Consumption of Housing During the 2000s Boom: Evidence and Theory*

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Abstract

Housing accounts for about 18 percent of personal consumption expenditures. Over the period 1998-2007, the price of houses increased over 50 percent relative to the price of consumption goods. In this paper I investigate the household consumption responses to this massive change in relative prices using the Panel Study of Income Dynamics matched with detailed geographic information for individual households. I then develop and solve a life cycle model that incorporates tenure choice, multiple house sizes, and non-recourse default. The main findings are that (1) households that already owned homes (continuing homeowners) bought larger homes while only marginally increasing their expenditures on non-housing goods and services; (2) in areas with high house price growth, renters became significantly less likely to transition into homeownership, and those that did bought smaller homes; and (3) my empirical results can be explained by optimistic beliefs for future rents that increased both the present price of housing and expectations for future prices. Higher expected capital gains lowered the user cost of owner occupied housing, increasing demand for housing services, while the debt-to-income constraint and higher current house prices limited the transition of renters into homeownership.

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1 Introduction

When relative prices change, consumers usually substitute away from the more expensive good[1]. However, I find that from 1998-2007, as house prices rose over 50 percent relative to other consumption goods (see the top left panel of Figure 1), unconstrained households increased their consumption of owner-occupied housing, while leaving their expenditures on other consumption goods relatively unchanged. Specifically I find that households that already owned homes (continuing homeowners) bought larger homes during the boom, where larger can be interpreted as an increase in the physical size of their primary residence or a positive change in quality of their house or neighborhood. In contrast, in areas with high house price growth, renters became less likely to transition to homeownership, and those that did bought smaller houses.

My main data set is the Panel Study of Income Dynamics (PSID) matched with detailed geographic information for individual households.[2] The panel nature of the PSID allows me to track households over time, to see whether they move, whether they rent or own, or if they transition into homeownership. The location information allows me to observe households moving from one neighborhood to another, and to compare characteristics—including home values—of those neighborhoods. Furthermore, using data on local house price appreciation, I can differentiate wealth effects for homeowners experiencing higher house price growth from stories such as optimistic expectations for future house prices. I can also control for household level information, including income and education.

I then test whether reasonable optimistic expectations for house prices can explain these results using a life cycle model of homeownership that incorporates tenure choice, multiple house sizes, and the option to default. In my simulations, expectations for higher future house prices raise the current price of housing and lower the user cost. The user cost is the price that enters the demand function, so all households demand more owner-occupied housing. Many households that already owned homes can purchase larger homes. However, higher current house prices increase the probability that renters are bound by loan-to-value and debt-to-income constraints. Renters that do transition to homeownership purchase smaller homes relative to their rented residences than they did prior to the boom.

The results are consistent with aggregate features of the boom. A defining feature of the boom is the fall in the rent-to-price ratio. Prices of owner-occupied housing rose much faster than rents on equivalent properties (see the bottom left panel of Figure 1). The price of a house should reflect the present value of the discounted flow of rents. The growth in prices without a parallel increase in rents implies that households expected higher future rents.

In the aggregate data, both existing home sales and the homeownership rate (top right

[1] Giffen goods excepted.

[2] This is restricted data only available via a contract with the PSID.

panel of Figure 1) reached peaks during the boom despite the higher house prices. In the PSID, continuing homeowners were more likely to change their primary residence and renters were more likely to transition into homeownership during this period (see Figure 2), consistent with this aggregate fact. However, the homeownership rate also provides evidence that as house prices reached their peak towards the end of the boom, it became more difficult to transition into homeownership. The homeownership rate peaked in 2005, prior to the end of the boom, and between 2005 and 2007, as house prices continued to rise, the homeownership rate fell. In the PSID, the probability of transitioning into homeownership peaked in 2005 and then fell significantly from 2005 to 2007. This drop in the homeownership rate happens at the same time as the income needed to qualify for the median home increased. In some areas of the country, the qualifying income doubled over the course of the boom, with the majority of the growth in qualifying income occurred from 2004 to 2007 (see the bottom right panel of Figure 1).

My results contribute to the new narrative of the housing boom by highlighting the increase in consumption of housing services among homeowners, and the limited role played by first-time home buyers. The old narrative centered on a relaxation of credit standards that increased access to mortgage credit and lowered the cost of transitioning to homeownership, allowing previously constrained households become homeowners.[3] The new narrative claims that while credit constraints may have been relaxed, there was a prominent role played by optimistic expectations for house price appreciation.[4] These competing narratives have direct implications for policy.

I also contribute to the literature on housing demand. This includes Henderson and Ioannides (1989) that solves a model describing why wealthier households are more likely to be homeowners because they have lower aboslute risk aversion; Ioannides and Rosenthal (1994), who find that the principal residence of most owner-occupiers is determined by their consumption demand for housing, not their investment demand; and Landvoigt (2017) who uses a pseudo panel created from the Survey of Consumer Finances to estimate short-run price expectations during the boom off of changes along the intensive and extensive margin of housing demand.

I follow in the footsteps of the literature that has developed life cycle models that incor-

[3]The root causes of these narratives vary depending on political leanings. On the right, the culprit is Clinton-era liberal politics that gave license to government agencies to boost homeownership among lower-income Americans. For example, see the column "The Clinton-Era Roots of the Financial Crisis" by Phil Gramm and Mike Solon in the Wall Street Journal, available at `http://tinyurl.com/gu4emzr`. On the left, it is the Reagan-era deregulation of the financial sector that set the stage for a surge in predatory lending to naive borrowers who did not have the knowledge or tools to protect themselves. See Paul Krugman's column "Reagan Did It" in the New York Times, available at `http://tinyurl.com/ya8v6tde`.

[4]Papers contributing to the new narrative include Adelino, Schoar, and Severino (2016), Glaeser, Gottlieb, and Gyourko (2013), Ferreira and Gyourko (2015), Albanesi, De Giorgi, and Nosal (2017), Kaplan, Mitman, and Violante (2017) and Foote, Loewenstein, and Willen (2016).

porate housing. These include Li and Yao (2007), who used a model to study the welfare effects of house price changes. Li et al. (2016) develop another, similar model, that allows them to directly estimate the parameters of a CES utility function from the PSID. I use their estimate for the parameterization of my model. The setup of the model in this paper is most closely related to Demyanyk et al. (2013) who incorporated realistic features of housing markets, including non-recourse foreclosure.

Lastly, this paper is related to the literature on the marginal propensity to consume (MPC) out of housing wealth. This supports other papers finding a relatively low MPC, including Levin (1998) who used the Retirement History Survey and found no effect of house prices on consumption; Skinner (1989) who also used data from the PSID; Ganong and Noel (2017) who estimate their MPC using variation in the application of Home Affordable Modification Program during the Great Recession; and Cooper (2013) who also used the PSID and found that house price drops have little effect on consumption for non-credit constrained households. Papers that found larger values include Campbell and Cocco (2007), who used a pseudo panel of micro data from the United Kingdom, and Mian, Rao, and Sufi (2013) who use U.S. data aggregated to the county. However, these larger values are hard to square with aggregate consumption, which did not increase much relative to income during the boom (see Figure 13 in the appendix).

Throughout this paper, I often refer to the pre-boom, boom and bust. I define these as as 1990 to 1998 (the 1991 to 1997 waves of the PSID), the boom 1998 to 2007 (the 1999 to 2007 waves of the PSID), and the bust as 2007 to 2013 (the 2009 to 2013 waves of the PSID), although my analysis uses data through the 2015 wave of the PSID. The rest of this paper is organized as follows. In Section 2 I detail the PSID and other data sources used; in Section 3 I describe the the analysis of transitions into homeownership and rate of housing transactions among continuing homeowners. In Section 4 I discuss the housing choices made by first-time home buyers and continuing homeowners; and Section 5 is about my analysis of non-housing consumption. Section 6 contains a description of the life cycle model, its simulation, and results. Section 7 concludes.

2 Data

The main data used in this paper comes from the Panel Study of Income Dynamics (PSID). The PSID is a longitudinal panel survey of households in the United States, conducted by the Survey Research Center at the University of Michigan. This paper uses data from the core and immigrant samples from 1991 onward, although the main focus is on the period from 1999 to 2007. The core sample was drawn in 1968 and is comprised of two separate random samples: a smaller one that over-sampled lower-income Americans, and a larger, nationally representative sample. Over time, this core sample has grown to include anyone born to or adopted by a sample member, even when those people leave to form their own households.[5] Because this sample design does not account for people who arrived in US after 1968, the PSID added an representative "Immigrant Refresher Sample" in 1997.

Together these samples are a national probability sample, and starting in 1997 the PSID provides weights to create statistics representative of the US as a whole. Table 1 contains summary statistics of the un-weighted sample.[6] After removing households with missing data, the number of families in the core and immigrant samples in range from 6,747 in 1997 to 9,062 in 2013.[7] Interviewers gather detailed demographic and financial information from each household.[8] The PSID was originally created to study the dynamics of income and poverty, so family income—the sum of taxable,[9] transfer, and social security income for all members of the family unit—and other variables of interest such as whether the family owns their home or rents, are available from 1968 until the most recent interview in 2015. Other variables were added over time.

The main variables used in this paper are the information on each family's homeownership status, whether the family has moved, and their specific geographic location. The PSID has collected all of this information since its inception in 1968. The public PSID only includes each household's state of residence. Through a contract with the PSID I have access to restricted data on geographic information down to the census tract. Using the geographic identifiers, I merge in census tract house price levels from the decennial censuses and the American Community Survey; yearly employment growth from the Quarterly Census of Employment and Wages (QCEW); and county-level house price appreciation from the Federal Housing Finance Association (FHFA).

I also make use of the PSID data on consumption expenditures. Since 2005, the PSID has collected information on enough categories to provide a relatively comprehensive measure of all consumption expenditures. Unfortunately, prior to 2005, questions were asked about fewer categories, and prior to 1999, data was only collected on food. That being said, the questions about food are detailed and include information about the dollar amount spent on food eaten at home and out since the PSID's inception in 1968.[10] In my analysis of

[5]The exception is in 1997 when, due to the growth in the core sample and for budgetary reasons, the PSID dropped a portion of its core sample.

[6]Weighted summary statistics from 1997 onward are available in Table 6 in the appendix.

[7]In much of my analysis I only use households to whom I can match local house price indices and other controls, which is consistently around 70 percent of the households

[8]Throughout this paper, unless otherwise noted, all dollar values are deflated to 2009 dollars using the chain price index for personal consumption expenditures from the National Income and Product Accounts. All values for income are net of federal and state income tax. Taxes for each household were estimated using the NBER's TAXSIM version 9.

[9]This component includes business income, taxable capital gains, and salary and wages.

[10]Data on these food expenditures are not available in 1988 or 1989.

non-housing consumption expenditures, I utilize the data on food expenditures, and data on all non-housing consumption expenditures collected since 1999. These include medical and dental expenditures, transportation expenditures, including the purchase and maintenance of cars, child care, schooling, and utilities.

The PSID matches characteristics of the mortgage boom and bust quite well. One important characteristic of the mortgage boom is that house price growth far exceeded rent growth, leading to a fall in the rent-to-price ratio. Renters in the PSID are asked how much money they spend on rent and homeowners are asked the value of their home. In the top panel of Figure 3 I plot the implied rent-to-price ratio in the PSID, along with the aggregate rent-to-price ratio calculated by Davis, Lehnert, and Martin (2008). These are not directly comparable. The values for rent from Davis, Lehnert, and Martin (2008) are imputed rents for owner-occupied houses, while the rents in the PSID are expenditures on rental properties. Despite this caveat, the ratio in the PSID tracks the aggregate value remarkably closely, especially from 1999 through 2010. Most importantly, both the PSID and the comparison series fall by about the same amount during the boom: from about 5 to 3 percent. The bottom left panel in Figure 3 plots the growth in the average house price and annual rent separately. In 1999, self-reported house values in the PSID started growing much more quickly than rents, similar to the bottom left panel of Figure 1.

Another feature of the boom is that first-time home buyers made up a smaller share of home purchases. The bottom right panel if Figure 3 plots the share of first-time buyers among all home buyers both from the American Housing Survey (AHS) and the PSID. While the PSID value is noisier, the shares are in the same range. Most importantly, both the AHS and the PSID show a decreasing share of first-time buyers in all housing purchases from the late 1990s until 2007.

3 Probability of Home Purchase

My empirical analysis of housing consumption proceeds in two steps. First I ask whether households were more likely to purchase homes during the boom. Second, I ask whether conditional on purchasing a home, they purchased a larger or smaller home. In this section I describe the empirical approach and results for the first question for which I employ two proportional hazards models.

3.1 First-Time Homeownership

The analysis of first time homeowners fits nicely into a survival analysis methodology. First-time homeownership is a life cycle event and a terminal state, meaning that someone cannot be a first-time home buyer more than once. I use the age of the household head as the metric of time and I assume that households become at risk of becoming first-time homeowners when a they enter the data and I observe them renting for at least one period (if a household indicates that they own their home during their first interview, they do not enter this analysis).

The proportional-hazards functional form allows estimation of a continuous-time model using discrete data (Prentice and Gloeckler 1978; Allison 1982). Let the continuous-time probability of first-time home purchase be defined as:

$$\lim_{\Delta \to 0+} \frac{Pr(t \leq T < t + \Delta | T \geq t)}{\Delta} = \lambda(X_{i,t}, t) = \exp(X_{it}'\beta)\lambda_0(t),$$

where T is the age of first-time homeownership, i represents individual households, t is the age since the head of the household, $\lambda_0(t)$ represents the baseline hazard function, and $X_{i,t}$ are the time-varying covariates.

The model is estimated using a complementary-log-log regression, which retains the proportional hazards assumption in a setting with discrete data. The dependent variable indicates whether a household has yet to purchase their first home, purchased their first home, or are censored (the households leaves the data because of attrition, death, or because the end of the sample was reached without purchasing a home). The baseline hazard is a quartic of age.[11] To account for the change in interview frequency, I drop all even years prior to 1997.[12] I follow the advice of Singer and Willett (2003) in handling late entrants to the data and only include households when I observe them. For example, if a household enters the data at age 30 and purchases their first house at age 33, they only enter the estimation of the hazard for ages 30 through 33.

The specification of the time-varying covariates is as follows:

$$\begin{aligned} X_{it} = & \boldsymbol{\alpha} * f(\text{hpa}_{it}) + \beta_1 * \ln(\text{Income}_{it}) + \beta_2 * (\text{Family Size}_{it}) \\ & + \boldsymbol{\beta_3} * f(\text{Years of Education}) + \beta_4 * \text{Census Tract Median Home Value}_{i,2000} \\ & + \beta_5 * \text{Months Since Last Interview}_{it} + \beta_6 * \text{County Employment Growth}_{it} + \gamma_t, \end{aligned}$$

where f(Years of Education) contains a quadratic of the years of education, and $f(\text{hpa}_{it})$ is

[11]This method for estimating hazards allows for a fully flexible baseline hazard by including a dummy for every age of potential first-time home buyers. The benefit of this approach is complete flexibility in the underlying hazard function, while the cost is the degrees of freedom available to estimate the parameters. Given the relatively small number of observations available in the PSID, I explored other options for the baseline hazard including a simple linear specification and polynomials of age. I used various model selection techniques such as comparing values of the Akaike Information Criteria (AIC) to choose my final model.

[12]Running the hazard separately for data before and after 1997, which allows me to use all the data prior to 1997, produced similar results.

a quartic the house price appreciation[13] from $t-1$ to t for the county in which the household resided at time $t-1$.[14] Home Value$_{i,2000}$ is the median owner-occupied house value in the census tract where the household resided at time $t-1$ from the 2000 decennial census, and γ_t are year fixed effects. The variable "Months Since Last Interview" controls for the fact that interviews happen at different times within the year.[15] All coefficients in bold indicate a vector of values. The use of the house price growth from the county from which the household moved assumes that households have a preference for owning a home in the same county in which they are renting.[16]

The parameters of interest are the vector $\boldsymbol{\alpha}$ and the coefficients on the year fixed effects (γ_t). The vector $\boldsymbol{\alpha}$ captures the impact of local house price appreciation on the probability of either first-time homeownership or the purchase of a new primary residence, while the coefficients on the year fixed effects will account for any time-varying changes not accounted for by the controls, including expectations for house price appreciation.

If households had optimistic expectations for capital gains on owner-occupied housing, the probability of transitioning to first-time homeownership should go up. However, since first-time home buyers are more likely to be constrained by increasing house prices, renters will be limited in their ability to transition to homeownership in areas with higher house price appreciation. Therefore, I expect to find that renters were more likely to transition, but less so in high house price growth areas.

3.2 Continuing Homeowners

I model the decision to purchase a new home conditional on already being a homeowner as a multiple failure hazard. As described in Willett and Singer (1995), the methods used above for estimating single failure hazards are easily extended to situations with multiple failures. Instead of households being removed from the data after they purchase a house, every time a family purchases a new residence, they become at risk of purchasing their next

[13]Unless otherwise noted, house price appreciation is net of national inflation.

[14]The quartic was chosen because for it allowed for enough flexibility without taking up too many degrees of freedom. Using a spline in house price appreciation instead of a quartic give similar results. The majority of households move within the same county and for them this reflects the house price appreciation of both where they moved from and where they moved to. Using house price appreciation from the location of the households at time t instead of $t-1$ also produced similar results.

[15]Most of the interviews are conducted in the first half of the prior year, but the exact month can vary. The wording of the questions about moving also vary slightly. The questions prior to 2003 asked whether a family had moved since its last interview, while after 2003 the question reads: "Have you moved since January [of the previous interview year]".

[16]The use of the house price appreciation from $t-1$ to t allows for more variation in house price appreciation. Different areas of the United States experienced different paths of house prices. Regressions were also run using annualized house price appreciation over the entire boom (from 1998 to 2007), with similar results.

home. The metric of time is the number of years since the previous home purchase. I remove left-censored households: if a household owns their home when they enter the data, they are not included in the regression analysis until they purchase their next home, so that I can correctly account for time since last home purchase. The parameters are then estimated in the same fashion as above with a complementary log-log regression.

The specification of the time-varying covariates for the continuing homeowner hazards is as follows:

$$\begin{aligned} X_{it} = & \boldsymbol{\alpha}_{1,T} * f(\text{hpa}_{it}) + \beta_1 * \ln(\text{Income}_{it}) + \beta_2 * (\text{Family Size}_{it}) \\ & + \boldsymbol{\beta_3} * f(\text{Years of Education}) + \beta_4 * \text{Previous Home Value}_{i,t} \\ & + \beta_5 * \text{Rooms in Previous Home} + \beta_6 * \text{Months Since Last Interview}_{it} \\ & + \beta_7 * \text{County Employment Growth}_{it} + \boldsymbol{\beta_8} * f(\text{age}_{it}) + \gamma_t, \end{aligned}$$

where $f(\text{age}_{it})$ is a quartic of age, which can be included here because the metric of time is years since previous home purchase, not age. As above, all coefficients in bold represent a vector of values. The census tract median house value has been replaced with the homeowners previous home value.[17] Otherwise, the controls are the same as those for included in the first-time home buyer hazards.

The parameters of interest are again the vector $\boldsymbol{\alpha}$ and the coefficients on the year fixed effects (γ_t). Studying these coefficients allows me to assess whether homeowners were simply responding to an increase in wealth due to growing house prices. If the pattern of higher rates of home purchase are due to a wealth effect, this will be captured by the coefficients on house price appreciation, and result in little time-varying change in the coefficients on the year fixed effects. In contrast, if the coefficients on the year fixed effects increase during the boom, this will imply that homeowners in areas with little to no house price appreciation were also more likely to purchase new homes.

3.3 Results

The bottom panels of Figure 4 contain plots of probabilities of purchasing a first home and purchasing a new primary residence by year. The two lines hold house price growth fixed at two different values: net zero house price growth and 15 percent appreciation. Over the course of the boom, the probability of continuing homeowners purchasing a new primary residence increases four percent while the probability of transitioning to homeownership increases two percent. The increase in new home purchase is more dramatic for continuing homeowners than for first-time home buyers in both absolute value and in percentage terms.

[17] Using teh census tract median house value does not affect the results.

The probability of continuing homeowners purchasing a new home increases over 50 percent from the pre-boom period, compared to a 20 percent increase in the probability of transitioning to first-time homeownership.

The other difference between first-time home buyers and continuing homeowners is that in 2007, at the peak of the boom when house prices were highest, the probability of continuing homeowners purchasing a new home remained high, while the probability of renters transitioning to first-time homeownership falls four percent, below its value at the beginning of the boom. There are two possible reasons for the decrease in transitions to homeownership. First, as house prices increase, more renters are limited by their income and are priced out of homeownership. Second, as seen in the bottom left panel of Figure 1, rents were not increasing as fast as house prices during the boom. Therefore, on the margin, renting was becoming more attractive, especially in areas with high house price growth. Unlike renters, homeowners benefit from rising house prices, and they are able to spend that increase on wealth on a down payment for a new house.

The top two panels of Figure 4 plot the estimated probabilities for different values of house price appreciation. High house price appreciation implies a lower probability of renters transitioning into homeownership, but a higher probability of continuing homeowners purchasing a new primary residence. Compared to a renter in an area with net zero house price appreciation (relative to inflation), a renter in an area with 15 percent house price appreciation is 2.5 percent less likely to transition into homeownership. The probability of first-time homeownership is also lower in areas with low house price appreciation, however, this is probably due to correlated economic conditions that are not picked up by the year fixed effects and the local employment growth. The larger standard errors on the probabilities for low house price appreciation reflect the fact that fewer renters transition to homeownership during times of low house price growth.

Continuing homeowners are more likely to purchase a new primary residence in high house price growth areas. Compared to a homeowner in an area with net zero house price appreciation, a homeowner is about 1 percent more likely to purchase a new home in an area with 15 percent house price appreciation. This can be interpreted as the wealth effect: as house prices increase, homeowners become wealthier and may want to adjust their consumption of housing. When thinking about wealth effects due to house price increases and consumption of housing, it is important to remember that the flow cost of housing is the user cost. If house prices rise, without any change in the user cost, the household is wealthier, but has not increased its expenditures on housing. One way to increase their expenditures on housing is to move to a larger home.[18]

[18]Table 2 contains additional regression details, including the parameter estimates on the remaining controls and measures of goodness of fit.

4 Consumption of Owner Occupied Housing Services

In this section, I ask whether conditional on purchasing a home, how did households change their consumption of housing? I estimate regression models on sub-samples of the data, such as households purchasing their first home or continuing homeowners buying a new primary residence, to see how those choices changed over time. The logic behind these regressions is that the decision to purchase a home, either for the first time or as a continuing homeowner, has multiple stages. The first stage of the decision is whether to move forward with the purchase. The second stage of the decision is which home to buy, which includes the location, size, price of the house, et cetera. The hazard models discussed above are about the first stage of this decision, while the regressions in this section are about the second stage.[19]

The specification for the conditional regressions is as follows:

$$Pr(Y|X) = f(\boldsymbol{\alpha} * f(\text{hpa}_{it}) + \boldsymbol{\beta} * X_{it}),$$

where the function $f()$ reflects the fact that the dependent variable can be continuous, so that $f()$ is linear in parameters, or binary, in which case $f()$ is the logit function. X_{it} includes the following controls:

$$\begin{aligned} X_{it} = & \boldsymbol{\alpha} * f(\text{hpa}_{it}) + \beta_1 * \text{Income}_{it} + \beta_2 * (\text{Family Size}_{it}) \\ & + \boldsymbol{\beta_3} * f(\text{Years of Education}) + \beta_7 * \text{Months Since Last Interview}_{it} \\ & + \beta_8 * \text{County Employment Growth}_{it} + \boldsymbol{\beta_9} * f(\text{age}_{it}) + \gamma_t, \end{aligned}$$

where the covariates are defined as described in Section 3.

[19] For discrete choices, it is also possible to use a competing hazards model, where the purchase of different types of homes would be viewed as alternative, competing outcomes. A hazard followed by conditional logits (since the choice is discrete) and competing hazards are not interchangeable models. The key question is whether the effect of house price appreciation on the purchase of a home is a population parameter that is invariant, or whether the effect of house price appreciation on the purchase of a *specific type* of home is the invariant population parameter. It is not feasible for them both to be invariant: one must be function of the other individual-level covariates. In the latter case—when the effect of house price appreciation on the purchase of a specific home is the invariant parameter—the competing hazards model is the correct specification (Hachen Jr 1988; Allison 2014).

It seems natural that the effect of house price appreciation on first-time homeownership should be independent of the types of houses available for first-time home buyers to buy. Therefore, first-time homeownership should be modeled as an overall hazard followed by conditional logistic regressions. The correct model for continuing homeowners is less clear. It is possible that the population invariant parameter is the effect of house prices on the purchase of a larger home as opposed to the effect on purchasing any new home. The results in the main body of this paper use an overall hazard followed by conditional regressions with a continuous left-hand side variable because this model produces results that are easier to interpret. A competing hazards specification using a binary dependent variable indicating whether households moved to a more expensive census tract was also implemented and the results were all qualitatively and quantitatively very similar.

Unlike for the hazards, I do not drop even years of data. Instead, I adjust all the left-hand-side variables and the information on which I condition, to reflect whether the event of interest took place in the past two years. For example, a family is coded as having moved in 1997 if it was coded in 1997 as having moved since its 1996 interview or if it was coded as having moved in 1996 since its 1995 interview.

The main dependent variable is the difference of the log of the median house value in the census tract the household moves to minus the log of the median house value in the census tract they moved from, which I interpret as the percent change in housing consumption.[20] Local house prices reflect both neighborhood characteristics and house sizes, and incorporate all other amenities in a given area, such as the quality of local public schools. Whether a household moves to a more expensive census tract therefore provides a reasonable measure of whether they are increasing their consumption of housing services, and the percent change in the median house value provides a measure of how much. The above regression specification is run separately on samples of continuing homeowners, first-time home buyers, and renters that moved to assess whether they were more likely to move to more expensive census tracts during the boom.

I also use information available in the PSID to ask if all homeowners, independent of whether they changed their primary residence, increased their consumption of housing services. and whether the household invested more then $10,000 in their primary residence above and beyond regular maintenance. In 1994, 1999, and from 2001 onwards, the PSID has included a question about whether the household invested more then $10,000 in their primary residence above and beyond regular maintenance. The question in 1994 and 1999 asks about the previous five years, while the from 2001 onwards, the question refers to the time since the previous interview. There is no perfect way to adjust these variables to be comparable. I convert this variable to a binary indicator of whether a household made a significant investment, and divide estimated year probabilities in 1994 and 1999 by 2.5.

Also, starting in 2001, the PSID asks households whether they own a second home. The PSID first asks whether the household owns any real estate other than their primary residence, and then follows up by asking whether this includes a second home. I use affirmative answers to the second question as an indicator for whether a household owns a second home, and identify a household as having purchased a second home if they did not answer in the affirmative during their previous interview. For purchasing a second home, I cannot see whether households were more likely to purchase second homes during the boom relative to

[20]The percent change in census tract house values from 1991 to 1995 are from the 1990 census, from 1996 to 2005 are from the 2000 census and from 2006 to 2009 are the 2009 5-year ACS estimates. The remaining years use the concurrent 5-year ACS estimates. All values are in 2009 dollars. I tried variety of other methods of estimating tract-level house prices in years for which I do not have data, including linear interpolation, and all gave very similar results.

prior to the boom, but only whether they were more likely to do so in higher house price growth areas, and whether they were more likely to do so during the boom than during the bust. The results using these two questions are purely suggestive.

Similar to the hazard models, the parameters of interest are the coefficients on the quartic of house price appreciation ($\boldsymbol{\alpha}$) and the year fixed effects (γ_t). The coefficients on house price appreciation should capture any wealth effect from increasing house prices, while the year fixed effects will pick up anything that was fundamentally different about the boom that is not captured by other covariates. If the housing boom was characterized by optimistic expectations for house prices, I would expect that continuing homeowners, independent of whether they live in an area with high house price growth, would increase their consumption of housing. On the other hand, assuming renters usually purchase the largest home they can, first-time home buyers would not increase their consumption of housing, and in areas with high house price growth, would decrease their consumption relative to what they would have purchased had house prices been lower.

4.1 Results

As can be seen in Figure 5,[21] during the boom first-time home buyers were moving to progressively cheaper census tracts relative to where they had rented. In 2007, when—as shown in section 3—fewer renters were transitioning to homeownership, those that were purchased homes in census tracts that were about 8 percent cheaper than those in which they were renting. By comparison, during the pre-boom and bust, first-time home buyers were moving to census tracts of comparable value to the ones in which they had been renting. These plots by year do not hold house price appreciation constant, so some of these results are driven by higher house price growth during boom.

Specifically, in areas with 15 percent house price growth, first-time home buyers were moving to census tracts that were 10 percent cheaper than those in which they were renting. This is in comparison to areas with net zero house price growth, where first-time buyers moved to comparable census tracts to those in which they were renting. Therefore, as expected, in areas where house prices were increasing rapidly, first-time home buyers were decreasing their consumption of housing relative to what they usually would have purchased.[22]

Unlike first-time home buyers, continuing homeowners were increasing their housing consumption throughout the boom. They were purchasing homes in census tracts up to 11 percent more expensive than their current census tracts, whereas during the pre-boom, con-

[21] Regression details including numbers of observations, goodness of fit, and parameter estimates for the controls for all regressions in this section are in Table 3.

[22] In counties with declining house prices, first-time buyers also move to cheaper census tracts. However, this is most likely due to correlated economic circumstances not captured by the controls.

tinuing homeowners purchased homes in census tracts that are on average 3 percent more expensive. The difference is statistically significant. As can be seen from the middle to panel of Figure 5, this pattern is independent of local house price appreciation. Therefore, this increase in consumption of housing is not due to wealth effect. Instead, these results are consistent with an increase in demand of housing due to a fall in the user cost.

Renters provide a useful comparison since they did not purchase homes. The estimated change in census tract house value by year for renters shows that renters do not consistently move to more expensive or cheaper census tracts. Instead, the change in census tract house value moves above and below zero without any obvious pattern and no significant change during the boom. The values for different levels of house price appreciation do imply that renters in high house price growth counties move to cheaper census tracts relative to renters in net zero house price growth counties, however, this effect is not statistically significant. It is possible that as renters are considering purchasing their first homes, they are moving to areas where housing is more affordable to save for a now larger down payment, or that some of the local increase in house prices is being passed through to local rents, causing renters to move to cheaper areas.

The PSID also provides limited evidence that homeowners increased their consumption of housing services via methods that did not involve changing their primary residence. Figure 6 contains results for the regressions of homeowners purchasing second homes or investing at least $10,000 in their primary residence. The predicted values by year show that these activities were higher on average during the boom. The effect for second home purchase is very slight and not statistically significant. However, up to 12 to 14 percent of homeowners during the boom invested more than $10,000 in their primary residence. This fell to about 9 percent during the bust. This is a statistically significant difference. This compares to fewer than 6 percent prior to the boom. Unlike for homeowners purchasing new homes, these effects were magnified in areas with high house price appreciation. The probability of purchasing a second home increases from just under 4 percent in net zero house price growth areas to over 4.5 percent in counties with 14 percent house price growth. The parallel increase for investing in their primary residence is from 11 percent to about 13 percent.

5 Non-Housing Expenditures

In this section, I address how much expenditures on non-housing consumption changed over the course of the boom and bust. First I plot average consumption expenditures separately for renters and homeowners from 1985 until the present. This allows me to see whether consumption expenditures increased more for homeowners than for renters during the boom. Second, I use the values of home equity for homeowners to estimate a marginal propensity to consume (MPC) out of housing wealth.

The specification for the regressions used to estimate the marginal propensity to consume out of housing wealth is as follows:

$$\text{Expenditures } = \boldsymbol{\beta} * X_{it} + \delta * \text{Equity}_{t-1}\gamma_t + \zeta_i,$$

where γ_t are year fixed effects and ζ_i are household fixed effects. The vector of controls includes:

$$\begin{aligned} X_{it} =& \boldsymbol{\alpha} * f(\text{hpa}_{it}) + \beta_1 * \text{Income}_{it} + \beta_2 * (\text{Family Size}_{it}) \\ &+ \boldsymbol{\beta_3} * f(\text{Years of Education}) + \beta_7 * \text{Months Since Last Interview}_{it} \\ &+ \beta_8 * \text{County Employment Growth}_{it} + \boldsymbol{\beta_9} * f(\text{age}_{it}) + \gamma_t, \end{aligned}$$

The parameter of interest is the coefficient on lagged home equity (δ).

5.1 Results

There is a limited amount of evidence that non-housing consumption increased more for homeowners than for renters. Figure 7 contains plots of the average of non-housing consumption expenditures by year for homeowners and renters. For the sum total of all expenditures collected by the PSID starting in 1999, the average amount spent does increase for homeowners from about $21 thousand to over $23 thousand annually, while the amount spent by renters stays relatively stable around $14 thousand per year. However, since I do not have data from prior to the boom, I cannot tell if this is part of a longer running trend or unique to the boom.

Expenditures on all food, in the top right panel, increased by a few hundred dollars a year for both homeowners and renters, although slightly more for homeowners. The bottom two panels, which divide food into food prepared at home and food eaten out, reveal that this increase is entirely due to an increase in the average of spending on food eaten out, with both renters and homeowners increasing their expenditures.

This parallel increase for both homeowners and renters is consistent with results from Yoshikawa and Ohtaka (1989) and Engelhardt (1994) who, using data from Japan and Canada respectively, found that when house prices rise, fewer renters plan to transition to homeownership. Beacuse they no longer need to save for a down payment, these renters lower their saving rates. This more than offsets any decrease in consumption among renters who continue to plan to buy a home.

Despite these patterns, I estimate a statistically positive, but small MPC out of housing wealth. Table 4 contains the regression results. Both home equity and the dollar amount of expenditures are in levels, so the marginal propensity to consume is simply the coefficient on home equity. The marginal propensity out of housing wealth is highest for all non-housing expenditures (0.371 percent), followed by all food (0.111 percent), and food eaten out (0.0791 percent). For food prepared at home, it is not statistically different from zero.

These values are on the low end of estimates from the literature, but not out of the range found by other researchers. It is in line with other estimates based on microdata including Levin (1998), who used the Retirement History Survey and found no effect of house prices on consumption; Skinner (1989) who also used data from the PSID; Ganong and Noel (2017) who estimate their MPC using variation in the application of Home Affordable Modification Program during the Great Recession and monthly expenditures based on credit card data; and Cooper (2013) who also used the PSID and found that house price drops have little effect on consumption for non-credit constrained households. Papers finding a larger MPC are mostly based on aggregated data. Carroll, Otsuka, and Slacalek (2011) use country- and state-level panel data to estimate an MPC out of housing wealth of about 5 cents per dollar. Mian, Rao, and Sufi (2013), who estimate an MPC of up to 15 percent for households underwater on their mortgages, used county-level data. The one exception is Campbell and Cocco (2007), who find values as large as 1.7 percent using a pseudo panel of micro data from the United Kingdom.

6 A Life Cycle Model of Homeownership

In this section I test whether optimistic expectations for future house prices can explain the empirical results. To this end, I solve a life cycle model in which households face income and house price uncertainty and that incorporates tenure choice. The rental rate and house price depend on one another, but the user cost of owner occupied housing is determined by the model and depends on transaction costs, future expectations for house price expectations, the cost of a mortgage, and the option to default.

The model is most closely related to Demyanyk et al. (2013) and has a number of realistic features: housing is both a consumption and an investment good, households can choose between renting and owning, house buyers pay a down payment, buyers and sellers pay transaction costs, home equity above a required down payment can be used as collateral for loans (although, there are no other forms of credit), taxes are preferential to homeownership, and both negative equity and foreclosure are allowed. Default prior to foreclosure is not allowed, and the model does not incorporate any explicit mortgage contract, nor is there a minimum mortgage payment payment required.

There is no closed form solution to this model, and the discrete choices and transaction costs necessitate solving for the policy functions on a discrete grid by starting in the terminal period at age 85 and solving backwards. Details of the solution method are described in Section B in the appendix.

6.1 The Model

6.1.1 Preferences and Demographics

All households are born at age 25, retire with certainty at age 65, and die with certainty at age 85. One period in the model is equivalent to five calendar years. Prior to certain death, households face an exogenous positive probability of dying. Until retirement, households receive uninsurable idiosyncratic stochastic labor income. Once retired, they receive a pension equal to a percent of their permanent income at age 65.

Household's preferences are given by:

$$U(C_t, J_t) = \frac{\left[(1-\omega)\left(C_t\right)^{(1-\frac{1}{\eta})} + \omega\left(J_t\right)^{(1-\frac{1}{\eta})}\right]^{\frac{1-\sigma}{1-\frac{1}{\eta}}}}{1-\sigma}$$

where C is non-housing, non-durable consumption; J is housing services, whether rented or owner-occupied (it is not possible to both rent and own); ω is the weight attached to housing consumption; σ is the curvature parameter;[23] $1/\sigma$ is the inter-temporal elasticity of substitution; and η is the elasticity of substitution between non-durable consumption and housing services. Once unit of housing stock provides one unit of housing services. I assume warm-glow bequest motives. Households pass on their remaining wealth, but houses are liquefied at death and newborns only receive financial assets.[24]

6.1.2 Homeownership and Mortgages

Households start every period with a stock of residential assets, H_t, deposits, A_t, and collateralized debt, M_t. Interest rates are constant. Households earn r_a on their deposits, and have to pay r_m on their debt, where $r_m > r_a$. Households can choose to be homeowners or rent every period, and houses purchased in period t—H_t—provide housing services from

[23]The discrete choices and transaction costs imply that this is not exactly equivalent to the coefficient of relative risk aversion.

[24]The bequest function is given by:

$$B(X_t) = \frac{\left[(1-\omega)C_t(r_{s,t}, X_t)^{(1-\frac{1}{\eta})} + \omega S_t(r_{s,t}, X_t)^{(1-\frac{1}{\eta})}\right]^{\frac{1-\sigma}{1-\frac{1}{\eta}}}}{1-\sigma}$$

where X_t is liquid financial assets inclusive of the value of liquidated housing stock, $r_{s,t}$ is the price of renting one unit of the housing stock, and $C(r_s, X)$ and $S(r_{s,t}, X)$ are the demand functions for non-durable consumption and rented housing services respectively.

the beginning of the period. The price of one unit of housing stock is q_t, while the rental price of one unit housing stock is $r_{s,t}$. If a household chooses to rent that period, they sell or foreclose on their previous residence if they were previously homeowners and choose an amount of housing to rent, J.

There are two constraints on the size of a mortgage: a loan-to-value (LTV) and a debt-to-income (DTI) constraint. Both of these constraints apply when purchasing a new home or when taking out a new mortgage against the same home, but not otherwise. The LTV constraint implies that a down payment is required to purchase a house, but that homeowners are not subject to margin calls when house prices fall:

$$\begin{cases} M_t \leq (1-\theta) q_t^* H_t & \text{if } I_m = 1, \\ M_t \leq \max(M_{t-1}, (1-\theta) q_t^* H_t) & \text{if } I_m = 0. \end{cases}$$

where I_m is equal to one when a household purchases a new home. The DTI constraint is given by:

$$M_t \leq \alpha * Y_t \text{ if } (I_m = 1) \text{ or } (M_t > M_{t-1} \text{ and } I_m = 0).$$

Households pay a fraction of the house value to purchase (κ) or sell (χ) a home, which can be interpreted as a search cost when purchasing a home and as fees to a real estate broker when selling. Owner occupied houses depreciate at the rate δ_h, and homeowners can choose the extent of maintenance.[25] Buying and selling costs are paid if $|H_t/H_{t-1} - 1| > \xi$, which indicates that only homeowners up-sizing or downsizing their house by more than ξ percent pay adjustment costs.[26]

Households are permitted to default on their homes without facing the risk of recourse. Default results immediately in foreclosure. The household forfeits their home and any positive equity, discharges all mortgage debt and pays percentages ρ_w and ρ_A of current income and liquid assets respectively; and is required to rent for one period. It faces no additional costs thereafter.

6.1.3 Employment and Earnings

Households of working age can be employed or unemployed and face uninsurable idiosyncratic income uncertainty. Prior to retirement, labor income—W_{it}—is the product of permanent income—P_{it}—and a transitory shock υ_{it}. Permanent income is subject to idiosyncratic shocks—ϵ_{it}—and a deterministic life cycle component, γ_t:

[25] This is limited by households being restricted to house sizes on the housing grid.

[26] This is necessary because the problem is normalized by permanent income and solved on a discrete grid of choice and state variables. As permanent income changes over the life cycle, the non-normalized values of grids change. To remain on the grid, households may be forced to adjust their house size somewhat. See Section B for details about the grid choices.

$$Y_{t+1} = \begin{cases} P_t \upsilon_{it};\ P_t = P_{t-1}\gamma_t \epsilon_{it} & \text{if } t \leq R \\ bP_R & \text{if } t > R, \end{cases}$$

Everyone retires with certainty at age R at which point households receive a pension proportional to permanent earnings in the last period of their working life.

The idiosyncratic transitory shock to income takes on a small, but positive value with 5 percent probability. I call this state unemployment. Otherwise, the transitory shock is log-normally distributed:

$$\upsilon_{it} = \begin{cases} u & \text{with probability } p \\ \frac{\delta_{it} * (1-up)}{1-p} & \text{with probability } (1-p). \end{cases}$$

where $\ln \delta_{it} \sim N(\frac{-\sigma_\delta^2}{2}, \sigma_\delta^2)$, p is the probability of unemployment, u is the unemployment replacement rate. This ensures that $E[\upsilon_{it}] = 1$.

Income is taxed at the rate τ_Y. Mortgage interest is assumed to be fully deductible from taxable income, and all households pay taxes on their interest earned on deposits. I set $\tilde{r}_a = r_a(1-\tau_y)$ and $\tilde{r}_m = r_m(1-\tau_y)$. These are the after tax return on deposits and effective interest rate on mortages once interest is deducted from taxable income, respectively.

6.1.4 The Household's Problem

The household's problem is given by:

$$\max_{C_t, J_t, H_t, A_t, M_t, X_t} E_0 \sum_{t=0}^{T} \beta^t \left[\zeta_t u(c_t, x_t S_t + (1-x_t)H_t) + (1-\zeta_t)B(X_t)\right], \tag{1}$$

where $x_t \in \{0, 1\}$ and is an indicator for whether the household rents their housing services ($x_t = 1$, S_t) or owns a home ($x_t = 0$, H_t); X_t is liquid financial assets inclusive of the value of liquidated housing stock[27]; $B()$ is the bequest function; ζ_t is the probability of being alive at time t; and $\beta^t = (1+\rho)^{-t}$ where $\rho \geq 0$ is the time discount rate. This household's problem

[27] $X_t = q^* H_t(1-\delta_h)(1-\chi) + A_t - M_t$.

is subject to:

$$
\begin{aligned}
C_t \ &+ r_{s,t} J_t\{x_t = 1\} + A_t + q^* H_t(1 + \kappa I_m) * \{x_t = 0\} - M_t \\
&= (1 - \tau_y) Y_t + [1 + \tilde{r}_a] A_{t-1} - \Big((1 + \tilde{r}_m) M_{t-1} \\
&\quad + (1 - \delta_h)(1 - \chi_j I_m) q_t^* H_{t-1}\Big)\{x_{t-1} = 0\} && \text{if } I_d = 0; \quad (2) \\
C_t \ &+ r_s J_t + A_t \\
&= (1 - \rho_Y)(1 - \tau_y) Y_t + (1 - \rho_A)(1 + \tilde{r}_a) A_{t-1} && \text{if } I_d = 1; \quad (3) \\
M_t &\leq (1 - \theta) q_t^* H_t && \text{if } I_m = 1; \quad (4) \\
M_t &\leq \max(M_{t-1}, (1 - \theta) q_t^* H_t) && \text{if } I_m = 0; \quad (5) \\
M_t &\leq \alpha Y_t && \text{if } I_m = 1. \quad (6)
\end{aligned}
$$

where I_d indicates whether a household defaults on their mortgage.

6.1.5 House Prices

To keep computational time in check, I assume there is no aggregate house price risk. However, households face idiosyncratic house price risk. The actual price paid by a household is higher or lower than the aggregate house price state by a certain percentage, with a 50 percent probability of each. The outcome of this shock is learned before decisions about the choice variables are made.

Aggregate house prices are set equal to the discounted flow of future expected rents:

$$q_t = \sum_{t=0}^{\infty} \left(\frac{1 - \delta_h - \delta_r}{1 + \tilde{r}_a} \right)^t E_t r_{s,t}{}^{28}$$

where the adjustment for income taxes implies that landlords pay taxes on their rental income. This is consistent with Sinai and Souleles (2003) who find that house prices reflect expected future rents, and closely follows Díaz and Luengo-Prado (2008) and Demyanyk et al. (2013).

During the boom, I assume that expected future rents increase. An expected future increase in rents raises prices today without increasing the current rental rate. This results in a fall in the rent-to-price ratio, similar to what is seen in Figure 3.

[28] This assumes that rental income is not taxed. If rental income were taxed, this would be adjusted by a factor of $(1 - \tau_y)$, which would raise the rent-to-price ratio, making renting less appealing at the margin. To account for the lack of aggregate house price risk and the fact that I do not include exogenous moving shocks, both of which decrease the use cost of homeownership, I lower the rent-to-price ratio by assuming that rental income is not taxed.

6.1.6 The User Cost

A close approximation of the user cost for housing services is the shadow price, which is given by the marginal rate of substitution. For renters and homeowners that are defaulting, optimization implies that:

$$\frac{u_s(c_t, s_t)}{u_c(c_t, s_t)} = r_{s,t}$$

.

For homeowners not defaulting this period, the user cost depends on their option to default next period. To simplify the notation initially, assume households are not bound by the LTV constraint and that there are no transaction costs. The user cost for homeowners is then given by:

$$\frac{u_s(c_t, s_t)}{u_c(c_t, s_t)} = q_t - E_t\left(\frac{1}{1+\tilde{r}_a} q_{t+1}(1-\delta_h)\right).$$

This is effectively the same user cost relationship in Kaplan, Mitman, and Violante (2017)[29], and very similar to that from Poterba (1984). The key take-away is that the user cost decreases as expectations for future house prices increase. As the user cost falls, demand for owner-occupied housing increases.

Including the LTV constraint and transaction costs, the marginal rate of substitution for homeowners not defaulting this period or next period is equal to:

$$\frac{u_s(c_t, s_t)}{u_c(c_t, s_t)} = q_t\left((1+\kappa I_m) - \frac{\mu_t}{\lambda_t}(1-\theta)\right) - E_t\left(\frac{\lambda_{t+1}}{\lambda_t} q_{t+1}(1-\delta_h)(1-\chi_j I_m)\right),$$

where λ is the Lagrange multiplier on the budget constraint, $\lambda_t/E\lambda_t + 1$ is the intertemporal marginal rate of substitution for nondurable consumption, and μ is the Kuhn-Tucker multiplier on the LTV constraint. This can be rewritten as:

$$\begin{aligned}\frac{u_s(c_t, s_t)}{u_c(c_t, s_t)} = \kappa I_m q_t + &\frac{[\lambda_t/E_t\lambda_{t+1} - 1]q_t}{\lambda_t/E_t\lambda_{t+1}} - \frac{E_t(q_{t+1} - q_t)}{\lambda_t/E_t\lambda_{t+1}} + \\ &\frac{E_t q_{t+1}(\delta_h + \chi_j I_m - \delta_h \chi_j I_m)}{\lambda_t/E_t\lambda_{t+1}} - (1-\theta)\frac{\mu_t}{\lambda_t} q_t - \xi_t.\end{aligned}$$ [30]

This implies that the user cost is comprised of current transaction costs ($\kappa I_m q_t$), the present value of the foregone return on housing equity ($\lambda_t/E_t\lambda_{t+1} - 1]q_t$), the present value of fu-

[29] Kaplan, Mitman, and Violante (2017) include property taxes and an additional operating cost incurred by landlords.

[30] $\xi_t = cov_t(\lambda_{t+1}/\lambda_t, q_{t+1})(1 - \delta_h - \chi_j I_m)$.

ture capital gains ($E_t(q_{t+1} - q_t)$), the present value of the cost of maintenance and future transaction costs ($E_t q_{t+1}(\delta_h + \chi_j I_m - \delta_h \chi_j I_m)$), the opportunity costs associated with buying housing ($(1-\theta)\frac{\mu_t}{\lambda_t} q_t$), and covariances ($\xi_t$).

For homeowners who will default next period, the user cost takes the form:

$$\frac{u_s(c_t, s_t)}{u_c(c_t, s_t)} = q_t \left((1 + \kappa I_m) - \frac{\mu_t}{\lambda_t}(1-\theta) \right).$$

which is significantly simpler since the household forfeits their ownership of the house.

It is important to note that for the majority of households $\frac{\mu_t}{\lambda_t}(1-\theta)$—opportunity costs associated with purchasing housing—does not enter the use cost formula. This term only enters the user cost formula if the household did not enter the period with a mortgage greater than $(1-\theta) * q_t H_t$ and is up against their borrowing constraint. If the household had a mortgage greater than $(1-\theta) * q_t H_t$ last period, the partial derivative of the LTV constraint does not depend on the size of the house and this term disappears from the user cost formula. If household is not up against their borrowing constraint, then $\mu_t = 0$. When this term does enter the user cost, it implies that the user cost depends on the mortgage interest rate ($\tilde{r}_m$) and the value of θ. The values of the Langrange multiplier, λ_t also depend on whether the household is up against their LTV constraint (see Díaz and Luengo-Prado (2008) for details).

The question answered by this model is whether reasonable expectations for future house prices is enough to offset the other components of the user cost, namely the transaction costs. There is no question that higher future expected house price lowers the user cost of housing because homeowners expect capital gains, which offset the other costs—transaction costs, maintenance, and the mortgage—of owning a home. However, it is not clear that optimistic expectations for future house prices within a reasonable range are enough of an incentive to cause homeowners to move to larger homes.

The user cost also reveals an insight about the dynamics of housing consumption during the boom and bust. The value of expected future house prices enters the user cost formula for homeowners who are not defaulting, but is not a component of the user cost for homeowners who default. Therefore, when future expected house prices fall, the user cost not only increases, but the option value of default also increases.[31] If the household sells their home

[31]The monthly payment on a mortgage can be interpreted as cost of a call option, giving the homeowner the right to purchase the house for the remaining mortgage balance in the future. In fact, for all payments prior to the penultimate mortgage payment, the value of the mortgage is the value a compound call option, made up of future call options. With stochastic house prices, the value of this option depends on both the variance of the overall house price process and expectations for the future path of house prices. As long as the mortgage payment is less than the intrinsic value of the compound option, the household will continue to make the payment. Assuming that housing is a necessity, it is the mortgage payment net of the market rent

or defaults, they lose the value of this option. This ability to default without recourse in the future offsets the increase in the user cost due to falling house prices. As a result, demand for housing does not fall as dramatically as it rose when house prices were increasing.[32]

6.2 Parameterization

The model is calibrated to match three statistics from the Survey of Consumer Finances (SCF): the median wealth-to-earnings ratio for households with a working-age head; the median house value-to-wealth ratio for homeowners; and the aggregate homeownership rate. Most of the parameters in the model are chosen based on empirical evidence. I then adjust the discount rate, the weight on housing in the utility function, the idiosyncratic house price risk, and the minimum house size (for purchase) relative to permanent income to match the targets from the SCF.

The complete parameterization for the baseline model is summarized in Table 5. To match the median house value-to-wealth ratio of 0.82, I set the weight on housing (ω) to 0.20. To the match the median wealth-to-earning ratio in the SCF of 1.8, I set the discount rate equal to 3 percent. I set the curvature parameter, σ equal to 1.5. Survival proabilities are based on the estimates for the U.S. population from the 2011 U.S. Vital Statistics from the National Center for Health Statistics.

I set the elasticity of substitution between housing and non-durable consumption to 0.5 based on the estimates of Li et al. (2016). They estimate the elasticity of substitution using a life cycle model that incorporates many (although not all[33]) of the same features as the one in this paper, and use the method of moments to match it against the PSID. They point out that papers that find a higher elasticity of substitution are based on macro data, while studies using microdata consistently estimated a lower value.[34]

The parameters for income come from Cocco, Gomes, and Maenhout (2005), who estimated life cycle profiles of income and the variance of permanent and transitory shocks for different education groups—no high school, high school, and college—in the PSID. I use the values for households whose head has a high school degree. The variance of permanent income shocks is set to 0.01. Unemployment is one state of the transitory shocks and occurs with a probability of 5 percent. The remaining shocks have a variance of 0.073. These values are in line with the literature (Storesletten, Telmer, and Yaron 2004). I use the life cycle profile for the same education group. Retirees receive a pension equal to 60 percent of their permanent income in their last working year. Cocco, Gomes, and Maenhout (2005)

of a comparable home relative to the value of the compound option that determines the default decision.

[32] Despite the lack of any aggregate house price risk, the option value of defaulting plays a role in this model because households face idiosyncratic house price risk.

[33] For example, they do not include the option to default on a mortgage.

[34] For example, see Flavin and Nakagawa (2008), Stokey (2009), and Hanushek and Quigley (1980).

estimated a replacement rate of 68 percent, which is slightly higher than that found in other literature.[35] The replacement rate for unemployment is set to 50 percent.

The income tax rate is set at 20 percent, following Demyanyk et al. (2013), who estimate this rate from the Income and Product Accounts from the Bureau of Economic Analysis, and information from TAXSIM. They then adjust their final number upwards to account for the fact that the marginal tax rate is higher than the average tax rate. Mortgage interest is fully deductible.

While I do not model a specific mortgage contract, to set the debt-to-income constraint (α) I assume that the mortgage is a 30 year fixed rate mortgage with standard amortization. I then limit the implied payment to be 30 percent of current permanent income. This implies a value for α of $6.\bar{6}$.

I set the interest rate on deposits equal to 4 percent based on the estimates of Díaz and Luengo-Prado (2010). The mortgage interest rate equal to 4.5 percent. The owner-occupied housing depreciation rate is set to 1.5 percent, as estimated by Harding, Rosenthal, and Sirmans (2007). The rental house depreciation rate—$\delta_h + \delta_r$—is set to 2 percent.

6.2.1 House Prices and Simulating the Boom

I set the rental rate on housing so that the baseline house price is equal to one. This implies an annual rental rate of 5.04, which is in the range of Davis, Lehnert, and Martin (2008) whose estimates of the rent-to-price ratio outside of the boom vary between 5 and 5.5 percent. This annual ratio implies a 5-year rent-to-price ratio of 22.96 percent. Individual house prices can be lower or higher than the aggregate house price by 7 percent.

During the boom, I assume that future rents are expected to increase 50 percent annually between the current and next model period (for a period of 5 calendar years).[36] I then assume that only a fraction of the implied increase in concurrent house prices are passed through to the present. The results are highly dependent on how much of this expected price increase is passed through, so I report results for three different rates of pass-through: 60, 75, and 100 percent.

In the boom state, households expect that rents will increase with almost certainty and that the aggregate house price will rise further to 7.59 in the next model period. Specifically, they expect the house price to rise with a probability of 99 percent, and to fall back to its pre-boom value of one with a probability of 1 percent.[37] The transition matrix for house

[35]Using data from the Health Retirement Survey and the Social Security Administration, Munnell and Soto (2005) estimate the replacement rate for newly retired workers at 42 percent.

[36]This is high rate of increase. Longer term expectations for rent increases would imply similar results, but would necessitate increasing computation time to allow for more house price states. There is survey evidence in Case, Shiller, and Thompson (2012) that long-run expectations exceeded short-run expectations.

[37]This is done for tractability purposes, since the boom is simulated by a transition to the state with high

prices is given by:

$$P(q_{t+1}|q_t) = \begin{bmatrix} 1 & 0 & 0 \\ 0.01 & 0 & 0.99 \\ 0 & 0 & 1 \end{bmatrix}$$

In the simulations, the highest house price state is never reached. The boom is simulated by a transition from the state where the house price is equal to one and expected to remain there to the state where house prices are equal to the intermediate state, which depends on the pass-through rate, and then expected to increase to 7.59 with a probability of 99 percent. The bust is a return to the state where the aggregate house price is equal to one with certainty.

The different rates of pass-through imply different values for today's house prices, expected house price appreciation, and changes in the rent-to-price ratio. A pass-through rate of 60 percent implies that the three house price states is given by $q = [1\ 4.02\ 7.59]$. Therefore, in the boom, house prices today increase from one to 4.02, the five-year rent-to-price ratio falls to 0.0572, and house prices are expected to increase 63.67 percent over five years (over 10 percent annually).

A pass-through rate of 75 percent implies the price states $q = [1\ 4.77\ 7.59]$. House prices today increase from 1 to 4.77, the five-year rent-to-price ratio falls to 4.81 percent, and expected house price appreciation is 45.59 percent. Lastly, 100 percent pass-through results in $q = [1\ 6.03\ 7.59]$, a five-year rent-to-price ratio of 0.0381 during the boom, and expected house price growth of 23.07 percent.

The expectations for future house prices are not unreasonable. Using survey methods, Case, Quigley, and Shiller (2003) find that new home buyers expected capital gains between 6 and 11 percent annually. A pass-through rate of 60 percent results in expectations of about 12 percent, while 100 percent pass-through implies and expected return of just under 5 percent. All three situations imply an expected return on housing greater than the five-year return on deposits of 21.67 percent.

The increase in the present value of housing and the fall in the rent-to-price ratio in the model is larger than that seen in the data. However, it is important to remember that this model abstracts from many elements of reality such as the existence of debt outside of mortgage debt, and the inclusion of this other debt in the the debt-to-income constraint by mortgage lenders.

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house price expectations and then a return to the state where the aggregate house price is equal to one with certainty. A positive probability on the base state implies that households make choices from which they can feasibly return to the base state.

6.3 Patterns of Homeownership and Wealth

Figure 8 plots the evolution of average life cycle paths from the simulations of the model, which are derived from a cross section of the simulated data.[38] All values are normalized by the average earnings of working-age adults. The top panel plots of the average values of financial assets, total wealth, and owner occupied house value. Financial assets and total wealth increase from age 24 to retirement at age 65 and decreases thereafter. The bottom panel of Figure 8 plots earnings and non-durable consumption. The hump shape in income comes from the deterministic life cycle profile from Cocco, Gomes, and Maenhout (2005). Earnings peak for households in the 45–49 age range, while consumption peaks for households aged 65–69.

Figure 9 compares life cycle profiles from the model to those from the SCF. The targets of the calibration were the median values, not the life cycle profiles. Despite this, the model matches certain elements of the life cycle profiles quite well. The top panel of Figure 9 plots the median wealth-to-earnings ratio of working age households in the model and in the SCF. These increase from less than one to over 6 over the course of the life cycle in both the SCF and the model. The bottom left panel displays the median house value-to-wealth ratios for homeowners. This is not matched as closely as the wealth-to-earnings ratio. For young households, it is higher in the model than in the data. The two become closer over time and the model matches the data fairly well for households age 45 and older.

The bottom right panel of Figure 9 plots the homeownership rate in the model and in the data. Homeownership is steadily increasing from birth in the data. In the model, it is almost always increasing except for households in their late thirties. In the data, the homeownership rate flattens out around age 50, while in the model it continues increasing steadily over the course of the life cycle. The rate for the youngest households is also over 10 percent higher in the model than in the data and consequently early in the life cycle, the slope is steeper in the SCF when compared to the model.

6.4 Model Results

The results vary significantly by the percent of pass-through. Figure 10 contains plots of the probability of continuing homeowners purchasing a new home and of renters transitioning into homeownership. Outside of the boom, only about 1 to 2 percent of continuing homeowners purchase new homes. When 60 percent of the future expected house price are passed through to the current price, 30 percent of continuing homeowners purchase new homes during the boom. Even after adjusting for the fact that one model period represents five calendar years, this is clearly higher than what is seen in the data. By contrast, when

[38] Details about the simulation are described in Section B in the appendix.

100 percent of the optimistic expectations pass-through, no more continuing homeowners purchase new homes during the boom than did prior to the boom.

The results for first-time home buyers also vary by the amount of pass-through. With 60 percent pass-through, the probability of transition jumps from close to 50 percent to over 75 percent. With 100 percent pass-through, no renters transition to homeownership during the boom.

The results for 75 percent pass-through are much more closely aligned with the data. The percent of continuing homeowners purchasing a new home jumps to 10 percent and the probability of transitioning to homeownership increases from about 47 percent to just over 50 percent. These are in the same range as the increases seen in the PSID. The top panels of Figure 11 show that almost all of continuing homeowners that purchased new homes during the boom, purchased larger homes.

In all three scenarios, first-time home buyers purchase smaller homes. The bottom panels of Figure 11 plot densities of the difference between the size of house purchased by first-time home buyers and the size of house they rented prior to transitioning. In all three cases, the density shifts down significantly during the boom, with the mean shifting down more the higher the pass-through.

The results for non-durable consumption from the model are more dramatic than those from the PSID. The top panels of Figure 12 show how non-durable consumption evolved for both homeowners and renters.[39] Unlike in the data, non-durable consumption for renters decrease. This is because renters that do not transition to homeownership expect higher rents in the future, and consequently their real expected lifetime earnings have decreased.

The bottom panels of Figure 12 plot the percentage of homeowners that sell their home and transition to renting by time period. The plots do not include households transitioning to renting because they default. Prior to the boom, just over 2 percent of homeowners transition to renting. In the scenarios with incomplete pass-through, this percentage falls during the boom and then increases during the bust. In the scenario with 100 percent pass-through, the probability of selling and transitioning to renting increases during the boom. This is because expected house price appreciation is lower in this scenario, so there is less of an incentive to own. While house prices have increased significantly, rental rates have not changed, so homeowners find it optimal to sell their homes and rent.

7 Conclusion

The housing boom that preceded the Great Recession was characterized by an increase in demand for housing services. This was driven by optimistic expectations for house prices

[39] These plots exclude homeowners that transitioned to renting.

that lowered the user cost of owner occupied housing. While all households experienced an increase in demand for owner occupied housing, only unconstrained households were able to increase their consumption of housing services. Results from the PSID show that renters were limited in their ability to transition to homeownership, while households that already owned homes purchased larger houses.

This paper provides more evidence in support of the new narrative of the housing boom: that house price expectations played a prominent and important role in the housing boom. I explicitly show that the empirical results can be explained by an increase of house price expectations within a partial equilibrium framework. A relaxation in credit constraints are not needed to explain the empirical results. That is not to say that there was not an expansion of credit, but just that it was not large enough to offset the increase in house prices.

The policy implications of this result are that the impulse to prevent lenders from relaxing standards for mortgages is based on an incorrect understanding of the boom. The Great Recession was not due to a drop in house prices per se, but rather an example of how the financial sector can have an outsized response to a fall in an asset price. The focus should instead be on designing policies that will increase the resilience of the financial sector to fluctuations in *any* asset prices, not just housing.

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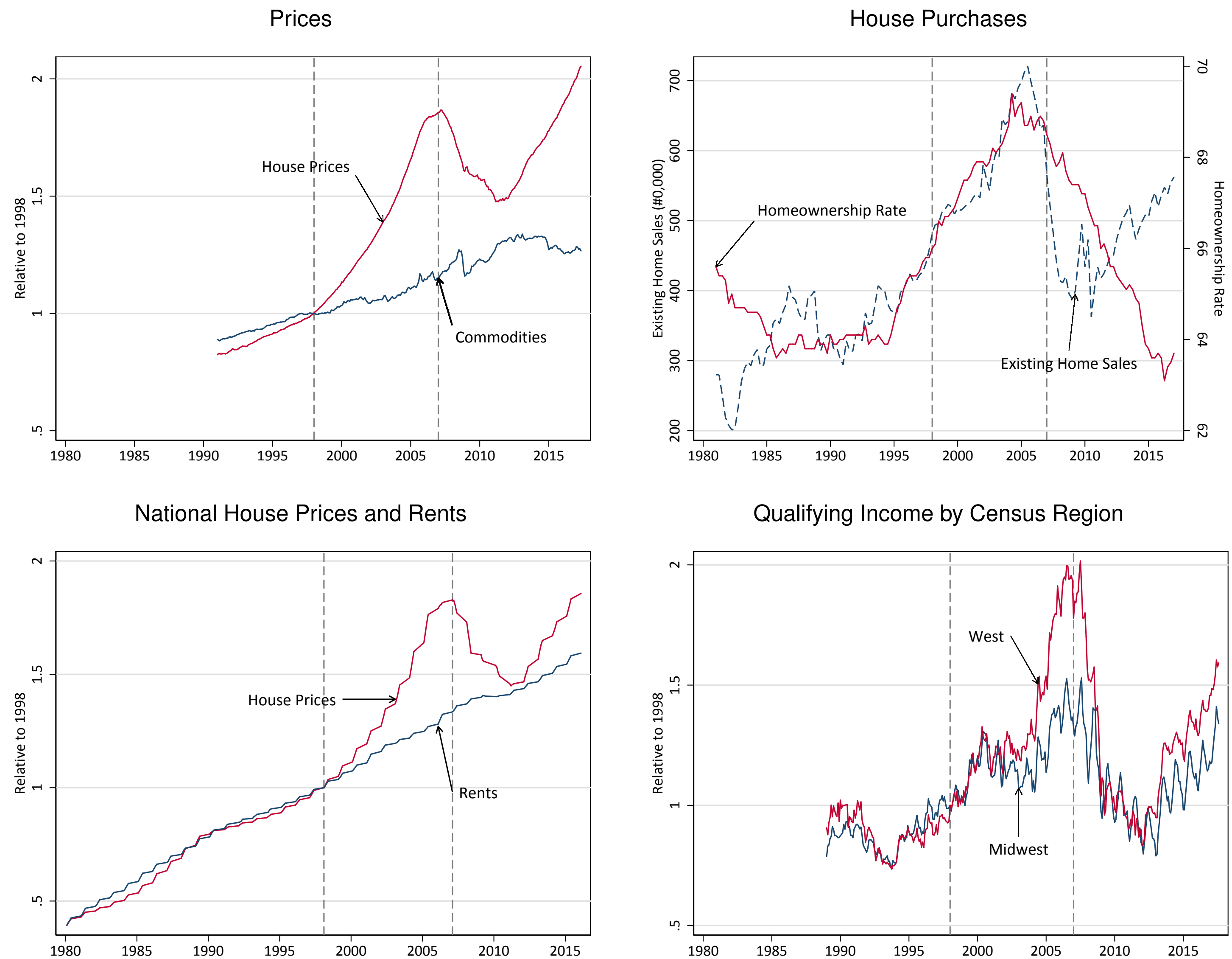

Figure 1. Characteristics of the Boom: *Note:* The two parallel lines mark beginning of 1998 and 2007 respectively. In the top left panel, the prices for commodities are a component of the CPI-U series and the house price index is the national index from the FHFA. The qualifying income assumes a 25 percent qualifying ratio for payment to income and a 20 percent downpayment. The rents and prices in the bottom left panel were calculated by Davis, Lehnert, and Martin (2008) using data from the decennial censuses and indices on house prices and rents. The rents are the estimated rent for owner occupied housing. These are derived from the parameter estimates from a hedonic regression of rent paid by renters on house characteristics. Values for rent in between decennial censuses are interpolated using the rent of primary residence index from the Bureau of Labor Statistics. House prices are interpolated using the Freddie Mac repeat sales index. Data beyond 2000 are extrapolated. *Source:* FHFA, Census, Davis, Lehnert, and Martin (2008), and the National Association of Realtors.

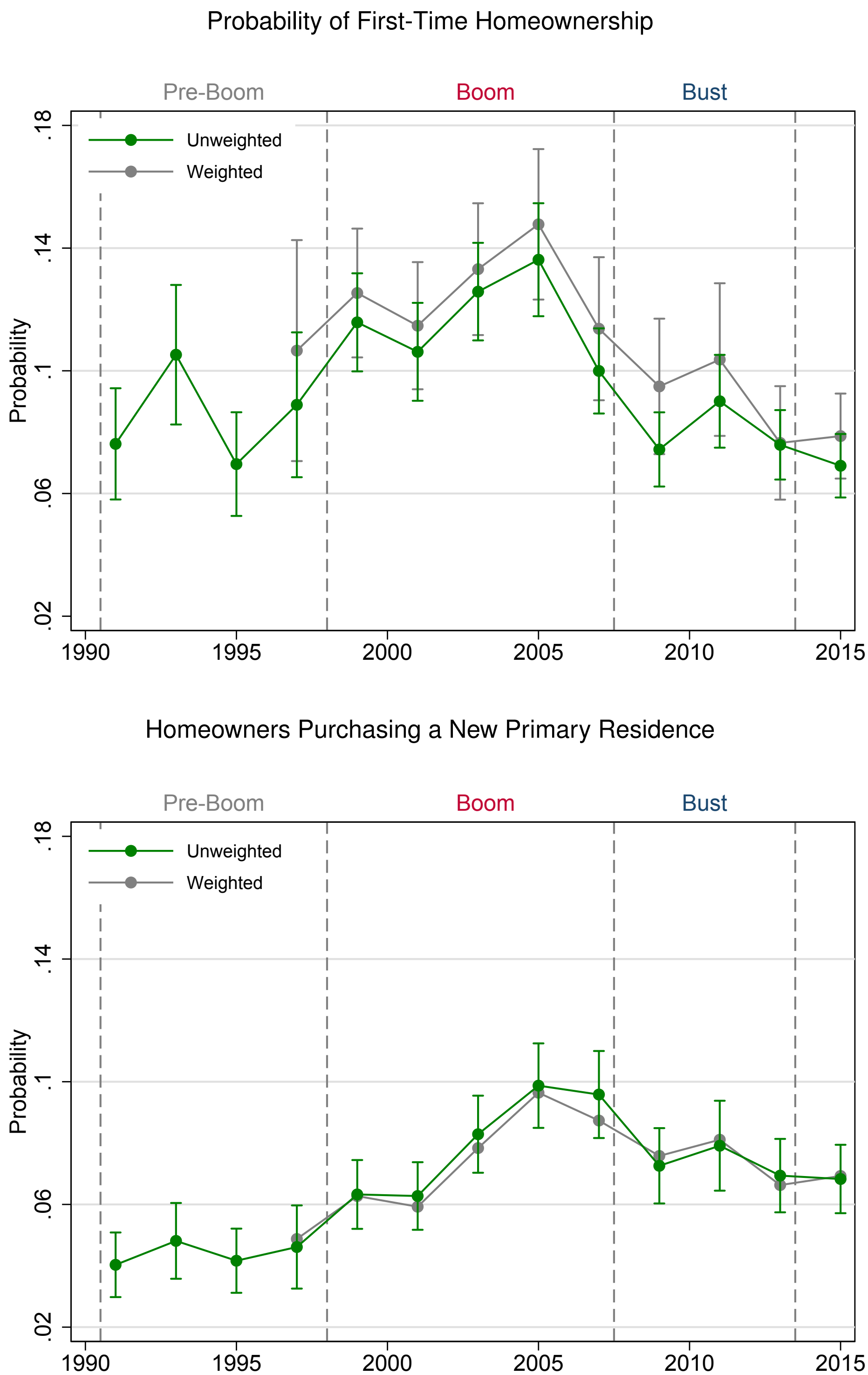

Figure 2. Probability of First-Time Homeownership or Purchasing a New Primary Residence. *Note:* Probabilities are calculated from the estimates of hazard model regressions with a baseline hazard, year fixed effects, and no individual controls. The probabilities of first-time homeownership are for a household with a 35 year old head. The probabilities of homeowners purchasing a new primary residence are for a household that purchased their previous home four years ago. The weighted values use the PSID cross sectional weights. *Source:* PSID.

Year	Households (#)	Bought First Home (#)	Bought Home (#)	Family Income ($)	Fiscal Wealth ($)	Family Size (#)	Age of Head	Homeowner (%)	Renter (%)
1989	7,114	168	398	32,945	11,603	2	38	54	40
1990	7,328	152	401	32,880	.	2	39	54	39
1991	7,375	154	398	32,524	.	2	40	55	39
1992	7,561	161	331	32,632	.	2	40	54	39
1993	7,873	218	427	33,113	.	2	40	55	39
1994	8,655	316	543	32,694	10,695	2	41	56	38
1995	8,567	180	408	33,572	.	2	41	56	38
1996	8,509	186	404	34,388	.	2	41	56	38
1997	6,747	154	369	36,259	.	3	41	59	36
1999	6,997	291	665	39,721	11,096	2	42	60	35
2001	7,406	312	720	41,119	10,621	2	43	61	34
2003	7,822	341	1,020	40,306	9,792	2	43	61	34
2005	8,002	344	1,007	40,939	8,671	2	44	60	35
2007	8,288	309	1,024	40,629	8,298	2	44	58	37
2009	8,689	241	784	41,770	6,500	2	44	56	38
2011	8,906	253	725	38,673	9,602	2	43	53	41
2013	9,062	251	704	38,472	9,300	2	43	51	43
2015	9,048	265	732	38,441	9,586	2	43	50	44

Table 1. Panel Study of Income Dynamics, Summary Statistics. *Note:* All dollar values are in 2009 dollars. Other than aggregates and percentages, reported numbers are medians. The years are PSID survey years. Dollar values reflect the previous fiscal year, while the number having moved or bought a home reflects the totals since the previous survey. Information on fiscal wealth was originally only collected with the wealth supplements before being added to the main survey in 2001. *Source:* PSID.

Figure 3. Comparison of PSID to Other Data Sources. *Note:* Data on rents and prices from the PSID are aggregated using PSID cross sectional weights, which become available in 1997. The rent-to-price ratio is calculated using the weighted mean of the annual expenditure on rent by renters over the weighted mean of house values reported by homeowners in the PSID. The share of first-time home buyers among all home buyers from the AHS is calculated as the number of households purchasing a home for the first time over the total number of households that purchased a home, both since the previous survey. *Source:* PSID, Davis, Lehnert, and Martin (2008) and the American Housing Survey.

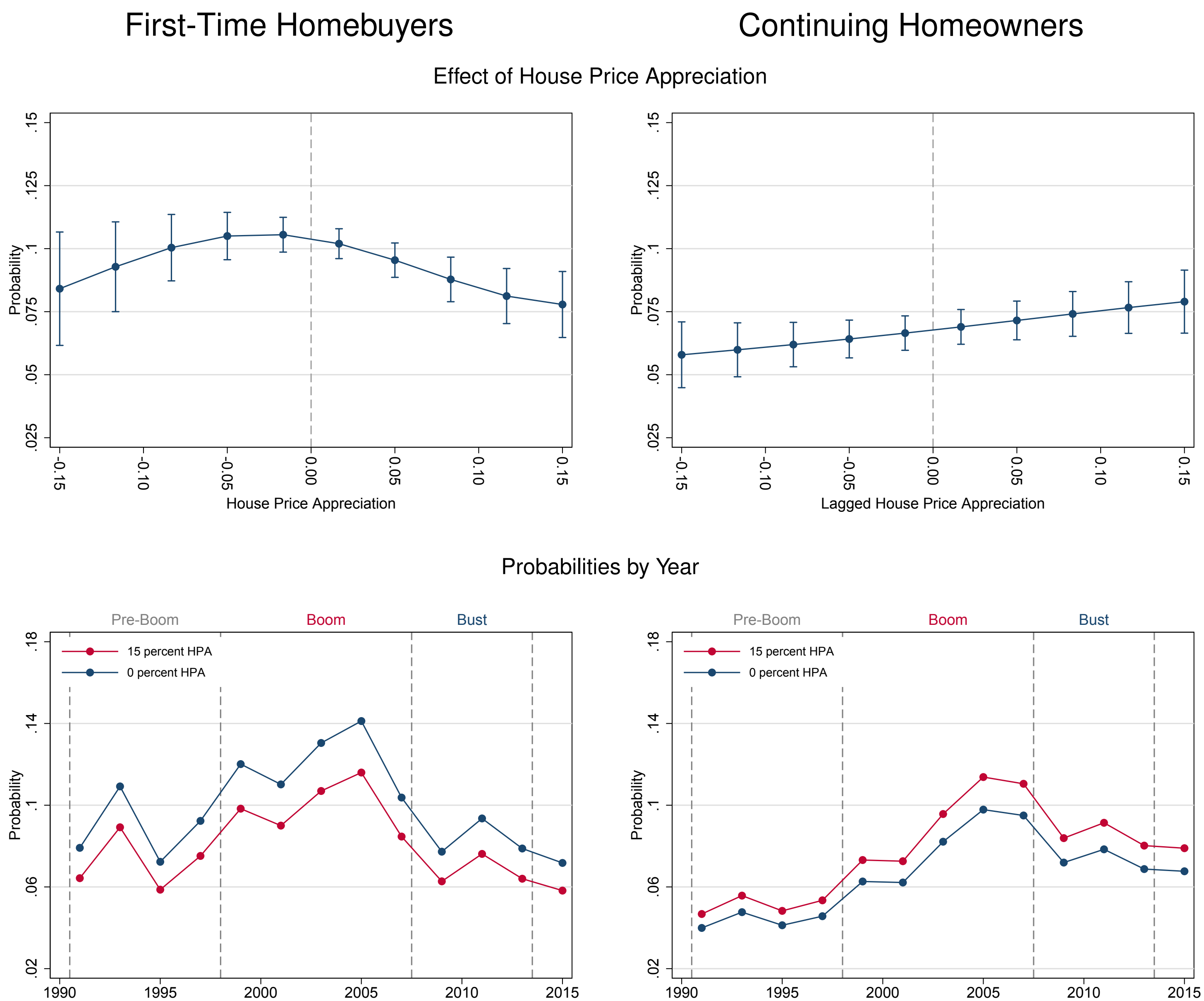

Figure 4. Effect of HPA on First Time Homeownership and Homeowners Purchasing New Home. *Note:* The probabilities for first-time home buyers are all estimated for a household whose head is 35 years old. The probabilities for continuing homeowners are all estimated for a household that purchased their previous home 4 years ago. For first-time home buyers, the house price appreciation is the concurrent value and for continuing homeowners it is the lagged annual house price appreciation. Both are based on the location from which the households moved. *Source:* PSID, QCEW, FHFA, Decennial Census.

	First-Time Home Buyers	Continuing Homeowners
ln(Family Income ($,000))	0.963***	0.341***
	(0.0535)	(0.0418)
Family Size	0.0907***	–0.00283
	(0.0144)	(0.0150)
Years of Education	–0.250***	–0.0854
	(0.0437)	(0.0497)
Months Since Last Interview	0.0180	0.00401
	(0.00932)	(0.00976)
Value of Previous Home ($,000)		–0.000452**
		(0.000138)
2000 Census Tract Median Home Value ($,000)	–0.00311***	
	(0.000311)	
Rooms in Previous Home	–0.00531	–0.0703***
	(0.0128)	(0.0113)
County Employment Growth	0.0417***	0.0412***
	(0.0119)	(0.0102)
Years of Education × Years of Education	0.0133***	0.00546**
	(0.00173)	(0.00188)
Age		–0.0190
		(0.113)
Age × Age		–0.00227
		(0.00332)
Age × Age × Age		0.0000440
		(0.0000416)
Age × Age × Age × Age		–0.000000222
		(0.000000188)
Year FEs	Yes	Yes
Chi-squared	9587	18243
Observations	24,213	43,549

Table 2. Hazard Specification Regression Results. *Source:* PSID, QCEW, and the Decennial Census.

Figure 5. PERCENT CHANGE IN CENSUS TRACT HOUSE VALUE. *Note:* For first-time home buyers and renters, the house price appreciation is the concurrent annual house price appreciation. For continuing homeowners, it is the lagged house price appreciation. All are based on the location from which the households moved. *Source:* PSID, QCEW, FHFA, decennial census, ACS.

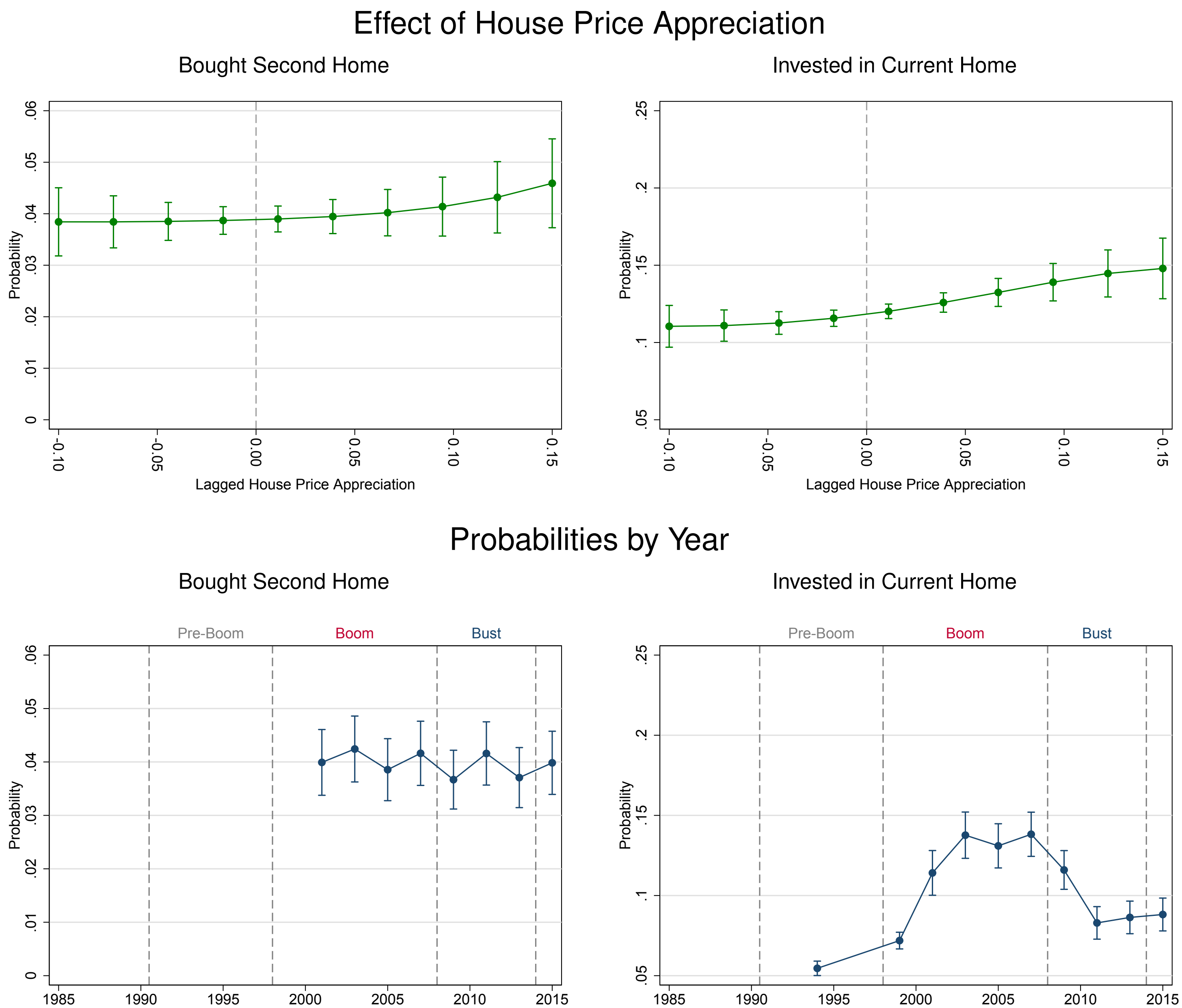

Figure 6. Other Measures of Housing Consumption. *Note:* All probabilities are estimated from logistic regressions with the same limited to homeowners. *Source:* PSID, FHFA, QCEW, Decennial Census.

	Households Moving			Homeowners		
	FTHB	Homeowners	Renters	Bought 2nd Home	Additional Repairs	Additional Repairs (IV)
ln(Family Income ($,000))	–0.00416	0.0241	0.00880	0.619***	1.066***	1.062***
	(0.00883)	(0.0153)	(0.00597)	(0.0535)	(0.0510)	(0.257)
Family Size	0.0176**	0.0148**	–0.00837*	–0.0141	–0.0810***	–0.0661
	(0.00637)	(0.00512)	(0.00355)	(0.0249)	(0.0218)	(0.103)
Years of Education	0.0125	0.0151	0.00816	0.0746	–0.0191	1.062
	(0.0198)	(0.0147)	(0.0118)	(0.0840)	(0.100)	(0.700)
Years of Education × Years of Education	–0.000600	–0.000622	–0.000612	–0.00201	0.00248	–0.0388
	(0.000809)	(0.000592)	(0.000500)	(0.00315)	(0.00365)	(0.0241)
Months Since Last Interview	–0.000920	0.00826*	–0.00158	0.0209	0.0259*	0.0169
	(0.00409)	(0.00399)	(0.00256)	(0.0142)	(0.0129)	(0.0490)
Age	0.0377	0.0549	0.0238	0.0528	0.730**	2.866
	(0.0322)	(0.0323)	(0.0243)	(0.210)	(0.268)	(1.542)
Age × Age	–0.00108	–0.00156	–0.000798	–0.00148	–0.0219**	–0.0899
	(0.000881)	(0.000935)	(0.000762)	(0.00593)	(0.00777)	(0.0470)
Age × Age × Age	0.0000126	0.0000178	0.0000106	0.0000236	0.000281**	0.00122*
	(0.00000983)	(0.0000113)	(0.00000999)	(0.0000717)	(0.0000971)	(0.000619)
Age × Age × Age × Age	–4.95e-08	–7.06e-08	–4.84e-08	–0.000000137	–0.00000130**	–0.00000602*
	(3.80e-08)	(4.84e-08)	(4.63e-08)	(0.000000314)	(0.000000442)	(0.00000298)
County Employment Growth	0.00800*	0.00782*	0.00368	0.000475	0.0621***	0.0354
	(0.00370)	(0.00354)	(0.00254)	(0.0165)	(0.0149)	(0.101)
Residuals						–25.42
						(20.35)
Constant	–0.489	–0.975*	–0.213	–7.875**	–15.77***	–47.82*
	(0.418)	(0.392)	(0.286)	(2.746)	(3.427)	(19.45)
Year FEs	Yes	Yes	Yes	Yes	Yes	Yes
R^2	0.016	0.030	0.005			
Chi-squared				285	961	105
Observations	2328	2575	8210	33519	19090	67227

Table 3. Housing Consumption Regression Results. *Note:* Standard errors for the last column are from a block bootstrap with 50 replications. *Source:* PSID, QCEW, FHFA, ACS.

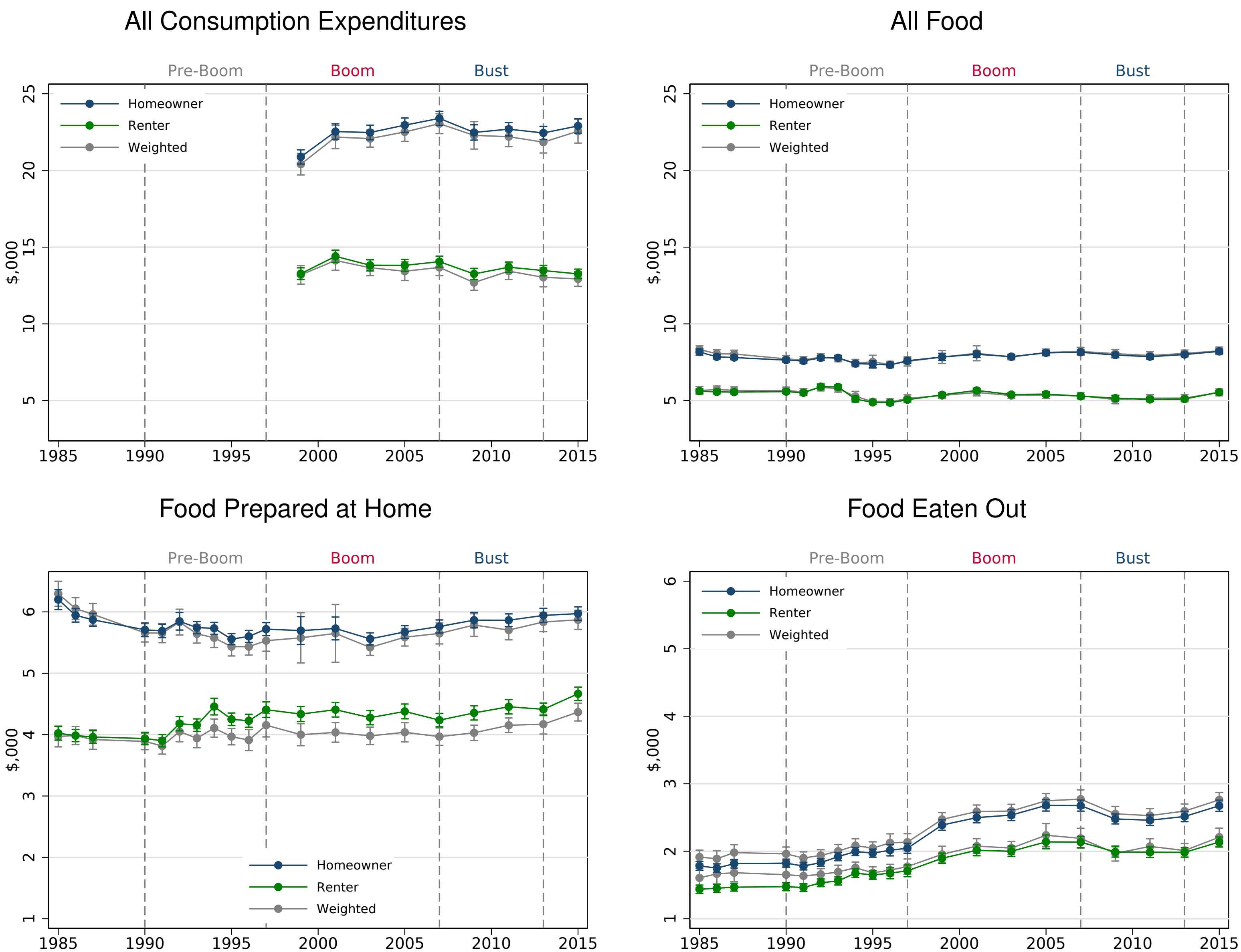

Figure 7. Average Expenditures By Type *Note:* No data on food expenditures is available in 1988 or 1989. "All food" includes food delivered, which is a separate category starting in 1994. In addition to food, "all consumption expenditures" include medical and dental expenditures, transportation including car maintenance and the purchase of new cars, child care, schooling, and utilities. All values are estimated by running a regression of individual annual consumption expenditures on year dummies without any controls. *Source:* PSID.

	All Expenditures	All Food	Food Prepared At Home	Food Eaten Out
Lagged Home Equity	0.00371**	0.00111**	0.000357	0.000791*
	(0.00141)	(0.000367)	(0.000224)	(0.000313)
ln(Family Income ($,000))	2.192***	0.549***	0.184***	0.298***
	(0.251)	(0.0588)	(0.0467)	(0.0272)
Family Size	1.722***	0.848***	0.913***	0.0142
	(0.142)	(0.0312)	(0.0245)	(0.0178)
Years of Education	–0.842	–0.356	–0.285	–0.0868
	(0.614)	(0.186)	(0.167)	(0.134)
Years of Education × Years of Education	0.0401	0.0164*	0.0118	0.00455
	(0.0251)	(0.00762)	(0.00645)	(0.00532)
Months Since Last Interview	0.0476	0.0262**	0.00629	0.0199***
	(0.0318)	(0.00939)	(0.00755)	(0.00573)
County Employment Growth	0.0470	0.0468*	0.0252	0.0138
	(0.0769)	(0.0201)	(0.0191)	(0.00918)
Age	–3.542**	0.172	0.163	–0.176
	(1.229)	(0.162)	(0.124)	(0.0980)
Age × Age	0.141***	0.00377	0.000815	0.00810**
	(0.0362)	(0.00457)	(0.00355)	(0.00279)
Age × Age × Age	–0.00204***	–0.000113*	–0.0000544	–0.000117***
	(0.000452)	(0.0000553)	(0.0000437)	(0.0000340)
Age × Age × Age × Age	0.00000979***	0.000000662**	0.000000360	0.000000541***
	(0.00000202)	(0.000000244)	(0.000000197)	(0.000000150)
Constant	30.95*	–2.844	–1.163	0.974
	(15.26)	(2.391)	(1.910)	(1.518)
Year FEs	Yes	Yes	Yes	Yes
Household FE	Yes	Yes	Yes	Yes
Adj. R^2	0.48	0.40	0.35	0.48
Obs.	37681	66485	63276	58949

Table 4. Marginal Propensity to Consume out of Housing Wealth. *Note:* Home equity is calculated as the self-reported house value minus the outstanding mortgage balance as of the previous interview. *Source:* PSID, QCEW.

Demographics	
	Households are born at age 24 and die at 85
	Mortality Shocks: U.S. Vital Statistics, 2011
Houses	
	Aggregate house prices: PV of future rents (see text).
	Individual house price risk: ± 0.07
	Rent-to-Price Ratio (r_s): 5.04 percent
	Expected Annual Rent Increase During Boom: 50 percent
	Down payment (θ): 10 percent
	Income constraint (α): $6.\bar{6}$
	Depreciation rate, owner occupied (δ_h): 1.5 percent
	Depreciation rate, rentals ($\delta_h + \delta_r$): 2 percent
Preferences	
	Weight on housing (ω): 0.20
	Elasticity of Substitution (η): 0.5
	Curvature parameter (σ): 1.5
	Discount rate (ρ): 3 percent
Income & Employment	
	Variance of permanent income shocks (σ^2_ϵ): 0.01
	Variance of transitory income shocks (σ^2_ν): 0.073
	Unemployment replacement rate: 50 percent
	Probability of Unemployment: 5 percent
	Pension rate (b): 60 percent
	Age of Retirement: 65
Taxes	
	Income tax (τ_Y): 20 percent
	Mortgage interest is fully deductable
Interest Rates	
	Interest on deposits (r_a): 4 percent
	Mortgage interest rate (r_m): 4.5 percent

Table 5. Model Parameters.

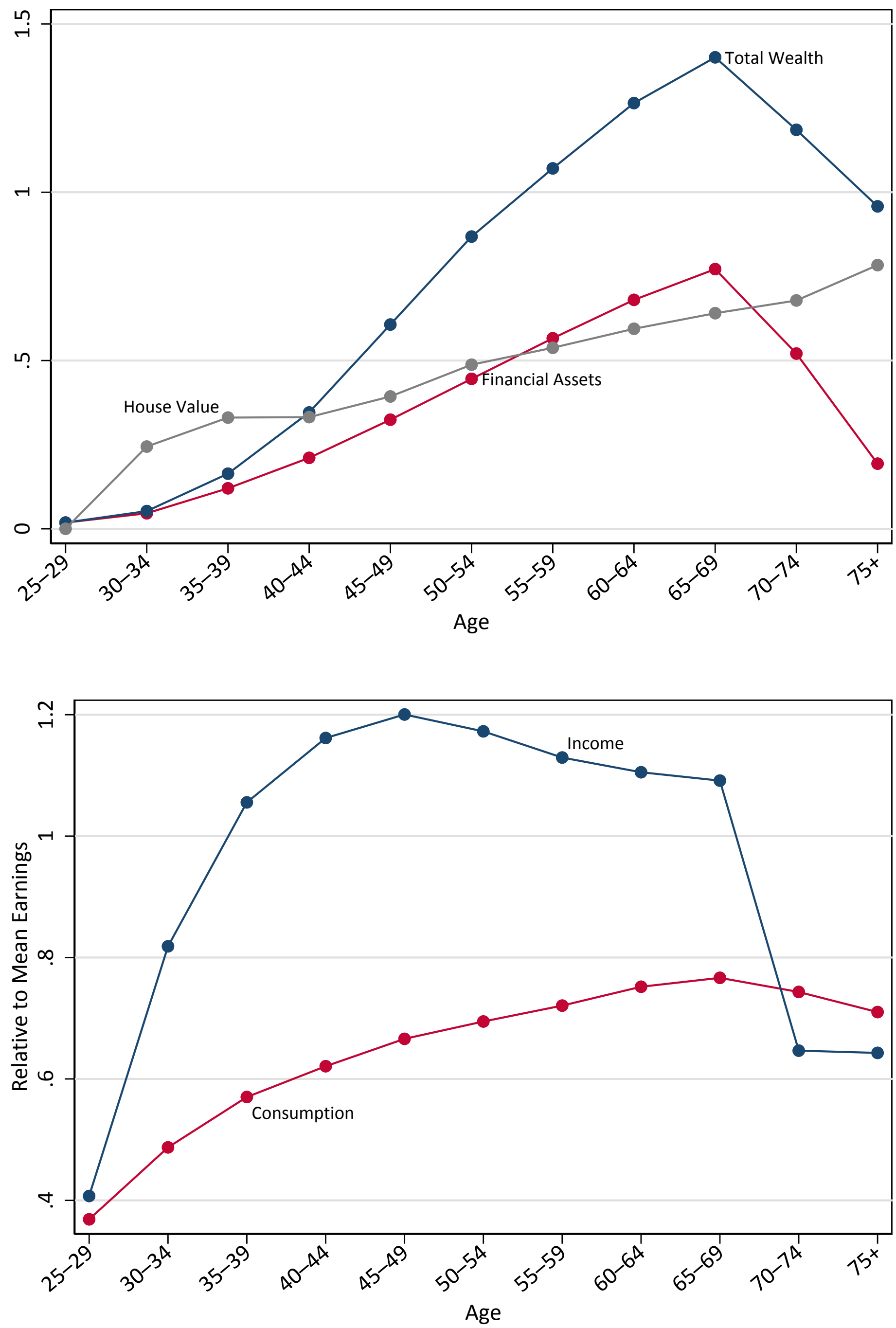

Figure 8. Life Cycle Profiles From Model *Note:* All variables are normalized by the mean earnings of the working aged population.

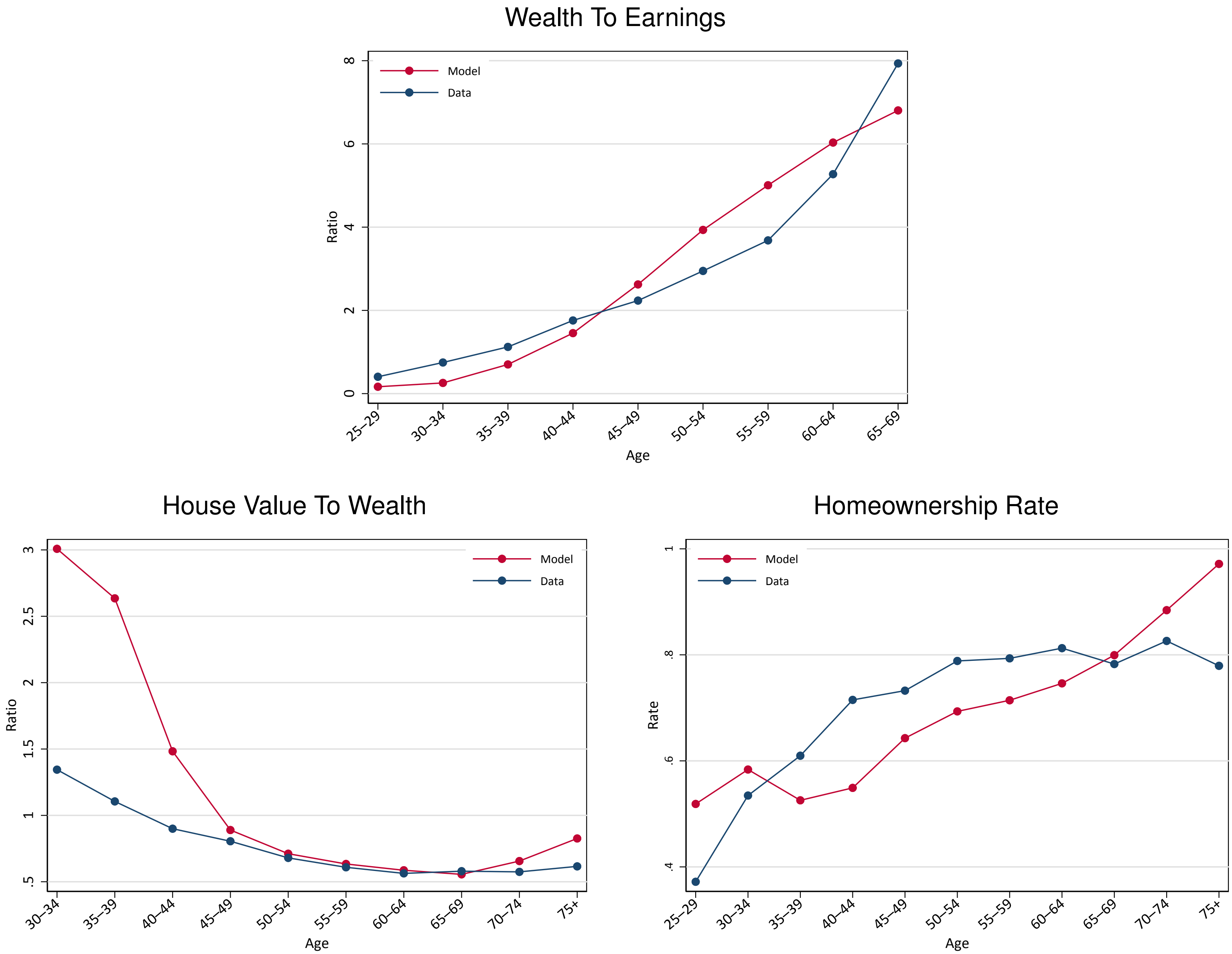

Figure 9. Model Calibration *Note:* The targets of the calibration were the median values of the wealth-to-earnings ratio and the house value-to-wealth ratio, and the mean homeownership rate, not the life cycle profiles. *Source:* SCF, author's calculations.

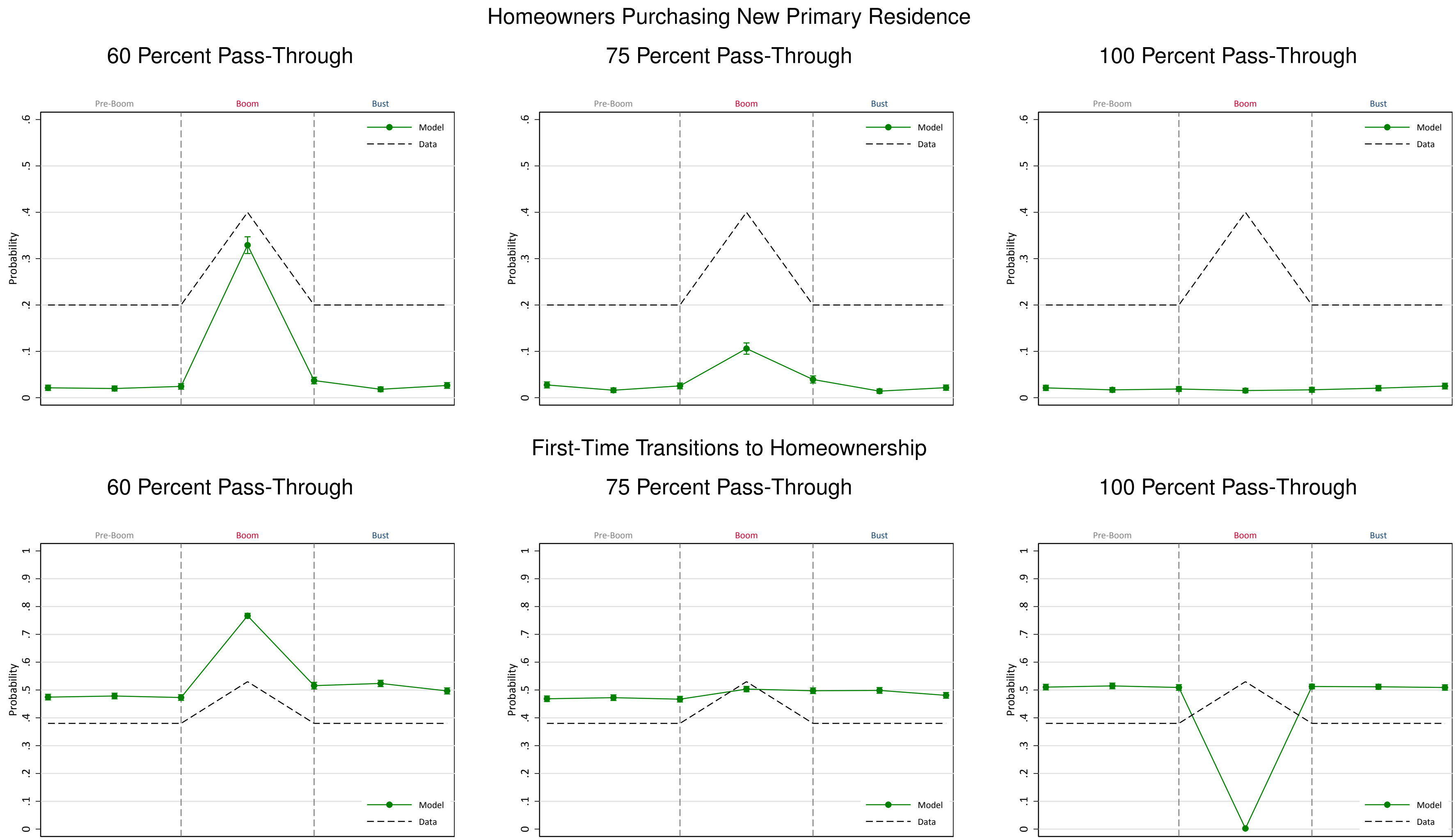

Figure 10. Model Results. *Note:* Plots for continuing homeowners are derived from a logistic regression of an indicator for having purchased a new home on time dummies. Probabilities for transitions to homeownership are calculated from estimates of a hazard model. The values from the data are implied five year probabilities based on results from the PSID.

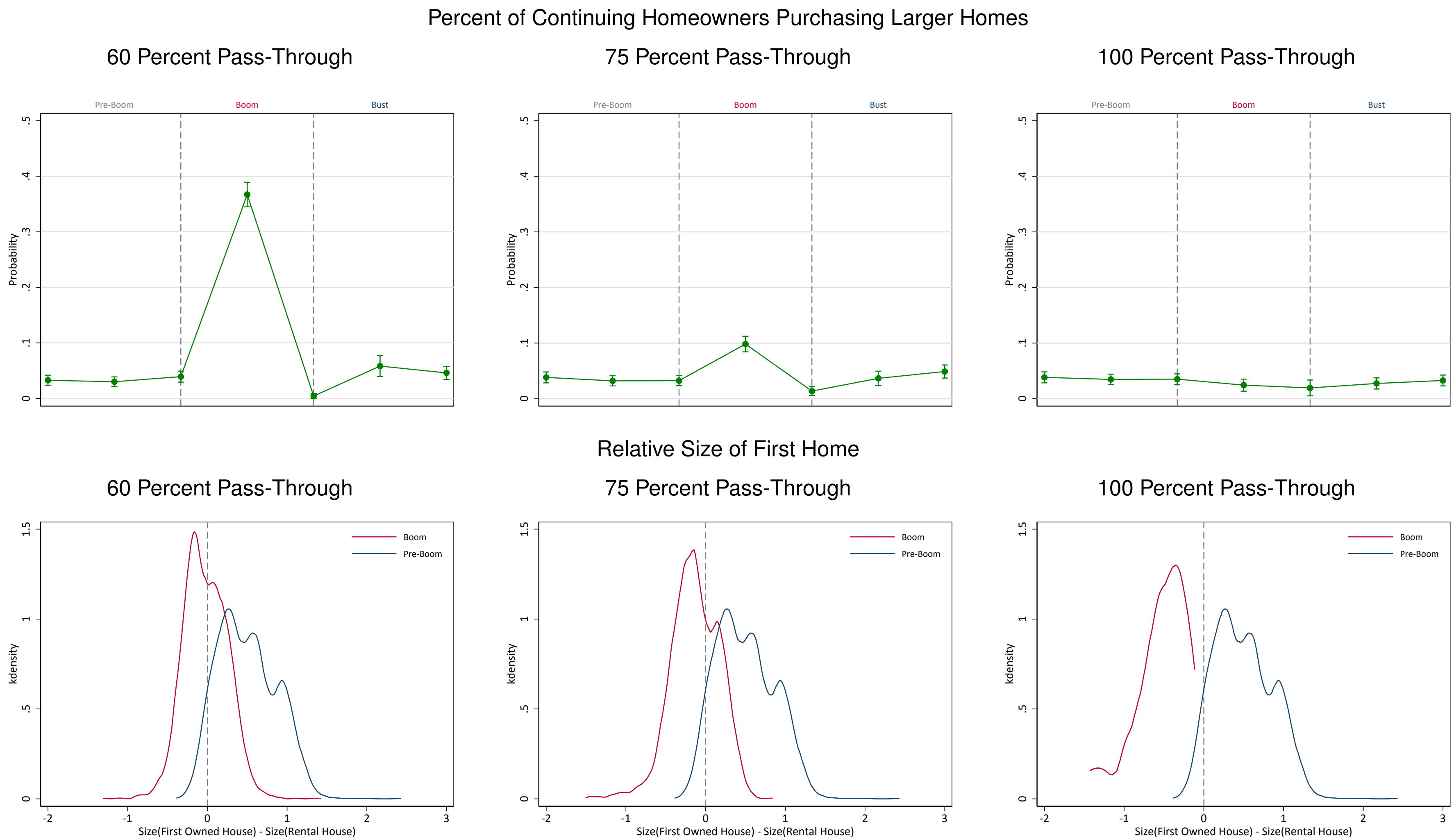

Figure 11. Model Results. *Note:* Values are from a logistic regression for continuing homeowners of an indicator of having purchased a larger home on time dummies.

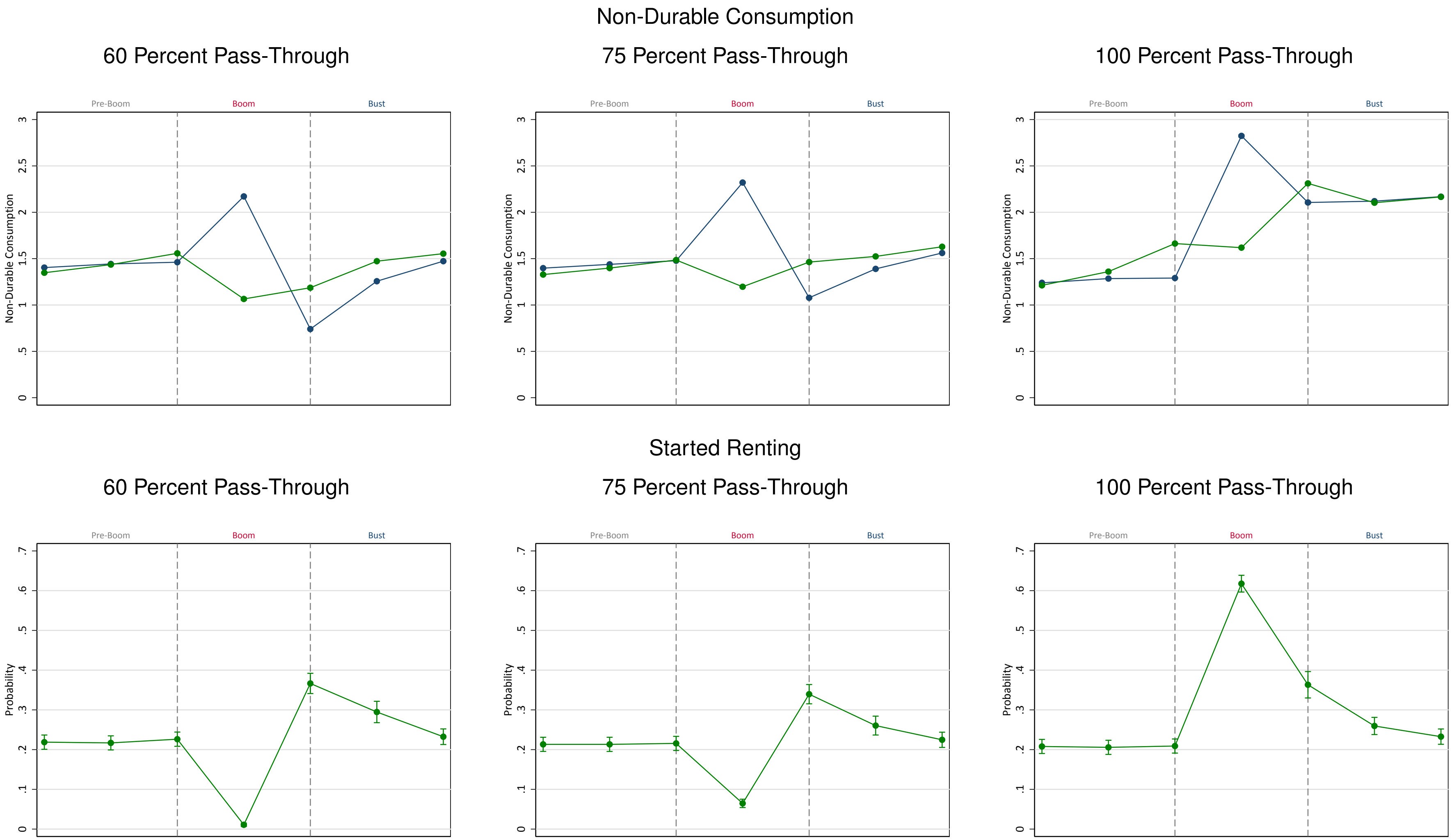

Figure 12. Model Results. *Note:* The paths for non-durable consumption are derived from a regression of consumption on time and household fixed effects. The estimates for homeowners transitioning to renting are based on a logistic regression for homeowners on an indicator of transitioning to renting (not including households that default) on time dummies.

A Concerns About Endogeneity

My results imply that there should be little concern about simultaneity. While demand for housing can certainly induce higher house prices, I found that households demanded more housing irrespective of whether house prices increased. The main effect of increasing house prices was to prevent first-time buyers from entering the market. That being said, to alleviate any concerns that the estimates of the parameters on the quartic of house price appreciation are biased, I test for the endogeneity of house prices using two components of the housing supply elasticities developed in Saiz (2010) that I also use to instrument for house price appreciation.

I follow Aladangady (2014) in using the proportion of unavailable land in an MSA and the Wharton Land-Use Regulation Index at the MSA-level to instrument for house price growth. The first of these components was developed by analyzing topographic maps and measures the proportion of land that is above a 15 percent grade or covered in water within a 50 kilometer radius of the city center.[40] Land with structures already present is considered "available", so this measure provides a time-invariant measure of the long-run housing supply elasticity of an MSA and is not dependent on land available for construction, which is apt to change over time.

The Wharton Land-Use Regulation Index was created by Gyourko, Saiz, and Summers (2008) and is a national survey that assesses the cost, both financial and in terms of time, of constructing a residential building in different MSAs. The variable used in Saiz (2010) and in this paper is the principal component of 11 survey measures, and is meant to be an index of local laws that affect the building of new housing. Unlike the topographic measure of land availability, local laws and regulations can change over time. However, the results are robust to using only land availability as an instrument. Saiz (2010) also found that these two measures were good predictors of housing supply elasticity for a variety of time between 1970 and 2010.

The hazards are nonlinear and all the regressions include a quartic of house price appreciation. To instrument for house price appreciation in this setting, I use a control function (Heckman and Robb 1985; Wooldridge 2015). This method has the added benefit of producing a heteroskedasticity-robust Hausman test to confirm that house price growth is exogenous, which I can then use to determine whether the original regression results are trustworthy.

I perform this Hausman test for all regressions where endogeneity is a concern. House prices are exogenous in almost all cases, implying that the main results discussed above are valid. The one exception is the regressions with an indicator for whether the household made

[40] Further details are available in Saiz (2010).

significant repairs or additions to their home. For this regression, I include results from the instrumented regression. The direction of the results and their significance remain intact when I instrument for house prices as described above. The results from the instrumented regression are included in Figure 17. The standard errors for the regression results for this regression are bootstrapped using a block bootstrap with 50 replications to account for the generated regressor problem.

B Additional Details On the Model

B.1 Value Functions

The households optimization problem in its recursive formulation can be written as follows:

$$V(A_t, H_t, M_t, Y_t, q_t, r_{s,t}) = \max\{V^{ND}(A_t, H_t, M_t, Y_t, q_t, r_{s,t}), V^D(A_t, H_t, M_t, Y_t, q_t, r_{s,t})\},$$

where V^D is the value of either renting or owning a home and not defaulting, and V^D is the value of defaulting, which is only possible for homeowners.

The value function for homeowners when not foreclosing or renters is:

$$\begin{aligned} V^{DF}(A_t, H_t, M_t, Y_t, q_t, r_{s,t}) = \max_{C_t, A_t, H_t, M_t, J_t} \Big\{ & U(C_t, (1-x_t)H_t + x_t J_t) + \\ & \beta E_t \Big[\zeta_t V(A_t, H_t, M_t, P_t, q_t) + \\ & (1-\zeta_t) B(X_t, q_t) \Big] \Big\}. \end{aligned}$$

The value function for homeowners when foreclosing on their home is given by:

$$\begin{aligned} V^{D}(A_t, H_t, M_t, Y_t, q_t, r_{s,t}) = \max_{C_t, A_t, J_t} \Big\{ & U(C_t, J_t) + \\ & \beta E_t \Big[\zeta_t V'(A_t, 0, 0, Y_t, q_t) + \\ & (1-\zeta_t) B(X_t, q_t) \Big] \Big\}. \end{aligned}$$

B.2 Normalizing by permanent income

The utility function is homothetic and therefore the model can be normalized by permanent income. After normalizing by permanent income, P_t, the budget constraints for those not defaulting and defaulting, respectively, become:

$$
\begin{aligned}
c_t + r_{s,t} j_t \{x_t = 1\} + a_t + (q_t(1+\mu)h_t(1+\kappa I_m) - m_t)\,\{x_t = 0\} \\
= (1-\tau_y)\upsilon\phi + (\gamma_t \epsilon_{it})^{-1}\Big([1+\tilde{r}_a]a_{t-1} \\
+ \big((1-\delta_h)(1-\chi_j I_m) q_t (1+\mu) h_{t-1} - [1+\tilde{r}_m] m_{t-1}\big)\{x_{t-1} = 0\}\Big)
\end{aligned}
$$

$$
c_t + r_{s,t} j_t + a_t = (1-\rho_W)(1-\tau_y)\upsilon\phi + (\gamma_t \epsilon_{it})^{-1}(1-\rho_A)[1+\tilde{r}_a]a_{t-1}.
$$

The moving indicator can be rewritten in terms of normalized variables as follows:

$$
I_m = \begin{cases} 0 & \text{if } |(h_t \gamma_t \epsilon_{it})/h_{t-1} - 1| \le \xi, \\ 1 & \text{if } |(h_t \gamma_t \epsilon_{it})/h_{t-1} - 1| > \xi. \end{cases}
$$

The collateral constraint becomes:

$$
\begin{cases} m_t \le (1-\theta) q_t (1+\mu) h_t & \text{if } I_m = 1, \\ m_t < \max((\gamma_t \epsilon)^{-1} m_{t-1}, (1-\theta) q_t (1+\mu) h_t) & \text{if } I_m = 0. \end{cases}
$$

The debt-to-income constraint becomes:

$$
m_t < \alpha \text{ if } I_m = 1 \text{or } (\gamma_t \epsilon_{it} m_t > m_{t-1} \text{ and } I_m = 0).
$$

Given my assumptions about the utility function, the value function must be normalized by the factor $(\gamma_t \epsilon_{it})^{1-\sigma}$.

B.3 Computational Methods

The discrete choices and presence of adjustment costs mean that I have to rely on solution methods that do not depend on differentiability. I therefore discretize the problem and solve it backwards via a grid search.

To keep the problem tractable, I use three grid points (each) to approximate transitory and permanent idiosyncratic income shocks. When choosing the grids for the key state variables (deposits, housing, and mortgages), I start by solving the household problem with coarse grids and increase the number of points in each grid until our results do not change significantly. Grids are denser for these three state variables around the neighborhoods where households are concentrated. Grids are for the normalized variables, and even a small number of points map into a large number of outcomes for the non-normalized variables. I use 21 grid points for housing, 41 for deposits and 37 for mortgages. In contrast to owner occupied housing, rental housing is a continuous choice variable.

I simulate 60,000 individual households over 100 life cycles to ensure that I get a stable distribution of ages in the cross section. The plots of the life cycle profiles of wealth, assets, and homeownership all come from the cross section five periods prior to the simulation of the boom.

C Supplemental Figures

This section includes supplemental figures.

Year	Households (#)	Bought First Home (#)	Bought Home (#)	Family Income ($)	Fiscal Wealth ($)	Family Size (#)	Age of Head	Homeowner (%)	Renter (%)
Unweighted summary statistics...									
1997	6,747	154	369	36,259	.	3	41	59	36
1999	6,997	291	665	39,721	11,096	2	42	60	35
2001	7,406	312	720	41,119	10,621	2	43	61	34
2003	7,822	341	1,020	40,306	9,792	2	43	61	34
2005	8,002	344	1,007	40,939	8,671	2	44	60	35
2007	8,288	309	1,024	40,629	8,298	2	44	58	37
2009	8,689	241	784	41,770	6,500	2	44	56	38
2011	8,906	253	725	38,673	9,602	2	43	53	41
2013	9,062	251	704	38,472	9,300	2	43	51	43
2015	9,048	265	732	38,441	9,586	2	43	50	44
Weighted summary statistics...									
1997	100,919,992	1,668,354	5,532,121	46,360	.	2	49	63	33
1999	103,717,096	3,616,617	9,427,418	51,685	157,299	2	49	64	31
2001	106,237,896	3,756,456	9,794,741	56,710	158,775	2	49	65	31
2003	111,087,472	3,872,413	13,617,412	54,479	158,095	2	49	66	29
2005	117,571,896	4,192,889	14,408,925	57,839	184,038	2	49	66	29
2007	120,494,680	3,586,253	13,921,123	57,728	224,643	2	50	65	30
2009	117,449,088	2,961,935	11,180,274	61,853	214,610	2	50	65	30
2011	126,996,328	2,929,489	10,064,857	54,793	161,710	2	50	60	34
2013	129,697,520	2,632,323	9,179,411	56,374	155,144	2	51	60	35
2015	136,429,712	2,942,560	10,358,336	56,317	180,105	2	51	58	36

Table 6. Panel Study of Income Dynamics, Summary Statistics. *Note:* All dollar values are in 2009 dollars. Other than aggregates and percentages, reported numbers are medians. The years are PSID survey years. Dollar values reflect the previous fiscal year, while the number having moved or bought a home reflects the totals since the previous survey. *Source:* PSID.

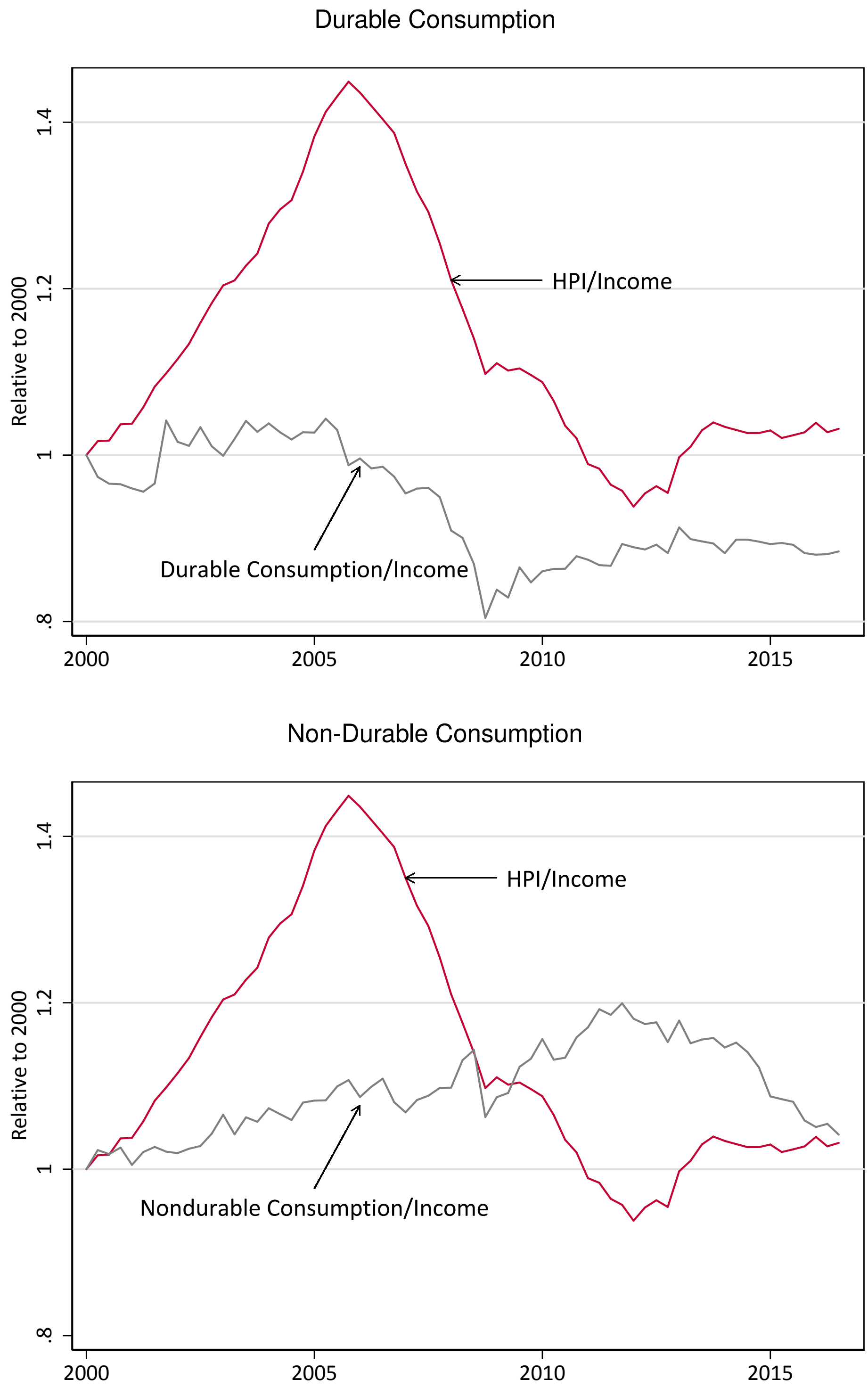

Figure 13. Consumption and HPI Relative to Income. *Note: Source:* Case-Shiller House Price Index, National Income and Product Accounts.

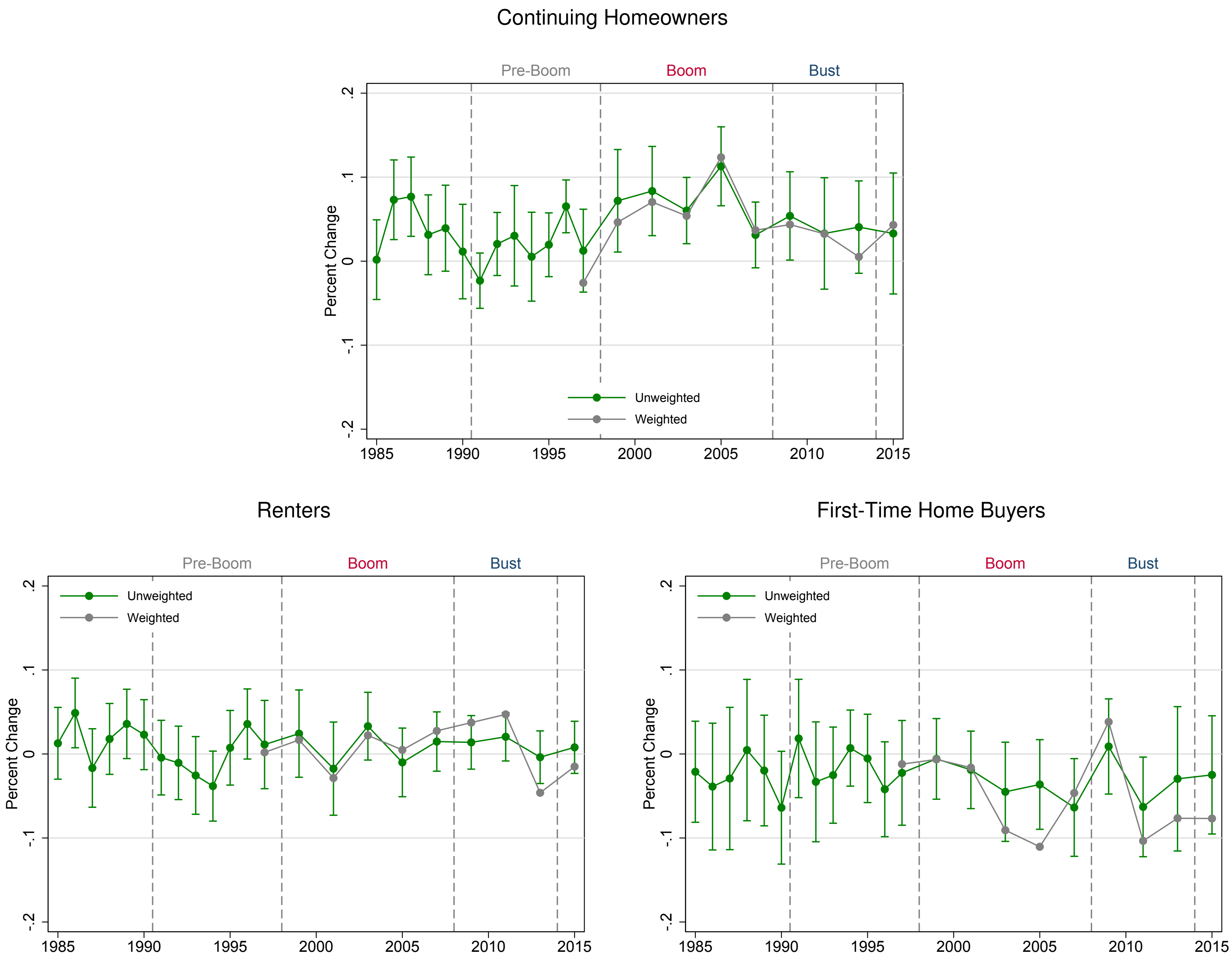

Figure 14. Percent change in census tract median house values by year. *Note:* From regressions of the log change in census tract median house values for continuing homeowners purchasing new homes, renters moving, and first-time home buyers respectively. *Source:* PSID.

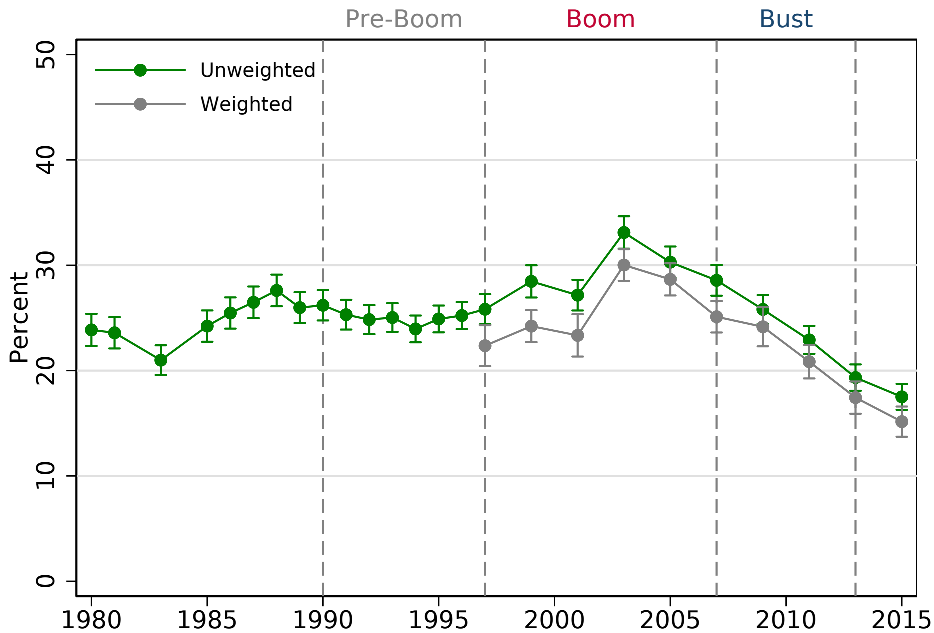

Figure 15. Percent of Homeowners Taking out More Mortgage Debt by Year. *Note:* Percentages are derived from a logit regression of all homeowners in the PSID on year dummies. *Source:* PSID.

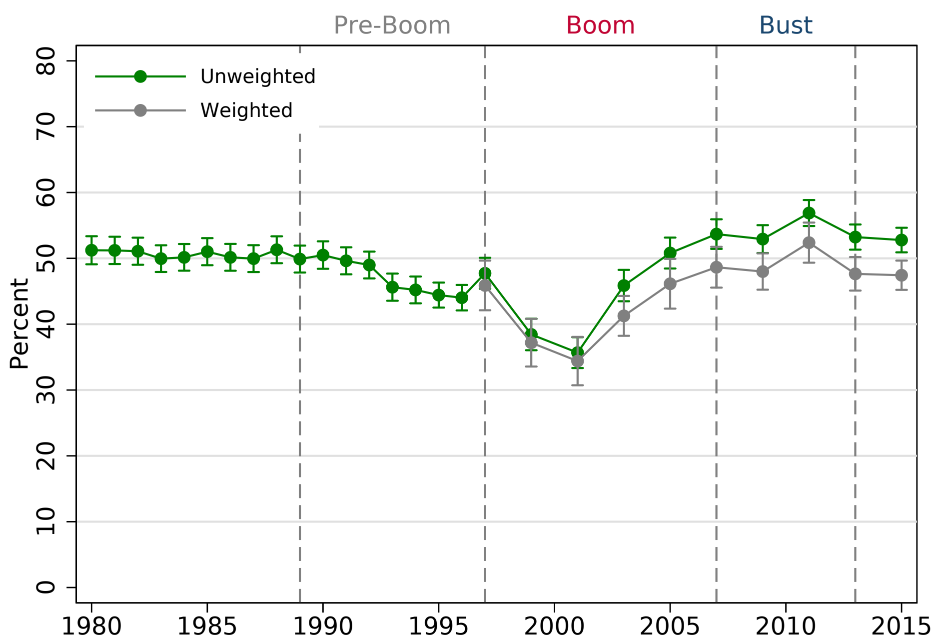

Figure 16. Percent of Renters Moving by Year. *Note:* These percentages are calculated using a logistic regression of a binary variable indicating a move on year dummies. *Source:* PSID.

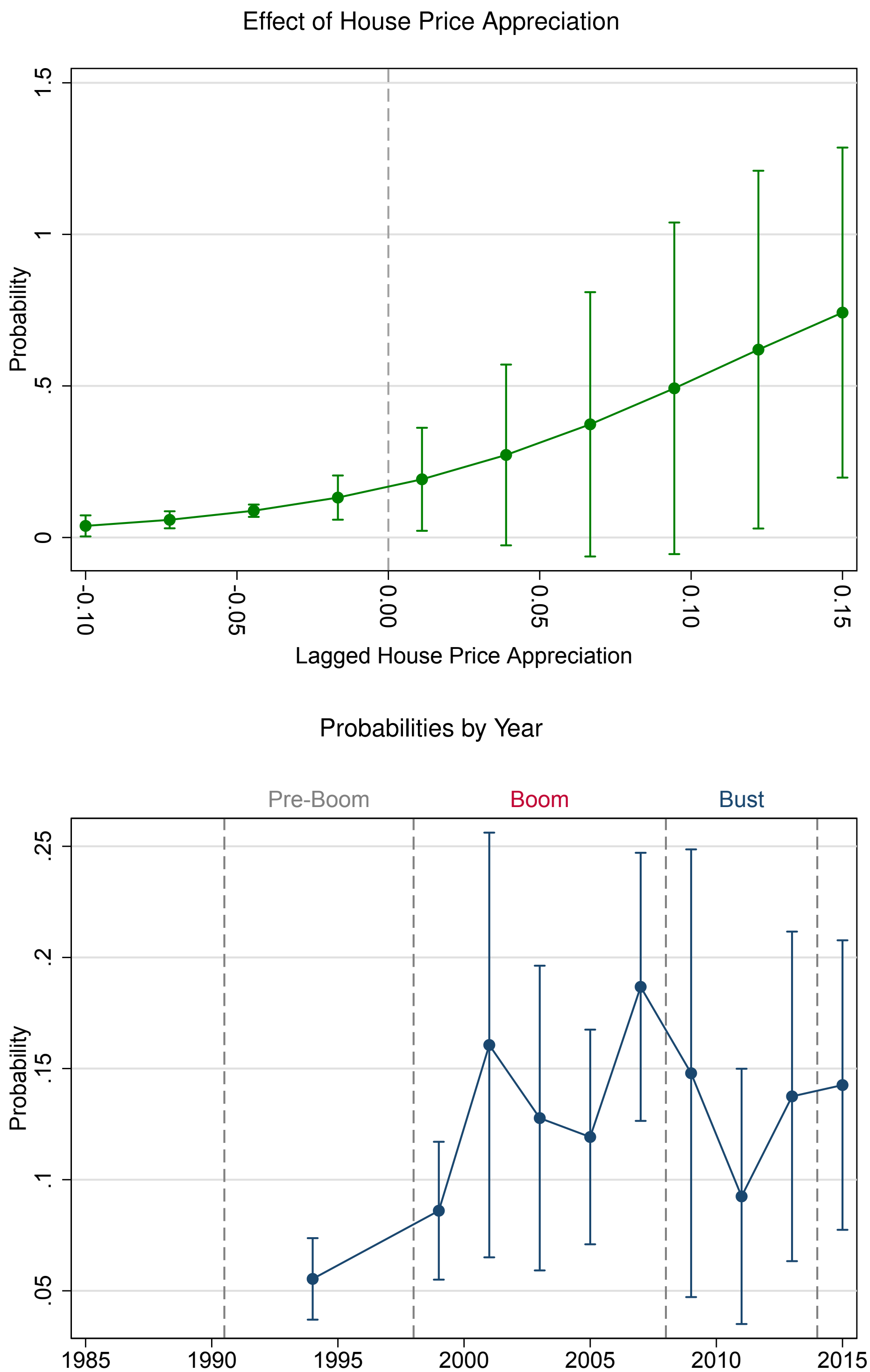

Figure 17. Effects of House Price Appreciation and Year Fixed Effects on Probability of Homeowners Investing in their Primary Residence. *Note:* These are derived from logistic regressions where the sample has been restricted to homeowners. House prices are instrumented for with the percent of unavailable land and an index representing the cost of constructing residential housing. *Source:* PSID.