to (9), we split homeowners again into three life-cycle groups. We find both young and old homeowners have large and positive consumption sensitivity to house prices, and the middle-aged have insignificant response. The dotted line in Figure 3(a) plots the estimated consumption sensitivities for the three age groups, which roughly follows a U shape. In the same graph, we also plot the estimated sensitivities for households with high (square marks) and low (triangle marks) liquid assets. Interestingly, those with less liquid assets tend to have higher sensitivity when young, and those with more liquid assets tend to have higher sensitivity when old.

Based on our model, the response of old households seems to be driven by the wealth effect, but the response of young homeowners could arise due to the wealth effect, borrowing constraints or the precautionary saving motive. The middle-aged have insignificant response perhaps because they enjoy less wealth effect compared to the old, particularly if they intend to up-size, and are less borrowing constrained compared to the young (Li and Yao, 2007). This life-cycle pattern alone however, cannot clearly pin down the specific mechanism of house-price consumption sensitivity. In subsequent sections 5.2 to 5.4, we will further explore heterogeneities of households within each life-cycle group.

The estimated consumption elasticity to housing price changes is 0.163 for all homeowners, which is broadly consistent with the literature. For example, Case et al. (2005) shows that the elasticity ranges from 0.04 to 0.11 for the U.S. states and 14 OECD countries, and the baseline results in Gan (2010) reports a value of 0.17. However, the elasticity varies significantly across the life cycle, and can be above 0.5 for young homeowners. These relatively large estimates for young and old homeowners confirm the recent U.S. findings in Mian et al. (2013) and Kaplan et al. (2015), and suggest a substantial impact of housing wealth on household consumption.

The marginal propensity to consume (MPC) out of housing wealth can be computed by multiplying the consumption elasticity with the consumption to housing wealth ratio. In the data, the median house value is AU$450,000 in 2009 and the median non-durable consumption of a household is AU$26,039 which is about 31% of total household consumption (about AU$84,000) according to Australian Bureau of Statistics. This gives a consumption to housing wealth ratio of about 18.27% and a MPC of housing wealth of 3 cents per dollar. Note because the consumption to housing wealth ratio can vary significantly across countries and over time, the MPC may not be comparable across countries and time (Gan, 2010).

[Insert Table 2 near here]

5.2. Young homeowners, precautionary saving motive and borrowing constraints

In this section, we further explore the heterogeneities within young homeowners and determine the dominant driver of their large housing-consumption sensitivity. According to our model, the young homeowners enjoy the least wealth effect as they have long remaining life horizon and their house value is of a small proportion of their expected total wealth. Meanwhile, we can see in Table 1 that they tend to have low liquid savings and high leverage in their homes, and are thus more likely to be borrowing constrained. In order to test the strength of different mechanisms, we split the young homeowners into subsamples based on various measures of borrowing constraints and compare the consumption sensitivities across these groups in Table 3.

In columns (1) and (2), we first equally split young homeowners by their (beginning of sample) net worth, which is the total value of their assets minus outstanding debts. We find that those with low net worth have a larger and more significant house-price consumption sensitivity, supporting the borrowing constraints effect or precautionary saving motive. As the two main components of net worth are liquid savings and home equity, we further split the sample using those two measures separately. In columns (3) to (5), we examine three sub-sample groups classified by the tercile of liquid savings, a measure that corresponds to the level of wealth on hand in our model. It turns out it is those with medium levels of liquid assets have the highest and most significant consumption sensitivity among the three subsamples. According to our model, this finding is strongly consistent with a precautionary saving motive channel.

In columns (6) and (7), we split young homeowners by their LTV ratio and find that those with high LTV ratios have higher consumption sensitivity. Lastly, we examine the mortgage payment coverage ability of households, where the a low coverage suggests borrowing constraints. In columns (8) and (9), we find that households with low mortgage payment coverage have a higher and more significant consumption sensitivity. The comparisons based on all these measures suggest that the dominant drivers of the large consumption sensitivity of young homeowners seem to be the precautionary saving motive or borrowing constraints, rather than the wealth effect.

[Insert Table 3 near here]

Next, we test our Prediction 2 of the precautionary saving motive. Our model indicates that the strength of young homeowners' precautionary saving motive relates to the income volatility measure: the higher the income volatility, the higher the consumption elasticity to house prices due to the precautionary saving motive (Refer to Equation 27). Therefore, we equally split young homeowners into those with high and low income volatility, indicated by the dummy variable $High\ Inc\ Vol$. We re-run the tests for all subsamples in Table 3, but interact the house price changes with the dummy $High\ Inc\ Vol$.[23] If Prediction 2 is correct, we should expect those with high income volatility to have higher consumption elasticity to house prices. For the ease of interpreting the results, we present the estimated coefficients for the two groups of households separately in Table 4 (rather than a baseline group and the incremental effect measured by an interaction term).

[23]We also interact other state level variables and year fixed effects with the dummy to make sure our results are not driven by these factors

For all young homeowners (column (1)) and across all subsamples (columns (2) to (9)), a consistent finding is that those with high income volatility have larger and more significant consumption sensitivity to house prices than those with low income volatility. This suggests a strong role of precautionary saving motive, even among those who are less constrained. For households with high income volatility, the more constrained tend to have higher sensitivities than the less constrained, implying an additional impact of borrowing constraints. Also, the consistent importance of high income volatility across various subsamples might indicate that most households have precautionary saving motive, while only a small portion might be totally constrained or unconstrained throughout the whole period. Overall, the findings in Table 4 support our Prediction 2 of the precautionary saving motive.

Our evidence of the importance of income volatility and precautionary saving motive enhances the finding of Gan (2010). Gan (2010) argues the household consumption sensitivity to house prices seems to be driven by the precautionary saving motive as it is stronger among the less constrained, younger homeowners, and for discretionary spending. However, as our model and the literature on precautionary saving suggest, the most important cause of precautionary saving motive should be income uncertainty, which cannot be measured in the dataset used in Gan (2010). Our study therefore provides the first direct evidence on the precautionary saving nature of housing assets.

[Insert Table 4 near here]

5.3. Old homeowners and the wealth effect

In this section, we examine the consumption sensitivity of old homeowners in more detail and test the Prediction 1 from our model. As we have seen in Table 2 old homeowners overall have a positive and significant consumption sensitivity to house prices, which is consistent with our model prediction of a wealth effect for old homeowners. To further ascertain this positive sensitivity is indeed driven by a wealth effect, rather than borrowing constraints, we first equally split old homeowners according to their level of liquid assets and present the estimated coefficients in columns (1) and (2) in Table 5. We find that those with more liquid assets have larger and more significant consumption sensitivity than those with less liquid assets. This suggests that old homeowners' response is unlikely to be driven by borrowing constraints.

In columns (3) and (4), we test Prediction 1 that the consumption elasticity of older homeowners are higher for those with a larger share of housing equity to total wealth. Inconsistent with our prediction, it is those with smaller shares have a larger sensitivity, although the coefficients for both groups are insignificant. One explanation of the inconsistency is that the sample are homeowners who did not move/down-size to extract home equity during the sample period, and for these households, their ability to increase consumption with rising house prices depends on their liquid savings. [24] If homeowners have little liquid savings, they cannot adjust their consumption even when house prices increase. Therefore in columns (5) and (6), we focus on homeowners who have a certain amount of liquid assets (above the 25th percentile). Now, we indeed find that those with a larger share of housing equity to total wealth have a larger and more significant consumption sensitivity than those with a smaller share, supporting our Prediction 1 of a housing wealth effect.

One constraint of the wealth effect among old homeowners is the bequest motive (Chiuri and Jappelli, 2010). As they effectively extend their tenure to the next generation, the wealth effect should be less significant. Therefore, we expect the wealth effect to be stronger for old homeowners who intend to move and tap into their accumulated home equity. We test this argument in columns (7) to (10). Following Sinai and Souleles (2005), we proximate a homeowners' expected tenure with a measure of households' moving probability reported in the survey, and assume that if old homeowners want to move, they are likely to downsize their houses. In columns (7) and (8), we split the sample on whether they are likely to move ($Likelytomove = 1$), and find that those who intend to move during the sample period

[24] The use of reverse mortgage is not common in Australia and in the data. There were only three cases of reverse mortgages over the whole sample period

(shorter tenure) have a higher consumption sensitivity than those who do not. For those not intending to move, their ability to increase spending with rising housing wealth again depends on their liquid savings. So in columns (9) and (10), we compare those with high and low liquid savings among those who do not want to move. Consistent with our conjecture, it is those with high liquid savings have higher consumption sensitivity.

To sum up, our analysis of old homeowners provides strong support to a housing wealth effect. We also highlight that the level of liquid savings and expected tenure of old homeowners can have significant impact on their housing-consumption sensitivity.

[**Insert Table 5 near here**]

5.4. The middle-aged homeowners

In this section, we further examine the drivers of housing-consumption sensitivity of middle-aged homeowners. In our baseline model, the middle-aged homeowners with high w_1 should respond positively to house prices due to a wealth effect and those with low w_1 respond due to borrowing constraints. We therefore split our the middle-aged homeowners into those with high and low levels of liquid assets and present the estimations in columns (1) and (2) in Table 6. Interestingly, although those with high liquid assets have a positive but insignificant coefficient, those with low levels of liquid assets have a significantly negative consumption response to house price increases.

We conjecture this is because some of these households plan to up-size their home for reasons outside the model, for example growing families, and have to cut consumption when house prices increase due to limited savings. As shown in our extended model in Appendix A.3, up-sizing and associated transaction costs might lead to a small or even negative wealth effect. To test our conjecture, we interact house price changes with the dummy variable *Likely to move* in columns (5) and (6). Consistent with our conjecture, households with low levels of liquid assets and who consider to move during the sample period have a significant negative incremental consumption sensitivity to house prices compared to those who do not intend to move. A similar patten can be observed if we split the households using net worth, although most of the estimated coefficients are insignificant. Overall, the insignificant sensitivity of the middle-aged seems to be consistent with our extend model of up-sizing with transaction costs, as well as the prediction of Li and Yao (2007).

[Insert Table 6 near here]

5.5. Mortgage refinancing and consumption growth

In our model, the young and middle-aged homeowners are more likely than the old to have optimal levels of consumption greater than their savings and borrowing capacity. This is because both young and middle-aged homeowners have future income, against which they can not borrow; rather their borrowing capacity is limited to the value of their house. Therefore, we should expect that rising house prices will relax the borrowing constraints more for the young and middle-aged than for the old-aged homeowners, and the relaxed constraints should lead to higher consumption: Prediction 3. To test this prediction, we can examine whether rising house prices will lead homeowners to borrow more against their home equity through cash-out refinancing and whether refinancing spurs consumption growth.

To study the influence of house price changes on refinancing probability, we estimate Equation 7 and present the average marginal effects of various factors in Table 7.[25] Columns (1) to (3) contain estimates for all homeowners using, respectively, a linear probability model, a pooled probit model, and a random effect (RE) probit model.[26] In all specifications, increases in house prices significantly increase the refinancing probability. The estimated average marginal effect from the random effect model is 0.076, meaning that for a 10% increase in house prices, the refinancing probability will increase by 0.0076, or 18.5% (0.0076/0.041,

[25]Since the refinance information is collected retrospectively in the special wealth wave every four years, we have households' refinance records only up to 2010. This leads to a shorter sample period in this section.

[26]We find similar estimates (unreported) using a pooled logit and a random effect logit model.

where 0.041 is the probability of a household refinancing in a particular year in our sample). Importantly, dummies for both middle-aged and old homeowners are significantly negative compared to the baseline group of young homeowners, indicating the probability of refinancing decreases with age.

Among other control variables, higher initial LTV ratio and lower liquid savings significantly increase the probability of refinancing, which suggests that borrowing constraints seem to be a main driver for refinancing. However, Hurst and Stafford (2004) note that if a homeowner already has a high level of leverage, its ability to refinance reduces. We find evidence consistent with their finding: the dummy variable $D.High\ LTV$ (for LTV greater than 0.8) has a negative coefficient. Further, we control for whether households experience liquidity shocks due to redundancy, illness, or worsening financial situations. Consistent with the U.S. evidence provided by Hurst and Stafford (2004), these variables all increase the refinancing probability. Lastly we consider the portfolio re-balancing motives of households by including dummies to indicate whether households become business owners and shareholders in 2010. These investment indicators reduce refinancing probability, suggesting refinancing is unlikely to fund other investments. Despite all these control variables, rising house prices still significantly boost refinancing probability.

In columns (4) to (6), we exam the refinancing determinants for the three age groups separately.[27] Most noticeably, the impact of house price changes on refinancing decreases with age. A 10% increase in house prices increases the probability of refinancing by 0.026 for the young homeowners, more than three times the impact for all homeowners. This is consistent with our Prediction 3 that young and middle-aged homeowners are more likely to be borrowing constrained than the old, and rising house prices relax these constraints.

As we have put year-fixed effects in all our specifications, we cannot separately control for the effects of changing interest rates, which is very important for refinancing decision.

[27]For both young and middle-aged, we have used RE probit model. Perhaps due to the small number of refinancing among old homeowners, the estimation using RE probit model cannot converge. We therefore apply a probit model.

In order to make sure that refinancing is not driven by changing interest rates, we compare refinancing drivers of households with adjustable rate mortgage (ARM) to those with fixed rate mortgage (FRM). As interest rate change is automatically adjusted in ARM mortgage payments, it should not be an important driver of refinancing for households with ARMs.[28] In columns (7) and (8), we examine the drivers of ARMs and FRM refinancing using a RE probit model. We find that even for ARM refinancing, house price changes are important, which suggests that our results are not driven by changing interest rates.

[Insert Table 7 near here]

Our analysis indicates that rising house prices significantly increase the refinancing probability of homeowners, particularly the young and middle-aged. An important question to ask then is whether households use the extracted home equity for consumption, a behavior that is likely to have important policy implications (Mian and Sufi (2011); Mian et al. (2013)). To answer this question, we examine the impact of cash-out refinancing on consumption growth and present the results in Table 8. We estimate Equation 6 with the additional dummy variable $Refinance_{it}$ to indicate whether a household has refinanced its mortgage in a particular year. In column (1), we find that refinancing significantly increases a household's consumption growth in that year. On average, if a household refinances its mortgage, their consumption increases by about 8.5%, which is quite large considering the average annual consumption growth of homeowners is roughly 2%.

In specification (2) of Table 8, we examine whether the amount of equity extracted affects consumption growth.[29] The variable $Refinance\ amount$ is the extracted equity scaled by last year's total disposable income of the household (so that they are comparable across households). The coefficient is positive and significant, suggesting that the more equity a

[28] One important feature of Australian mortgage markets is that both ARMs and FRMs are present, with the former taking a dominant share of the markets. This pattern is evident in the HILDA data: about 68% of households who refinanced their mortgage have ARMs in 2010, while 14.7% have FRMs, with the rest being a mixed form of ARMs and FRMs or unknown types.

[29] There are some cases where the amount of refinancing is missing in the data, resulting in a slight reduction of sample size.

household extracts from refinancing, the higher their consumption growth. Next, in columns (3) to (5) we explore the impact of refinancing on consumption for the three age groups. Interestingly, although the young are more likely to refinance, the middle-aged and old homeowners seem to increase consumption more after refinancing. In columns (6) and (7), we compare the impact of refinancing between homeowners with ARMs and those with FRMs. For both types of mortgage contracts, refinancing significantly boosts household consumption growth, and the effect is particularly large for those with FRMs. These results provide strong evidence that households who refinance their mortgages spend at least part of the withdrawn equity for current consumption.

[Insert Table 8 near here]

5.6. Robustness tests

In this section, we conduct various robustness tests of our key empirical results and presents the estimation in Panel A to E of Table 9.

5.6.1. Robustness test 1: Alternative consumption measure

We have also conducted all the estimations using the alternative measure of consumption, which include both the discretionary and staple items: groceries, public transport and utilities. Naturally, the expenditure on staple items are less elastic compared to discretionary spending, and the consumption sensitivity to house price changes should be smaller. Our estimation results confirm this: estimated coefficients of house price changes are all consistent with our main results in sign, but are of smaller magnitude and less statistical significance in some cases. To reserve space, we report the estimation results of all non-moving homeowners and over the life cycle groups in Panel A of Table 9 and plot the estimated sensitivities against our main results using discretionary spending in Figure 3(b). The consumption sensitivity of all consumption items has less variation over the life cycle compared to that of discretionary spending.

5.6.2. Robustness test 2: Self-assessed house value changes

As the self-assessed house value is contaminated with household spending on repair and renovation, and potentially biased (Agarwal, 2007), we opt to use the more objective house price changes. However, most of our estimations are consistent if we use the self-assessed house value changes, although the estimated coefficients are of smaller magnitudes. We present the estimation results for all non-moving homeowners, and over the life cycle in Panel B of Table 9. Additional results are available upon request.

5.6.3. Robustness test 3: Including moving homeowners

In our main results, we focus on non-moving homeowners so that we can isolate the impact of house price changes from that of changing housing assets, as well as reducing the estimation bias arising from self-selected housing transactions. Again, our main results are largely consistent if we include homeowners who have moved during the sample period despite the additional noise in this test. Panel C of Table 9 contains the estimation for all homeowners including those who have moved. In these baseline tests, our results are highly consistent with the main results.

5.6.4. Robustness test 4: Five life-cycle groups

In our main results, we have divided our sample into three age groups, which is consistent with the literature. We also conduct our test using five age groups with each group covering roughly 10 years. The results using the discretionary consumption measure are presented in Panel D of Table 9. As we can see, the overall U-shaped pattern of consumption sensitivity over the life-cycle is still present. We also conduct the same test using all consumption items and obtain similar results. We do not report the estimated coefficients but instead plot the two sets of estimation in Figure 3(c), where a U shape is roughly followed by the two series.

5.6.5. *Robustness 5: Predictable and unpredictable changes in house prices*

To further test the impact of credit constraints, we follow the literature and distinguish between predictable and unpredictable changes in house prices. If there are no borrowing constraints, forward-looking households should have factored the predictable changes in house prices into their saving and consumption plan; consumption should only change due to unpredicted housing returns (Campbell and Cocco, 2007; Gan, 2010; Browning et al., 2013). With borrowing constraints, in particular if households can only borrow against realized housing returns, they can also respond to predictable house price changes. We test this argument and present the results in Panel E of Table 9. We use the predicted values from specification (4) in the Table of C as the predictable changes in house prices and the residuals from the estimation as the unpredictable changes. Column (1) shows that the consumption of all homeowners is more sensitive to predictable changes in house prices, although neither coefficient is statistically significant. In columns (2) and (3), we compare the responses of the more credit-constrained and less constrained households.[30] Consistent with a credit constraint effect, the constrained households respond strongly to predictable changes in house prices.

Columns (4) to (7) demonstrate the effect of specific aspects of credit constraints. As before, we define low- and high-saving households based on their liquid savings, and high- and low-LTV households based on their initial LTV ratio.[31] The households with more liquid savings are sensitive only to unpredictable changes in house prices, suggesting they are more able to optimize intertemporally. Households with high LTV ratios are most sensitive to predictable changes in house prices, which may indicate that those are the households who are more likely to borrow against home equity to relax their credit constraints.

[Insert Table 9 near here]

[30]Here the measure of credit constraints is an equally weighted average of standardized value of liquid savings and LTV ratio. More credit constrained households are defined as those with a *Credit constraint* value above the median value of their age groups and the less credit constrained households are the remaining half.

[31]The LTV ratio groups are not evenly split because the median value is 0.

6. Conclusion

Using a parsimonious life-cycle model that captures the essential role of housing assets and risky labor income, we are able to demonstrate the channels through which house price changes affect household consumption decisions over the life cycle. First, there is a housing wealth effect for all homeowners where household optimal consumption should increase with rising housing wealth, and this wealth effect increases with age. With credit constraints however, the less-wealthy young and middle-aged homeowners exhibit excess consumption sensitivity to house prices because rising housing wealth enable them to borrow more for current consumption. Lastly, for young households, the prospects of future borrowing constraints due to labor income uncertainty induce a precautionary saving motive. This motive is influenced by house prices as higher house value will enable households to borrow more in times of need to smoothen consumption. Our closed-form solution provides clear economic intuition and a unified framework to understanding existing empirical work.

Using a rich panel data of households with consumption records, we test our model and examine how house price changes affect household consumption over the life cycle. We find that young homeowners have a large positive and significant consumption sensitivity to house prices. This sensitivity is likely to be driven mostly by the precautionary saving motive as young homeowners with higher income volatility tend to have higher housing consumption sensitivity. Further, consistent with our model, young homeowners with low and medium levels of liquid wealth tend to have the largest sensitivity. For old homeowners, we find a positive and significant consumption sensitivity to house prices, which supports a housing wealth effect. Consistent with our model prediction, this sensitivity tends to be higher if they have a large share of housing wealth to total wealth. We also find that both young and middle-aged homeowners are more likely to use cash-out refinancing to support their consumption when house price changes. This is consistent with our model, which suggests that both young and middle-aged homeowners are more likely to be borrowing constrained than then old.

In the aftermath of the Great Recession, regulators and economists in the US are concerned about the dampening effect of lower house value on household consumption. Our study indicates that this negative impact operates through various channels, and has distinct implications for households in different life-cycle stages. The housing market crash can mean substantial destruction of the wealth portfolio of older homeowners, which may have severe impact on their living standards, particularly after retirement. Young homeowners are adversely affected not only due to a decline in their wealth but also in their housing collateral, restricting them from consumption smoothening in times of credit constraints and periods of volatile labor income. Policy makers should recognize this heterogeneity and account for demographics in developing targeted and effective policies.

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Appendix A. Solution of the model

To illustrate the role of borrowing constraints, we consider two cases: when homeowners faces no borrowing constraints (unlimited borrowing is available to households), and when homeowners can only borrow up to a fraction of their house value.

A.1. Case 1: Optimal consumption in the unconstrained borrowing case

In this case, households can borrow against their future labor income and housing wealth, and the only constraint on consumption is the life-time total resources. It is well known that optimal consumption is certainty equivalent ($c_t = E_t[c_{t+1}]$) when utility is quadratic and only the life-time resource budget constraint is binding (Hall, 1978). Each period, households consume an equal share of their total life-time wealth each period:

$$c_0^* = E_0[c_1] = E_0[c_2] = \frac{1}{3}(w_0 + E_0[y_1] + E_1[y_2] + E_0[h_2]), \tag{8}$$

$$c_1^* = E_1[c_2] = \frac{1}{2}(w_1 + E_1[y_2] + E_1[h_2]), \tag{9}$$

where $w_1 = w_0 - c_0^* + y_1$.

$$c_2^* = w_2, \tag{10}$$

where $w_2 = w_0 - c_0^* - c_1^* + y_2 + h_2$.

Notice that for this unconstrained homeowner, housing wealth only affects consumption through a wealth effect: the young and middle-aged are sensitive to the expected housing wealth in the final period, and the old react to the realized house prices in the last period. This wealth effect increases with age as housing wealth becomes a larger portion of unconsumed wealth with age. The young and the middle-aged have a wealth effect as long as $v < 1$ as the expected housing wealth at the end of their lifetime depends on current house prices. If $v = 1$, consumption is not sensitive to house prices for young and middle-aged households.

A.2. Case 2: Optimization problem with constrained borrowing

In the borrowing constrained case, households can only borrow against their housing wealth but not future labor income. To find the optimal consumption, we solve the model recursively from the last period using standard dynamic programming techniques. The fundamental recursion relation is

$$V_t(w_t) = \max_{c_t}(c_t + \frac{\theta}{2}c_t^2) + E_t[V_{t+1}(w_{t+1})] \tag{11}$$

In the final period, the household consume all its savings and the realized value of its house so that: $c_2^* = w_2$ and $V_2(w_2) = U(c_2)$. We therefore have $E_1[V_2'(w_2)] = 1 + \theta(w_1 - c_1 + E_1[y_2] + E_1[h_2])$, where $'$ represents the first derivative.

In period-1, homeowners solve

$$V_1(w_1) = \max_{c_1}(c_1 + \frac{\theta}{2}c_1^2) + E_1[V_2(w_2)] + \lambda_1(w_1 + \phi h_1 - c_1). \tag{12}$$

The first order conditions for maximization are:

$$1 + \theta c_1 - E_1[V_2(w_2)] - \lambda_1 = 0 \tag{13}$$

$$\lambda_1(w_1 + \phi h_1 - c_1) = 0 \tag{14}$$

$$\lambda_1 \geq 0, w_1 + \phi h_1 - c_1 \geq 0 \tag{15}$$

These can be solved for the optimal c_1 to obtain

$$c_1^* = \begin{cases} \frac{1}{2}(w_1 + E_1[y_2] + E_1[h_2]), & \text{if } w_1 \geq E_1[y_2] + E_1[h_2] - 2 * \phi h_1 \\ w_1 + \phi h_1, & \text{otherwise} \end{cases} \tag{16}$$

The optimal consumption decision for the middle-aged homeowners depends on w_1: the savings/debt they bring from last period and the realized labor income. Note that w_1

excludes expected future labor income and housing wealth. While the households with high w_1 are not constrained and consume half of their total expected lifetime wealth, those with lower w_1 are constrained and have to borrow the maximum amount against their home equity for consumption. The threshold w_1 at which borrowing constraints become binding is $w_1 < E_1[y_2] + E_1[h_2] - 2 * \phi h_1$. Households that expect to have larger future labor income are more likely to be constrained to consume against that future labor income. Also lower house prices (h_1) or lower ability to borrow against the house prices (ϕ) are also associated with a higher threshold for w_1 and thereby a higher likelihood for being constrained.

In period-0, homeowners solve

$$V_0(w_0) = \max_{c_0}(c_0 + \frac{\theta}{2}c_0^2) + E_1[V_1(w_1)] + \lambda_0(w_0 + \phi h_0 - c_0). \tag{17}$$

Before deriving the optimal period-0 consumption, we introduce two thresholds of w_0 that are relevant for our results. From Eq. 17, we see that whether the household is constrained in period-1 depends on how much savings/debt it has accumulated and the realized income of y_1. Therefore, period-0 financial wealth determines not only whether c_0^* is constrained, but also whether c_1^* will be constrained.

Accordingly, we define the threshold w_u as the level above which the consumer's optimal consumption is not constrained in both period-0 and period-1. That is, if the consumer's initial wealth is high enough ($w_0 \geq w_u$), then c_0^* and c_1^* are not constrained even if the household receives low income $y_1 = \bar{y} - \delta_y$ in period-1. Note: c_1^* is unconstrained if $w_1 > E_1[y_2]+E_1[h_2]-2*\phi h_1$. With the optimal unconstrained $c_0^* = \frac{1}{3}(w_0+E_0[y_1]+E_0[y_2]+E_0[h_2])$ and eliminating c_0^*, we obtain the expression for $w_u = \bar{y}+(5p-1)\delta_y+\frac{1}{2}E_0[h_2]+\frac{3}{2}E_1[h_2]-3\phi h_1$. Assuming $h_1 = h_0 + (\bar{h} - h_0)v - \delta_h$ and substituting in $E_0[h_2]$ and $E_1[h_2]$, we have [32]

$$w_u = \bar{y}+(5p-1)\delta_y+[2*(1-v)^2-3(1-v)\phi]h_0+[(4-3\phi)v-2v^2]\bar{h}-[\frac{3}{2}(1-v)-3\phi]\delta_h. \tag{18}$$

[32] Here we have assumed that $\phi > \frac{1-v}{2}$ so that the lower realization of house price y_1 will give a larger value of the upper boundary.

On the other extreme, we define the threshold w_d as the level below which the consumer's optimal consumption is constrained in period-0 and $c_0^* = w_0 + \phi h_0$. In this case, $w_1 = -\phi h_0 + y_1$ and whether c_1 is constrained depends on income and house prices in period-1. We assume that liquidity constraints arise only due to low income in period-1.[33] Specifically, we assume c_1 is constrained if $y_1 = \bar{y} - \delta_y$ and is unconstrained if $y_1 = \bar{y} + \delta_y$.

The first order condition for Eq. 18 is

$$u_0'(w_0) = E_0[V_1'(w_1)] + \lambda_0. \tag{19}$$

Using Equations 13 and 16, and applying the envelope theorem, we obtain: $V_1'(w_1) = E_1[V_2'(w_2)] + \lambda_1$. Substituting for V_2' and λ_1 gives

$$V_1'(w_1) = \begin{cases} \alpha + \frac{\theta}{3}(w_1 + E_1[y_2] + E_1[h_2]), & \text{if } w_1 \geq E_1[y_2] + E_1[h_2] - 2 * \phi h_1 \\ \alpha + \theta(w_1 + \phi h_1), & \text{otherwise} \end{cases} \tag{20}$$

Substituting Equation 20 in Equation 19 we obtain:

$$\frac{\lambda_0}{\theta} = w_0 - \frac{p}{2}(-\phi h_0 + y_u + E_0[y_2] + E_0[h_2]) + (1-p)(-\phi h_0 + y_d + \phi E_0[h_1]) \leq 0. \tag{21}$$

Substituting in the expectation of housing wealth, we obtain the expression

$$w_d = \bar{y} - (p^2 + p - 1)\delta_y + [\frac{p}{2}(1-v)^2 + \phi(1-v)(1-p) - \phi(1-\frac{p}{2})]h_0 + [\frac{p}{2}v(2-v) + (1-p)\phi v]\bar{h}. \tag{22}$$

In between these two extremes, $w_d < w_o < w_u$, c_0^* is unconstrained but c_1^* may be constrained if low income is realized in period-1. From Equation 18, the first order condition

[33] This is true if c_1 is constrained with a low realization of y_1 and high realization of h_1, and unconstrained with a high realization of y_1 and a low realization of h_1. After simplification, we obtain two conditions: $p\delta_y > \phi h_1 - \frac{1}{2}(E_1[h_2] + \phi h_0)$ and $(1-p)\delta_y \geq \frac{1}{2}(E_1[h_2] + \phi h_0) - \phi h_1$. This basically requires that the variation of income realization to be large enough relative to that of house prices.

is $u_0'(c_0) = E_0[V_1'(w_1)] + \lambda_0$, which yields the following expression for c_0:

$$c_0 - \frac{p}{2}(w_0 - c_0 + \bar{y} + \delta_y + E_0[y_2] + E_0[h_2]) - (1-p)(w_0 - c_0 + \bar{y} - \delta_y + \phi E_0[h_1]) = 0. \quad (23)$$

Solving this equation, we obtain the optimal consumption rule for the young homeowners:

$$c_0^* = \begin{cases} \frac{1}{3}(w_0 + E_0[y_1] + E_1[y_2] + E_0[h_2]), & \text{if } w_0 \geq w_u \\ \frac{1}{4-p}\{(2-p)w_0 + 2\bar{y} + 2(p^2+p-1)\delta_y + v(p+A)\bar{h} + (1-v)Ah_0\}, & \text{if } w_d < w_o < w_u \\ w_0 + \phi h_0, & \text{if } w_0 \leq w_d \end{cases} \quad (24)$$

where $A = p(1-v)+2(1-p)\phi$. Similar to the middle-aged, the young homeowners with high w_0 are unconstrained and consume one-third of their expected total wealth, and those with low w_0 are constrained and need to borrow the maximum amount against their home for consumption. The consumption of those with intermediate levels of w_0 differs from that of the unconstrained due to a precautionary saving motive: the prospect of being constrained in the next period cause them to save more. This precautionary saving motive is affected by house prices because higher house prices enable a household to borrow more in the middle age, relaxing their borrowing constraints.

For $v < 0$, the effect of v is purely quantitative. Qualitatively, the mechanisms influencing consumption elasticity remain the same. To improve exposition, we present the elasticities for the case of $v = 0$. In $t = 2$,

$$E_{h_2} = \frac{\partial c_2^*}{\partial h_2} * \frac{h_2}{c_2} = \frac{h_2}{w_2}. \quad (25)$$

The consumption elasticity therefore depends on the ratio of housing wealth to w_2. In $t = 1$, we have

$$E_{h_1} = \frac{\partial c_1^*}{\partial h_1} * \frac{h_1}{c_1} = \begin{cases} \frac{h_1}{w_1+E_1[y_2]+h_1}, & \text{if } w_1 \geq E_1[y_2] + E_1[h_2] - 2*\phi h_1 \\ \frac{\phi h_1}{w_1+\phi h_1}, & \text{otherwise.} \end{cases} \tag{26}$$

For the unconstrained middle-aged homeowners, the consumption elasticity depends on the house value relative to w_1 plus expected labor income and house value, and for the constrained, it equals to their ability to borrow against their home equity relative to this borrowing ability plus w_1. In $t = 0$, we have

$$E_{h_0} = \frac{\partial c_0^*}{\partial h_0} * \frac{h_0}{c_0} = \begin{cases} \frac{h_0}{w_0+2\bar{y}+2(2p-1)\delta_y+h_0}, & \text{if } w_0 \geq w_u \\ \frac{[p+2(1-p)\phi]h_0}{(2-p)(w_0)+2E_0[y_2]-\sqrt{p(1-p)}\sigma_y+[p+2(1-p)\phi]h_0}, & \text{if } w_d < w_o < w_u \\ \frac{\phi h_0}{w_0+\phi h_0}, & \text{if } w_0 \leq w_d. \end{cases} \tag{27}$$

where $\sigma_y = \sqrt{4p(1-p)\delta_y^2}$ is the standard deviation of income growth. The elasticity of the wealthy and poor young homeowners are of similar forms of those of the middle-aged. For the intermediate-wealth range, the elasticity also depends on the volatility of income growth measured by σ_y: the higher the volatility, the higher the elasticity.[34]

A.3. Extended model with up-sizing and transaction costs

One limitation of our model is that we omit the optimal housing choice and transactions. Both micro-data and theoretical studies, such as Yang (2009), indicate that households tend to up-size their houses during middle-age period. To explore the implications of up-sizing, we extend our model to include transaction costs associated with up sizing. Specifically, we assume that households are endowed with half a unit of housing (with value $\frac{1}{2}h$) in $t = 0$ with a price p_0, and have to sell this half unit and buy a larger house (one unit housing with

[34]Note that $2E_0[y_2] - \sqrt{p(1-p)}\sigma_y = 2\bar{y} + 2(p^2 + p - 1)\delta_y$. Solving $p^2 + p - 1 < 0$, we can find as long as $p < 0.618$, the larger the δ_y, the higher the consumption elasticity.

value h) in $t = 1$ at a price p_1. The advantage of this setting is that the end of life housing wealth remains the same as our baseline model. In the last period, households sell one unit of housing at a price p_2.

The main difference from the baseline model is that the purchase and sales of housing by middle-aged homeowners incurs a substantial transaction cost that is proportion to the value of the house $\tau h p_t$.[35] An additional implication from the extended model is that upsizing and a high transaction cost can significantly reduce the consumption elasticity of the middle-aged homeowners. For example, $\tau = 0.1$ halves their wealth effect and substantially reduces their borrowing constraints effect. Specifically, the consumption elasticity of the old, middle-aged and young will become:[36]

$$E_{p_2} = \frac{\partial c_2^*}{\partial p_2} * \frac{p_2}{c_2} = \frac{(1-\tau)hp_2}{w_2}. \tag{28}$$

$$E_{p_1} = \begin{cases} \frac{(\frac{1}{2}-\frac{5}{2}\tau)hp_1}{w_1+E_1[y_2]+(1-\tau)hp_1}, & \text{if } w_1 \geq E_1[y_2] + (1-\tau)E_1[hp_2] - 2 * \phi hp_1 \\ \frac{(\phi-\frac{1}{2}-\frac{3}{2}\tau)hp_1}{w_1+\phi hp_1}, & \text{otherwise.} \end{cases} \tag{29}$$

$$E_{p_0} = \begin{cases} \frac{(\frac{1}{2}-\frac{5}{2}\tau)hp_0}{w_0+E_0[y_1]+E_0[y_2]+(\frac{1}{2}-\frac{5}{2}\tau)hp_0}, & \text{if } w_0 \geq w_u \\ \frac{(2\phi-\frac{1}{2}-\frac{11}{2}\tau)hp_0}{3w_0+4\bar{y}-\delta_y+(2\phi-\frac{1}{2}-\frac{11}{2}\tau)hp_0}, & \text{if } w_d < w_o < w_u \\ \frac{\frac{1}{2}\phi hp_0}{w_0+\frac{1}{2}\phi hp_0}, & \text{if } w_0 \leq w_d. \end{cases} \tag{30}$$

Proof. Online Appendix (available upon request)

[35]The transaction cost could include property transaction taxes charged by most governments, real estate agent commission, legal fees, and the time and effort involved

[36]For simplicity, we have assumed the probability of $y_1 = y_u$ is equal to 0.5, $p = 0.5$, and $v = 0$.

Appendix B. Data Description

B.1. Details of sample selection and variable construction

Item	Description
Initial sample selection procedure:	The basic economic unit in this study is household. However, only individuals are linked across waves in HILDA. As households split and reunite over time, we have to track a household by identifying and following the head of the household, the household member who has the highest regular income in 2005. Specifically, when a household splits, we follow the one with the existing head; and when two household heads enter into one household (reunion), both involved households are excluded. This procedure is necessary as changes in household structure alter the measure of many key economic variables, such as consumption and income. We also require that the household head has been interviewed in all subsequent waves because some variables are collected through the Person Questionnaire, which is available only if a person is interviewed. These procedures lead to a balanced panel of 4620 households with both household and individual information. The reduction in household number is mainly due to natural attrition in responding households. HILDA has retention rates ranging from 86.9% in wave 2 to around 95% in wave 5 and after. Among those households, we further exclude from the main analysis those who live in someone's house free of charge, who live in social housing and who switch between owner, renter and other types of homeownership more than once. The last group of households is excluded because the frequent change of homeownership may add noise to the analysis.
The stratification approach:	This approach first classifies all residential properties into sub-samples (strata) according to various criteria, and each quarter uses the median price of all transactions of properties in that stratum to derive the value of all dwellings in the stratum. Index numbers are subsequently derived from that total value. For a more detailed description and a comparison with other construction methods, such as repeated-sales index and hedonic approach, please refer to the ABS notes: http://www.abs.gov.au/ausstats/abs@.nsf/mf/6464.0.

Appendix C. Predict house price changes

This table presents OLS estimates of housing returns predictability. The dependent variable is the annual growth in house prices of each state in year t, $\Delta Log(HP)_t$. All other variables are measured at year $t-1$. *Rent to price* is the state annual rent per capita to median house price ratio. *Price to income* is the state median house price to gross income per capita ratio. *State Rent* is the state rent per capita. *Gross state product* is the gross state product. *Exchange rate* is the Australian dollar against the U.S. dollar. *Interest rate* is the yield on a 10-year government bond. *Share market return* is the annual returns of the All Ordinaries Index. $\Delta Log(National\ HP)$ is the change in the log of national residential property index, a weighted average of the indexes of the eight states. All data are obtained from Australian Bureau of Statistics. Robust standard errors are in the parentheses and significance level at the 1%, 5% and 10% is indicated by ***, **,and *, respectively.

	(1)	(2)	(3)	(4)
$\Delta Log(HP)_{t-1}$	0.209*	0.019	0.147	0.272**
	(0.123)	(0.106)	(0.100)	(0.136)
State level predictors				
$Rent\ to\ price_{t-1}$		13.054***	10.646***	5.840
		(3.905)	(3.887)	(4.305)
$Price\ to\ income_{t-1}$		0.012***	0.015***	0.006
		(0.004)	(0.005)	(0.005)
$\Delta Log(State\ Rent)_{t-1}$		1.781***	-0.666	-1.140
		(0.585)	(0.864)	(0.792)
$\Delta Log(Gross\ state\ product)_{t-1}$		0.862	-0.036	0.313
		(0.687)	(0.722)	(0.672)
National level predictors				
$\Delta Exchange\ rate_{t-1}$			-0.296***	-0.213**
			(0.077)	(0.085)
$Interest\ rate_{t-1}$			-0.123*	-0.191**
			(0.069)	(0.072)
$Share\ market\ return_{t-1}$			0.026	0.049
			(0.045)	(0.043)
$\Delta Log(National\ HP)_{t-1}$				-0.301**
				(0.119)
Constant	0.020***	-0.292***	-0.300***	-0.126
	(0.007)	(0.094)	(0.104)	(0.120)
Observations	72	72	72	72
Adjusted R-squared	0.034	0.223	0.467	0.525

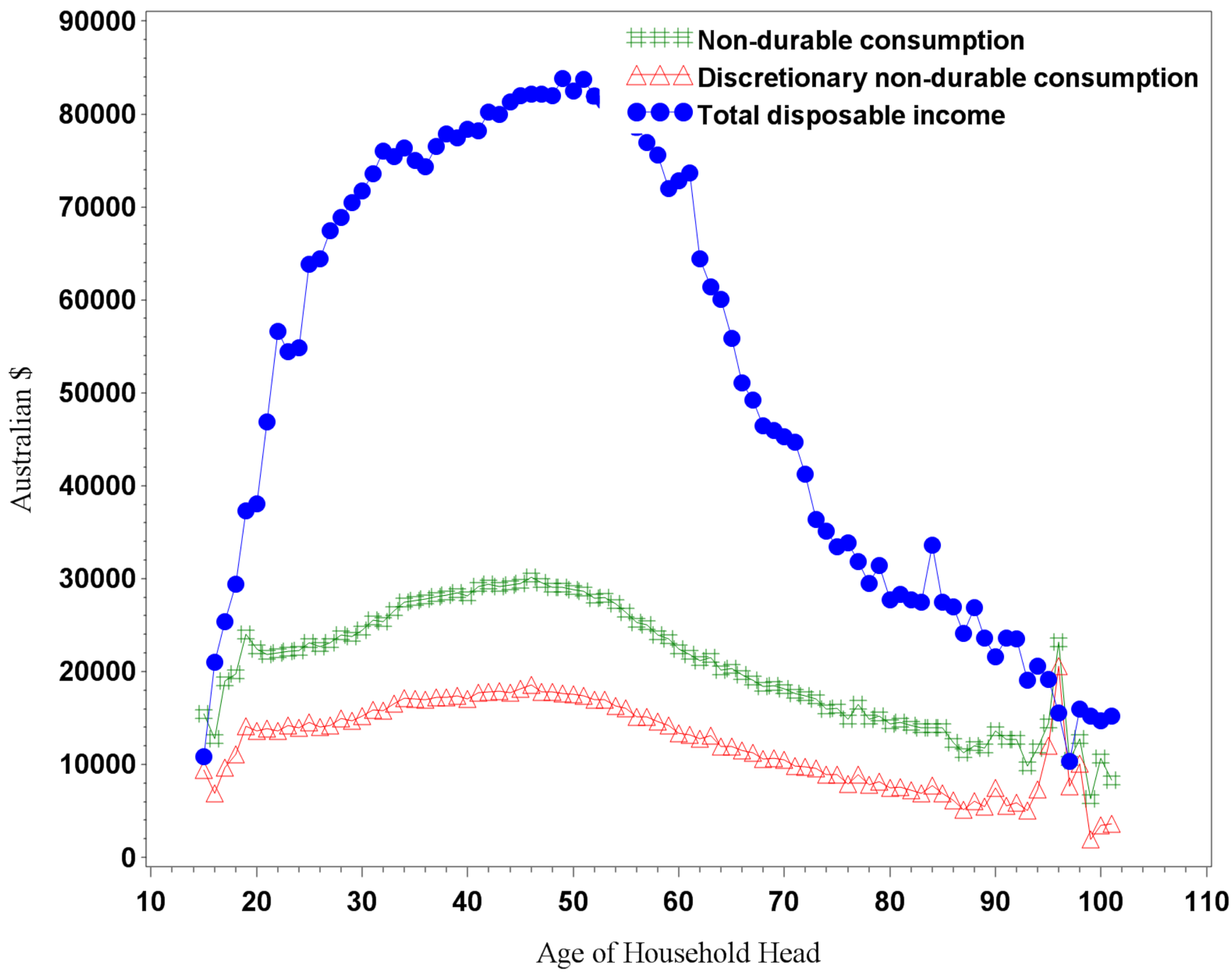


Fig. 1. Household consumption and income over life cycle. This figure presents non-durable consumption and total disposable income over the life cycle of the households in the sample.

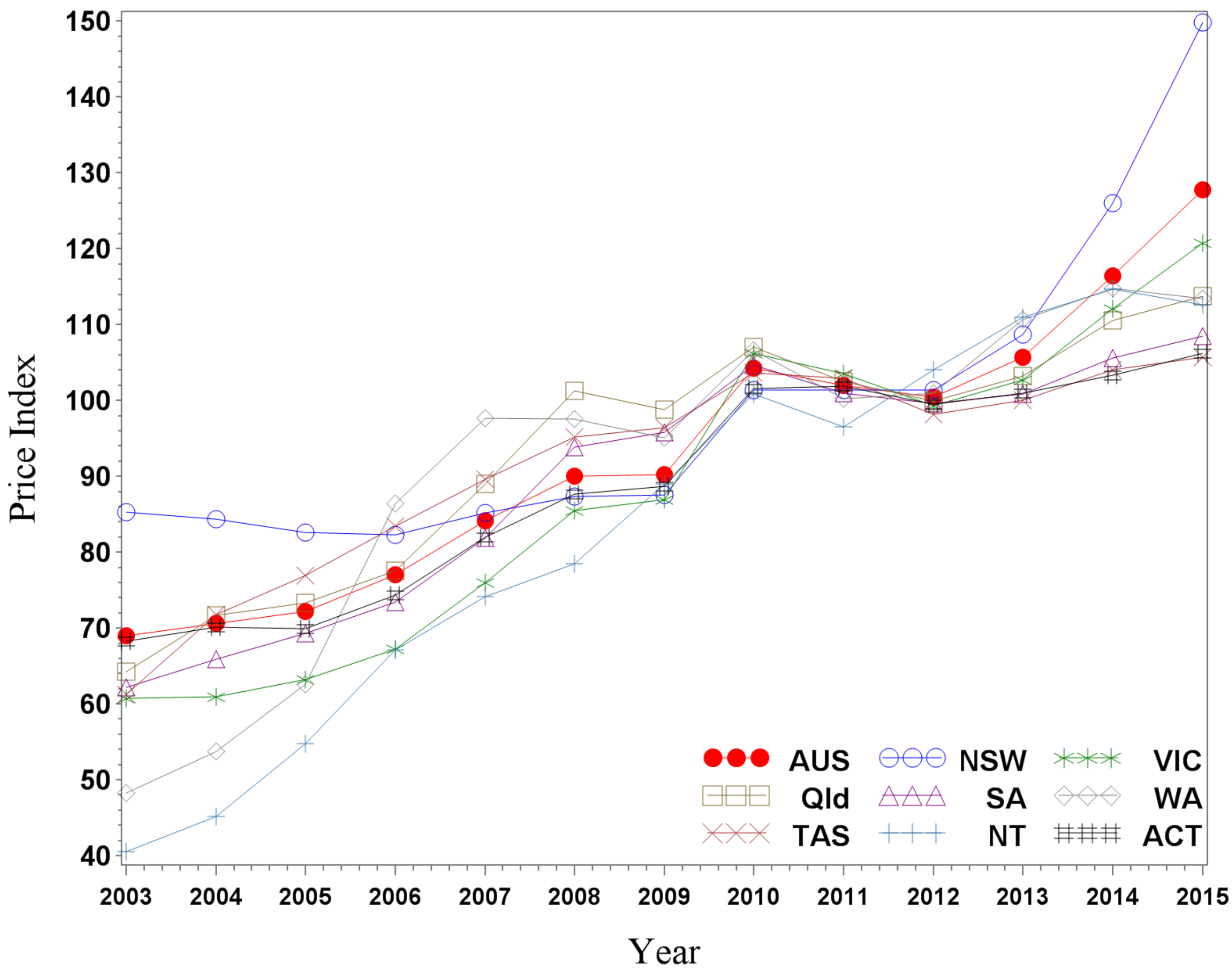
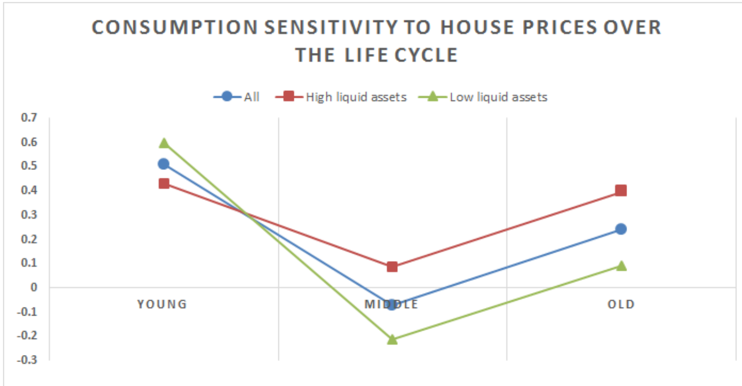
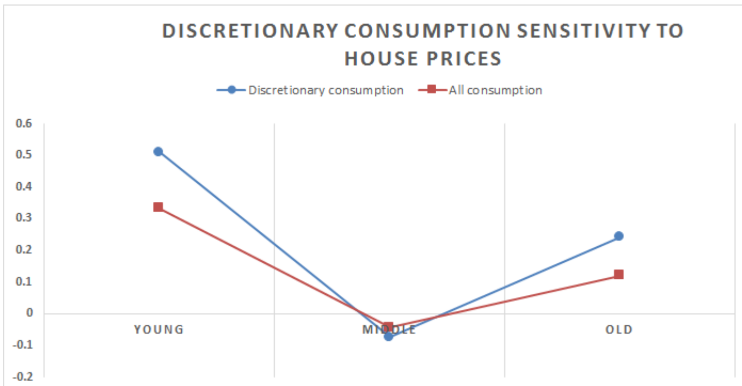


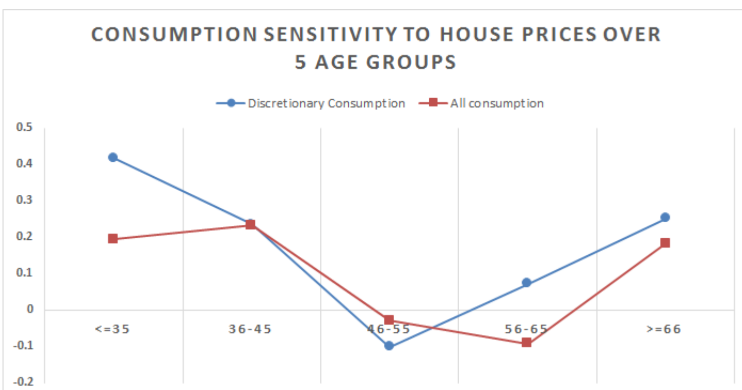
Fig. 2. House price indexes. This figure presents the Residential Property Price Indexes for Australia and its 6 states and 2 territories between 2003 and 2015.



(a) Consumption sensitivity over the life cycle



(b) Alternative consumption measure



(c) Alternative age groups

Fig. 3. House price consumption sensitivity over the life cycle. Figure (a) illustrates the life-cycle pattern of consumption sensitivity of all homeowners, those with above- and below-median levels of liquid assets. Figure (b) illustrates the life-cycle pattern of consumption sensitivity by using discretionary non-durable consumption and all non-durable consumption, where discretionary consumption excludes spending on groceries, public transport and utilities. Figure (c) illustrates the life-cycle pattern of consumption sensitivity for 5 age groups by using discretionary and all non-durable consumption.

Table 1: Summary statistics of main variables across homeownership groups

This table presents summary statistics of the main variables across homeownership groups. Growth is measured as the first-difference of the logged variables. Consumption is the aggregate annual household spending on non-durable goods and services in HILDA. Discretionary consumption excludes groceries, public transport and utilities. Income is household annual disposable income. Mortgage payments are the annual payments for all properties owned by the household. All variables are deflated using CPI to 2005 price level. Head age is the age in 2005 of the household head, the person with the highest regular income. Household size is the number of household members enumerated each year, including children. Refinance is a dummy variable equal to 1 if a household refinance their mortgage in a particular year. Initial liquid savings is the sum of bank savings, and bond and share investments in 2006. Initial net worth is the total household asset minus debt. The initial LTV (loan to value) ratio is the LTV ratio of their home property in 2006. Likely to move is dummy variable equal to 1 if a household ever intended to move in the next 12 months in any year of the sample period. % Ever refinanced is the fraction of households that have refinanced their mortgage during the sample period(based on the strength of moving intention collected in the survey. Refer to the data section for detail). Wage is household income from wage and salary and volatility is measured as the standard deviation of the growth in wage over the sample period. House prices are the Residential Property Price Indexes of states and territories in Australia. The age groups thresholds are 40 and 60 years old as of 2005.

	Homeowners				Young homeowners (≤ 40)				Middle-aged homeowners (40-60)				Old homeowners(> 60)			
	n	Mean	Std.	Median	n	Mean	Std.	Median	n	Mean	Std.	Median	n	Mean	Std.	Median
Household year level variables																
Consumption growth(disc)	15648	0.020	0.421	0.019	2752	0.039	0.382	0.040	8296	0.013	0.406	0.013	4600	0.021	0.469	0.016
Consumption growth	15648	0.002	0.321	0.003	2752	0.022	0.289	0.025	8296	-0.003	0.312	-0.002	4600	0.001	0.354	-0.002
Total income growth	15648	0.013	0.509	0.024	2752	0.027	0.405	0.029	8296	0.014	0.506	0.028	4600	0.004	0.567	0.014
Mortgage payment growth	15648	-0.083	2.547	0.000	2752	0.021	2.602	0.000	8296	-0.147	3.011	0.000	4600	-0.031	1.283	0.000
Household size	17604	2.558	1.361	2.000	3096	3.538	1.338	4.000	9333	2.746	1.373	2.000	5175	1.631	0.577	2.000
Refinance %	11736	0.041	0.199	0.000	2064	0.102	0.303	0.000	6222	0.043	0.202	0.000	3450	0.002	0.048	0.000
Household level variables																
Head age in 2005	1956	53.028	13.520	52.000	344	34.174	4.890	35.000	1037	49.974	5.676	50.000	575	69.814	6.161	69.000
Initial liquid assets	1956	115.269	320.290	21.861	344	60.625	278.230	7.952	1037	100.585	301.789	19.702	575	174.444	364.790	47.001
Initial net worth	1956	910.670	1242.487	573.100	344	556.426	816.916	370.000	1037	988.358	1238.085	674.392	575	982.494	1414.671	562.000
Initial LTV ratio	1956	0.186	0.284	0.000	344	0.430	0.309	0.433	1037	0.202	0.284	0.075	575	0.013	0.074	0.000
Likely to move	1956	0.112	0.316	0.000	344	0.169	0.375	0.000	1037	0.118	0.322	0.000	575	0.070	0.255	0.000
% Ever refinanced	1956	0.199	0.399	0.000	344	0.468	0.500	0.000	1037	0.213	0.410	0.000	575	0.012	0.110	0.000
Wage volatility	1956	1.323	2.085	0.240	344	0.965	1.868	0.232								
State level variable																
House price growth	72	0.027	0.069	0.015												
State gross product growth	72	0.002	0.019	-0.001												
State income capita growth	72	0.029	0.029	0.032												

Table 2: Baseline results across homeownership groups and the life cycle

This table presents the estimates of consumption sensitivity to house prices across homeownership and life-cycle groups. Columns (1) to (6) examine the sample of homeowners, renters and those who change between owner and renter once during the sample period, and column (7) to (10) the sample of non-moving homeowners. The dependent variable is the growth in discretionary non-durable consumption $\Delta Log(C)_t$. $\Delta Log(HP)_t$ is the growth in house prices. $Renting_t$ is a dummy variable equal to 1 if a household is renting in a particular year. $\Delta Log(Income)_t$ is the growth in disposable income. $\Delta Log(Household\ size)_t$ is the change in number of household members. $\Delta Log(Rent)_t$ is the growth in rent payments, and $\Delta Log(Mortgage\ payment)_t$ is growth in mortgage payments. $\Delta Unemployment_t$ is the change in the unemployment rates of the local area a household resides. $\Delta Log(Gross\ state\ product_t)$ is growth in gross state product. $\Delta Log(State\ income)_t$ is the growth in state income per capita. All growth variables are measured in logged difference. We control for household and year fixed effects and report clustered standard errors by households in parentheses. Significance level at the 1%, 5% and 10% is indicated by ***,**,and *, respectively.

	Homeowners and renters						Homeowners			
	All			Young	Middle	Old	All	Young	Middle	Old
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\Delta Log(HP)_t$	0.125**	0.111*	0.163**	0.327**	0.044	0.210	0.131*	0.509***	-0.073	0.241*
	(0.052)	(0.059)	(0.064)	(0.135)	(0.084)	(0.133)	(0.075)	(0.189)	(0.094)	(0.146)
$\Delta Log(HP)_t * Renting_t$			-0.188	-0.465*	-0.001	-0.116				
			(0.161)	(0.255)	(0.235)	(0.481)				
$Renting_t$			0.092***	0.087**	0.069	0.037				
			(0.028)	(0.038)	(0.049)	(0.130)				
$\Delta Log(Income)_t$	0.030***	0.030***	0.030***	0.026*	0.034***	0.025*	0.023***	-0.026	0.025**	0.033**
	(0.006)	(0.006)	(0.006)	(0.014)	(0.008)	(0.013)	(0.008)	(0.022)	(0.011)	(0.016)
$\Delta Log(Household\ size)_t$	0.189***	0.189***	0.189***	0.212***	0.156***	0.192***	0.174***	0.230***	0.176***	0.119*
	(0.018)	(0.018)	(0.018)	(0.026)	(0.026)	(0.063)	(0.030)	(0.063)	(0.039)	(0.072)
$\Delta Log(Rent)_t$	-0.009	-0.009	-0.010	-0.010	0.024	-0.147**				
	(0.022)	(0.022)	(0.022)	(0.027)	(0.042)	(0.074)				
$\Delta Log(Mortgage\ payment)_t$	-0.001	-0.001	-0.001	-0.002	-0.001	-0.007	-0.002	-0.005**	-0.002	-0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.005)	(0.001)	(0.003)	(0.002)	(0.006)
$\Delta Unemployment_t$		-0.001	-0.004	-0.003	-0.002	-0.012	-0.005	-0.005	0.000	-0.014
		(0.005)	(0.005)	(0.009)	(0.007)	(0.012)	(0.007)	(0.014)	(0.009)	(0.013)
$\Delta Log(Gross\ state\ product_t)$		0.219	0.222	-0.138	0.848	-0.570	0.458	-1.648	1.529**	-0.121
		(0.374)	(0.399)	(0.709)	(0.576)	(0.897)	(0.496)	(1.056)	(0.671)	(0.998)
$\Delta Log(State\ income)_t$		-0.086	-0.154	-0.184	-0.401	0.477	-0.193	0.291	-0.292	-0.183
		(0.245)	(0.265)	(0.457)	(0.376)	(0.624)	(0.327)	(0.654)	(0.443)	(0.673)
$\Delta Unemployment_t * Renting_t$			0.014	-0.000	0.007	0.087**				
			(0.012)	(0.017)	(0.019)	(0.038)				
$\Delta Log(Gross\ state\ product_t) * Renting_t$			-0.138	0.413	-1.554	2.310				
			(0.936)	(1.323)	(1.603)	(2.666)				
$\Delta Log(State\ income)_t * Renting_t$			0.241	0.513	-0.086	0.410				
			(0.641)	(0.842)	(1.138)	(1.985)				
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	30480	30480	30480	10152	13656	6672	15648	2752	8296	4600
Adjusted R-squared	0.033	0.032	0.033	0.047	0.032	0.023	0.024	0.040	0.029	0.017

Table 3: Young homeowners, liquid wealth and credit constraints

This table presents estimates of consumption sensitivity to house prices across subsamples of young homeowners. Mortgage coverage is the ratio of household annual disposable income over mortgage payments in 2006. All other variables are as defined in the notes of Table 1. The sample splits between high and low is based on the median values of net worth, LTV ratio and mortgage coverage. The three subsamples using liquid assets are the based on the tercile of liquid assets. We control for household and year fixed effects and report clustered standard errors by households in parentheses. Significance level at the 1%, 5% and 10% is indicated by ***,**,and *, respectively.

	Net worth		Liquid assets			LTV ratio		Mortgage coverage	
	High (1)	Low (2)	High (3)	Medium (4)	Low (5)	High (6)	Low (7)	High (8)	Low (9)
$\Delta Log(HP)_t$	0.296	0.749***	0.279	0.745***	0.436	0.586**	0.426	0.353	0.641**
	(0.254)	(0.284)	(0.369)	(0.253)	(0.353)	(0.250)	(0.275)	(0.297)	(0.254)
$\Delta Log(Income)_t$	-0.045*	0.018	-0.054	-0.008	-0.013	0.019	-0.051**	-0.044*	-0.004
	(0.026)	(0.039)	(0.034)	(0.028)	(0.054)	(0.043)	(0.023)	(0.025)	(0.040)
$\Delta Log(Household\ size)_t$	0.285***	0.201**	0.332***	0.231**	0.171	0.252***	0.167*	0.361***	0.128*
	(0.095)	(0.078)	(0.092)	(0.105)	(0.108)	(0.085)	(0.087)	(0.092)	(0.077)
$\Delta Log(Mortgage\ payment)_t$	-0.005	-0.009	-0.002	-0.010**	-0.008	-0.000	-0.008**	-0.005*	-0.004
	(0.003)	(0.006)	(0.003)	(0.005)	(0.006)	(0.004)	(0.003)	(0.003)	(0.004)
$\Delta Unemployment_t$	-0.008	-0.010	-0.020	-0.025	0.020	0.010	-0.017	-0.023	0.012
	(0.017)	(0.020)	(0.021)	(0.021)	(0.026)	(0.019)	(0.020)	(0.019)	(0.019)
$\Delta Log(Gross\ state\ product_t)$	-0.005	-3.207**	1.886	-3.213**	-2.998	-2.325	-0.769	-0.476	-2.669*
	(1.569)	(1.476)	(2.042)	(1.619)	(1.898)	(1.453)	(1.507)	(1.609)	(1.450)
$\Delta Log(State\ income)_t$	-0.930	1.690*	-2.414**	1.394	1.521	1.237	-0.644	0.718	-0.080
	(0.900)	(0.934)	(1.188)	(1.146)	(1.085)	(1.024)	(0.869)	(0.939)	(0.942)
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1368	1384	912	920	920	1384	1368	1376	1376
Adjusted R-squared	0.049	0.032	0.060	0.045	0.027	0.031	0.050	0.052	0.029

Table 4: Young homeowner and the precautionary saving motive

This table presents the estimates of consumption sensitivity to house prices of young homeowners with different levels of income volatility. $High\ Inc\ Vol$ is dummy variable equal to 1 if the income volatility (the standard deviation of wage growth) of a young homeowner is above the median value. All other variables are as defined in the notes of Table 1. We control for household and year fixed effects and report clustered standard errors by households in parentheses. Significance level at the 1%, 5% and 10% is indicated by ***,**,and *, respectively.

	All	Net worth		Liquid assets			LTV ratio		Mortgage coverage	
		High	Low	High	Medium	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\Delta Log(HP)_t * High\ Inc\ Vol = 0$	0.182	-0.231	0.448	-0.235	0.230	0.328	0.150	0.194	-0.011	0.384
	(0.228)	(0.239)	(0.334)	(0.379)	(0.225)	(0.379)	(0.259)	(0.369)	(0.269)	(0.315)
$\Delta Log(HP)_t * High\ Inc\ Vol = 1$	0.952***	0.689*	1.416***	0.435	1.798***	0.980**	1.400***	0.697*	0.749	1.166***
	(0.308)	(0.385)	(0.502)	(0.488)	(0.556)	(0.412)	(0.417)	(0.409)	(0.503)	(0.379)
Household level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State level controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2752	1368	1384	912	920	1376	1384	1368	1376	1376
Adjusted R-squared	0.042	0.049	0.033	0.061	0.055	0.042	0.035	0.050	0.054	0.032

Table 5: Old homeowners and the wealth effect

This table presents the estimates of consumption sensitivity to house prices for subsamples of old homeowners. Home equity is the value of home property minus any outstanding mortgage in 2006. *D.Likely to move* is a dummy variable equal to 1 if a household ever intended to move in the next 12 months during the sample period(based on the strength of moving intention collected in the survey. Refer to the data section for detail). Other variables are as defined in the notes of Table 1. We control for household and year fixed effects and report clustered standard errors by households in parentheses. Significance level at the 1%, 5% and 10% is indicated by ***, **,and *, respectively.

	Liquid assets		Home equity/net wealth		Liquid assets		Likely to move			
	High	Low	High	Low	High		Yes	No		
					Home equity/net wealth			All	Liquid assets	
					High	Low			High	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
$\Delta Log(HP)_t$	0.398**	0.092	0.189	0.296	0.545**	0.249	0.699	0.214	0.382*	0.054
	(0.193)	(0.216)	(0.229)	(0.186)	(0.236)	(0.238)	(0.517)	(0.152)	(0.205)	(0.221)
$\Delta Log(Income)_t$	0.013	0.055**	0.039*	0.020	0.040*	0.015	0.100*	0.029*	0.013	0.046*
	(0.019)	(0.025)	(0.023)	(0.020)	(0.023)	(0.023)	(0.050)	(0.016)	(0.019)	(0.027)
$\Delta Log(Household\ size)_t$	0.164***	0.068	0.173	0.030	0.230***	0.142	0.046	0.127*	0.154**	0.096
	(0.060)	(0.131)	(0.105)	(0.077)	(0.083)	(0.089)	(0.242)	(0.077)	(0.061)	(0.147)
$\Delta Log(Mortgage\ payment)_t$	-0.014	0.005	-0.001	-0.003	-0.003	0.004	-0.024**	0.003	-0.014	0.010
	(0.012)	(0.007)	(0.008)	(0.008)	(0.014)	(0.006)	(0.011)	(0.007)	(0.014)	(0.007)
$\Delta Unemployment_t$	-0.033*	0.009	0.009	-0.036**	-0.016	-0.047**	-0.013	-0.013	-0.029	0.006
	(0.018)	(0.020)	(0.021)	(0.017)	(0.023)	(0.020)	(0.047)	(0.014)	(0.018)	(0.021)
$\Delta Log(Gross\ state\ product_t)$	-0.940	0.703	-0.732	0.443	-1.685	0.792	2.951	-0.518	-1.797	0.648
	(1.449)	(1.393)	(1.499)	(1.314)	(1.627)	(1.584)	(2.806)	(1.059)	(1.480)	(1.513)
$\Delta Log(State\ income)_t$	0.250	-0.609	0.246	-0.676	-0.114	-0.667	-2.867	0.093	1.117	-0.913
	(0.949)	(0.967)	(1.010)	(0.881)	(1.066)	(1.068)	(2.669)	(0.695)	(0.935)	(1.035)
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	2288	2296	2296	2304	1728	1720	320	4280	2144	2136
Adjusted R-squared	0.020	0.014	0.015	0.020	0.018	0.022	0.025	0.016	0.019	0.014

Table 6: The middle-aged homeowners

This table presents estimates of consumption sensitivity to house prices of subsamples of the middle-aged homeowners. All variables are as defined in the notes of Table 1. We control for household and year fixed effects and report clustered standard errors by households in parentheses. Significance level at the 1%, 5% and 10% is indicated by ***, **, and *, respectively.

	Liquid assets		Net worth		Liquid assets		Net worth	
	High	Low	Hig	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta Log(HP)_t$	0.087	-0.214*	-0.100	-0.044	-0.005	-0.131	-0.146	0.014
	(0.140)	(0.126)	(0.127)	(0.140)	(0.136)	(0.133)	(0.127)	(0.144)
$\Delta Log(HP)_t * Likely\ to\ move$					0.888	-0.866*	0.422	-0.505
					(0.592)	(0.473)	(0.577)	(0.566)
$\Delta Log(Income)_t$	0.024*	0.027*	0.030**	0.018	0.024*	0.026	0.029*	0.016
	(0.014)	(0.016)	(0.015)	(0.015)	(0.015)	(0.016)	(0.015)	(0.016)
$\Delta Log(Household\ size)_t$	0.135**	0.206***	0.164***	0.187***	0.137**	0.202***	0.167***	0.186***
	(0.062)	(0.048)	(0.060)	(0.050)	(0.062)	(0.049)	(0.060)	(0.050)
$\Delta Log(Mortgage\ payment)_t$	-0.002	-0.002	0.000	-0.004	-0.002	-0.002	0.000	-0.004
	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)	(0.002)	(0.003)
$\Delta Unemployment_t$	-0.006	0.006	-0.013	0.014	-0.007	0.008	-0.016	0.018
	(0.012)	(0.013)	(0.012)	(0.013)	(0.013)	(0.014)	(0.013)	(0.014)
$\Delta Log(Gross\ state\ product_t)$	-0.373	3.237***	1.588	1.500	0.001	3.491***	1.561	2.211**
	(0.961)	(0.920)	(0.964)	(0.938)	(0.966)	(0.990)	(0.999)	(0.987)
$\Delta Log(State\ income)_t$	0.127	-0.709	-0.828	0.174	0.249	-1.229*	-0.713	-0.403
	(0.615)	(0.634)	(0.597)	(0.652)	(0.658)	(0.671)	(0.627)	(0.702)
$\Delta Unemployment_t * Likely\ to\ move$					0.007	-0.026	0.026	-0.039
					(0.042)	(0.041)	(0.039)	(0.043)
$\Delta Log(Gross\ state\ product_t) * Likely\ to\ move$					-2.964	-2.458	0.821	-6.645**
					(3.870)	(2.597)	(3.748)	(3.088)
$\Delta Log(State\ income)_t * Likely\ to\ move$					-1.159	4.978**	-1.387	5.567***
					(1.938)	(2.022)	(2.060)	(1.824)
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	4152	4144	4152	4144	4152	4144	4152	4144
Adjusted R-squared	0.025	0.032	0.028	0.028	0.024	0.033	0.027	0.031

Table 7: Credit constraints and cash-out refinances

This table presents the average marginal effects of various factors on the probability of cash-out refinancing when estimating Equation 7 with various models. The dependent variable $Refinance_t$ is a dummy variable equal to 1 if a household refinanced its mortgage in year t. ARM indicates that a household has adjustable rate mortgage in 2010, and FRM indicates fixed rate mortgage. $D.Middle-aged$ and $D.Old$ are dummies equal to 1 if a household is in the middle- and old-aged groups respectively. $Initial\ LTV$ is the LTV ratio of the home property in 2006. $D.High\ LTV$ is a dummy variable equal to 1 if a homeowner's initial LTV ratio is above 0.8. $D.Made\ redundant_t$ is a dummy equal to 1 if the household head is made redundant in year t. $D.Health\ shock_t$ is dummy equal to 1 if any household member experiences severe illness in year t. $D.Worsening\ in\ finance_t$ is a dummy equal to 1 if a household experience worsening financial situation in year t. $D.Business\ owner$ and $D.Shareholder$ are dummies equal to 1 if a household is a business owner or holds stocks in 2010. Note the refinance information is collected retrospectively in 2006 and 2010, which leads to a shorter sample period in the data. All other variables are as defined in Table 1. Standard errors clustered by households are reported in parentheses. Significance level at the 1%, 5% and 10% is indicated by ***, **, and *, respectively.

	All			Young	Middle-aged	Old	ARM	FRM
	LPM	Probit	RE probit	RE probit	RE probit	Probit	RE probit	RE probit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\Delta Log(HP)_t$	0.101**	0.079***	0.079***	0.257**	0.070*	0.001	0.059**	0.004
	(0.043)	(0.030)	(0.030)	(0.115)	(0.041)	(0.026)	(0.025)	(0.006)
$D.Middle-aged$	-0.033***	-0.025***	-0.025***				-0.015***	-0.003*
	(0.007)	(0.006)	(0.006)				(0.005)	(0.001)
$D.Old$	-0.045***	-0.055***	-0.055***				-0.036***	-0.004**
	(0.007)	(0.006)	(0.007)				(0.006)	(0.002)
$\Delta Log(Income)_t$	-0.000	-0.001	-0.001	0.009	-0.002	-0.002	-0.003	0.001
	(0.003)	(0.004)	(0.004)	(0.017)	(0.005)	(0.002)	(0.003)	(0.001)
$Initial\ LTV$	0.118***	0.075***	0.075***	0.137***	0.090***	0.027**	0.051***	0.007**
	(0.013)	(0.007)	(0.008)	(0.026)	(0.012)	(0.013)	(0.007)	(0.003)
$D.High\ LTV$	-0.072***	-0.045***	-0.045***	-0.068***	-0.062***	0.000	-0.032***	-0.003
	(0.017)	(0.009)	(0.009)	(0.024)	(0.016)	(.)	(0.008)	(0.002)
$Log(liquid\ assets)$	-0.002**	-0.002***	-0.002***	-0.004	-0.003***	-0.001	-0.002***	-0.000
	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)	(0.000)
$D.Made\ redundant_t$	0.033*	0.020**	0.020**	-0.018	0.027**	0.009**	0.014*	0.003
	(0.018)	(0.009)	(0.009)	(0.043)	(0.011)	(0.004)	(0.008)	(0.002)
$D.Health\ shock_t$	0.009*	0.009**	0.009**	0.020	0.009	0.003	0.005	0.001
	(0.005)	(0.004)	(0.004)	(0.017)	(0.006)	(0.003)	(0.004)	(0.001)
$D.Worsening\ in\ finance_t$	0.017	0.012	0.012	0.010	0.011	0.004	-0.009	0.005**
	(0.014)	(0.010)	(0.010)	(0.051)	(0.012)	(0.002)	(0.011)	(0.002)
$D.Business\ owner$	-0.004	-0.003	-0.003	-0.025	0.003	0.000	-0.003	0.000
	(0.006)	(0.005)	(0.005)	(0.017)	(0.006)	(.)	(0.004)	(0.001)
$D.Shareholder$	-0.004	-0.005	-0.005	-0.014	-0.003	-0.003	-0.006*	-0.001
	(0.004)	(0.004)	(0.004)	(0.014)	(0.006)	(0.004)	(0.004)	(0.001)
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9780	9780	9780	1720	5185	1650	9780	9780
Adjusted R-squared	0.051	Probit models						

Table 8: The impact of cash-out refinancing on consumption growth

This table presents estimates of the impact of refinancing on consumption growth across household groups. $Refinance\ amount_t$ is the change in outstanding mortgage after refinance scaled by household total income from the previous year. $ARM\ Refinance_t$ is dummy equal to 1 if a household has adjustable rate mortgage in 2010 and refinance its mortgage in year t. $FRM\ Refinance_t$ is a dummy equal to 1 if a household has fixed rate mortgage in 2010 and refinance its mortgage in year t. Other control variables are as defined in the notes of Table 1. We control for household and year fixed effects and report clustered standard errors by households in parentheses. Significance level at the 1%, 5% and 10% is indicated by ***, **, and *, respectively.

	All		Young	Middle-aged	Old	All	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$\Delta Log(HP)_t$	0.124	0.135	0.663***	-0.103	0.205	0.010	0.015
	(0.095)	(0.095)	(0.229)	(0.125)	(0.181)	(0.104)	(0.104)
$Refinance_t$	0.084***		0.072*	0.092***	0.197**		
	(0.025)		(0.039)	(0.034)	(0.093)		
$Refinance\ amount_t$		0.012**					
		(0.005)					
$ARM\ Refinance_t$						0.081**	
						(0.037)	
$FRM\ Refinance_t$							0.154*
							(0.090)
$\Delta Log(Income)_t$	0.024**	0.023**	-0.018	0.041***	0.012	0.029***	0.029***
	(0.010)	(0.010)	(0.030)	(0.013)	(0.018)	(0.011)	(0.011)
$\Delta Log(Household\ size)_t$	0.218***	0.221***	0.332***	0.171***	0.242***	0.189***	0.189***
	(0.040)	(0.039)	(0.093)	(0.051)	(0.080)	(0.043)	(0.043)
$\Delta Log(Mortgage\ payment)_t$	-0.003	-0.003	-0.005	-0.003	0.003	-0.002	-0.002
	(0.002)	(0.002)	(0.004)	(0.002)	(0.007)	(0.002)	(0.002)
$\Delta Unemployment_t$	-0.006	-0.006	-0.014	0.002	-0.018	-0.004	-0.004
	(0.008)	(0.008)	(0.015)	(0.011)	(0.015)	(0.009)	(0.009)
$\Delta Log(Gross\ state\ product_t)$	0.593	0.606	-1.851	0.916	1.381	1.113	1.120
	(0.648)	(0.648)	(1.407)	(0.888)	(1.287)	(0.732)	(0.732)
$\Delta Log(State\ income)_t$	-0.024	-0.037	0.874	-0.180	-0.095	-0.225	-0.236
	(0.501)	(0.502)	(0.989)	(0.704)	(0.993)	(0.574)	(0.574)
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9780	9769	1720	5185	2875	8060	8060
Adjusted R-squared	0.039	0.038	0.069	0.042	0.026	0.034	0.034

Table 9: Robustness tests

This table summarizes robustness test results. Panel A uses an alternative measure of consumption including all non-durable expenditure items. Panel B uses an alternative measure of house prices: self-assessed value of the house. Panel C extends the sample to include those homeowners who have moved during our sample period. Panel D examines a finer age-grouping using five life-cycle stages. Panel E examines the impact of predicted and unpredicted changes in house prices. $\Delta Log(HV)_t$ is the change in household self-assessed value of the house. $(Un)Predicted\ \Delta Log(HP)_t$ is the (Un)predicted change in house prices using lagged house price changes, interest rate, rent and income growth. Borrowing constraints are measured as the equally weighted value of the standardized liquid savings and LTV ratio. All variables are defined as before and all tests include the same household level variables, state level variables, year and household fixed effects. Standard errors are clustered by households. Significance level at the 1%, 5% and 10% is indicated by ***, **, and *, respectively.

Panel A: All non-durable consumption

	All	Young	Middle	Old
$\Delta Log(HP)_t$	0.074	0.333**	-0.043	0.121
	(0.058)	(0.135)	(0.077)	(0.109)
Observations	15648	2752	8296	4600
Adjusted R-squared	0.013	0.017	0.020	0.008

Panel B: Self-assessed house value change

	All	Young	Middle	Old
$\Delta Log(HV)_t$	0.027	0.108**	-0.015	0.060
	(0.024)	(0.054)	(0.031)	(0.045)
Observations	15648	2752	8296	4600
Adjusted R-squared	0.024	0.039	0.029	0.017

Panel C: With homeowners who moved

	All	Young	Middle	Old
$\Delta Log(HP)_t$	0.166**	0.380**	0.036	0.217*
	(0.067)	(0.156)	(0.086)	(0.131)
Observations	20832	4600	10672	5560
Adjusted R-squared	0.027	0.037	0.030	0.020

Panel D: Five life-cycle groups

	<=35	36-45	46-55	56-65	>65
	(5)	(6)	(7)	(8)	(9)
$\Delta Log(HP)_t$	0.417	0.236	-0.101	0.072	0.251
	(0.271)	(0.151)	(0.133)	(0.152)	(0.190)
Observations	1392	3544	4288	3200	3224
Adjusted R-squared	0.037	0.033	0.027	0.025	0.016

Panel E: Predicted and unpredicted changes in house prices

	All	borrowing constraints		Liquid savings		LTV ratio	
		High	Low	High	Low	High	Low
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
$Predicted\ \Delta Log(HP)_t$	0.242	0.587	-0.262	-0.171	0.632	0.141	0.446
	(0.291)	(0.384)	(0.444)	(0.394)	(0.426)	(0.370)	(0.464)
$Unpredicted\ \Delta Log(HP)_t$	0.106	0.062	0.172	0.348**	-0.122	0.095	0.141
	(0.120)	(0.157)	(0.186)	(0.171)	(0.169)	(0.156)	(0.188)
Observations	15648	9072	6576	7824	7824	9800	5832
Adjusted R-squared	0.024	0.024	0.026	0.026	0.024	0.022	0.029