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

Lara Loewenstein†

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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. 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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†Federal Reserve Bank of Cleveland. Email: Lara.Loewenstein@clev.frb.org.

1 Introduction

When relative prices change, economists expect that consumers will 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 panel of Figure 1), unconstrained households increased their consumption of owner-occupied housing, while leaving their non-housing expenditures relatively untouched. 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 renters that did transition purchased smaller houses relative to first-time home buyers prior to the housing boom.

These results are consistent with optimistic beliefs about house prices. Like for any durable good, the price of housing that enters the demand function is the user cost of housing. The canonical definition of the user cost implies that higher expectations for capital gains lowers the user cost, increasing demand for housing. The majority of households do not have the means to own more than one home. They therefore increase their consumption of housing services by increasing the size of their primary residence, using the sale of their previous home to fund the purchase. By contrast, renters looking to purchase a home for the first time are more likely to be constrained in the size of house they can afford. As house prices rise in response to the increase in demand, they are less likely to transition to homeownership or—if they do purchase a home—they purchase a smaller home than they would have otherwise.

Optimistic expectations is also consistent with a defining feature of the housing boom: the fall in the rent-to-price ratio. Prices of owner-occupied housing rose much faster than rents on equivalent properties (see the bottom panel of Figure 1). The price of a house should reflect the present value of the discounted flow of rents. A plausible story for for this divergence in rents and prices is that households expected higher future rents. Higher future rents would have led to higher present-day house prices without affecting present-day rents.

I use 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; I see whether households move, whether households rent or own their primary residence, and if they transition from renting into homeownership. Using the geographic information for each household, I can observe to and from which neighborhoods households are moving, and to compare characteristics—including home values—of those

[1] Giffen goods excepted.

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

neighborhoods. I am also able to control for a variety of other household level characteristics available in the PSID, including household income, education, and financial wealth. To alleviate concerns about sample sizes, I corroborate my results for first-time home buyers using the New York Consumer Credit Panel.

An alternative theory of the housing boom consistent with the empirical facts in this paper is a fall in interest rates, possibly driven by a global savings glut. To test the plausibility of this alternative hypothesis I develop and solve a life cycle model of homeownership that incorporates tenure choice, multiple house sizes, and the option to default. My results cannot be explained solely by a significant drop in interest rate. However, my empirical results are consistent with reasonable optimistic expectations for house prices, possibly even combined with a drop in interest rates.

My results contribute to the new narrative of the housing boom by providing empirical evidence that housing consumption changed in a manner consistent with optimistic expectations for house prices. The old narrative claimed that an exogenous increase in credit supply was a causal driver of the boom. The new narrative asserts that the more prominent role was played by optimistic expectations for house price appreciation.[3] This is not to say that credit standards were not relaxed during the boom, but that they were endogenous to housing market conditions.

I also contribute to the literature on housing demand. This includes Henderson and Ioannides (1989) who solve a model describing why wealthier households are more likely to be homeowners because they have lower abosolute 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 incorporate 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,

[3]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).

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, Case, Quigley, and Shiller (2005) who used state- and country-level panels, 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 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). 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 6 is about my analysis of non-housing consumption. Section 7 contains a description of the life cycle model, its simulation, and results. Section 8 concludes.

2 Data

2.1 Panel Study of Income Dynamics

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.

Table 1 contains summary statistics of the un-weighted sample.[4] After removing households with missing data, the number of families in the core and immigrant samples ranges from 6,747 in 1997 to 9,062 in 2013.[5] Interviewers gather detailed demographic and financial

[4]Weighted summary statistics from 1997 onward—when weights become available—are in Table 6 in the appendix.

[5]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.

information from each household.[6] Family income—the sum of taxable,[7] 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 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).[8]

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.[9] In my analysis of 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 the 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 2 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

[6]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.

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

[8]I use county-level house price indices because they have the highest match rate with the PSID geographic identifiers. The indices from the FHFA have significantly more coverage than those from proprietary sources such as Corelogic because they are annual, not monthly, and therefore can be calculated for counties with fewer housing transactions. Unlike Corelogic, the FHFA also does not fill-in any county-level information with indices from larger geographic levels.

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

to 3 percent. The bottom left panel in Figure 2 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.

2.2 New York Consumer Credit Panel

The main disadvantage of the PSID is the relatively small sample size. This is especially true when looking at first-time home buyers in a given year. I corroborate my findings for first-time homeowners using the New York Federal Reserve Bank Consumer Credit Panel (CCP). The CCP is a quarterly, longitudinal 5 percent sample of individual credit histories from the Equifax credit bureau. Individual-level credit histories are included in the sample based on the last two digits of the individual's social security number, so the dataset is updated automatically to incorporate new entrants over time. The CCP begins in 1999, but it contains information on the age of the oldest mortgage known by Equifax for each person. This information is based on the full history of credit reports from Equifax, so references mortgages originated and terminated prior to 1999. So, even though someone taking out a mortgage in, say, 1985 may not have an active mortgage account in the Consumer Credit Panel, we will still know that the person previously had a mortgage, which is information we can use to identify individuals taking out first mortgages after 1999.[10] Combining my identification of first-time home buyers with their geographic location (the CCP records an individual's geographic information down to the census tract), I can validate my results from the PSID using a much larger sample.[11]

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.

[10] See Figure 18 for a comparison of my identified first-time home buyers in the CCP and the share of all home buyers made by first-time buyers from the National Association of Realtors.

[11] Unfortunately, I cannot use the CCP to confirm my results for continuing homeowners. The CCP does not identify purchase mortgages. While in theory, it should be possible to identify purchase mortgages using changes in an individual's geographic information, in practice that is not possible prior to 2005. Starting in 2005, Equifax improved how it records address information. Prior this change, there are far too many moves in Equifax relative to other data sources. There was also a refinancing boom in the early 2000s, which combined with the high number of moves, makes the reliable identification of purchase mortgages for continuing homeowners impossible.

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 of 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.[12] To account for the change in interview frequency, I drop all even years prior to 1997.[13] 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.

[12]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.

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

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 $f(\text{Years of Education})$ contains a quadratic of the years of education, and $f(\text{hpa}_{it})$ is a quartic the house price appreciation[14] from $t-1$ to t for the county in which the household resided at time $t-1$.[15] Family size includes children.[16] 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.[17] 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.[18]

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,

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

[15]The quartic was chosen because it allows for enough flexibility without taking up too many degrees of freedom. Simpler specifications, including a quadratic, provide similar results, but the measures of goodness of fit are higher when using a quartic. Using a spline in house price appreciation also gives 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.

[16]The number of children is highly collinear with family size, so it was not included separately. Its inclusion has little impact on the other parameter estimates.

[17]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]".

[18]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.

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 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.[19] 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.

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

3.3 Results

The top panels of Figure 3 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—to illustrate how these probabilities vary across geographic areas with different levels of house price appreciation.[20] The latter value is the approximate annualized appreciation in the highest house price growth areas during the boom. Over the course of the boom, the probability of continuing homeowners purchasing a new primary residence increases four percent (from 6 percent to 10 percent in areas with no house prices growth) while the probability renters of transitioning to homeownership for the first time increases three percent (from 12 percent to 15 percent in areas with no house price growth). 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. This is consistent with other data sources (including the American Housing Survey) that show that the share of first-time home buyers in all housing transactions decreases over the course of the boom.

Furthrmore, 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 to below its value at the beginning of the boom. This is consistent more renters becoming limited priced out of homeownership as house prices reached their peak in 2007. 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 bottom two panels of Figure 3 plot the estimated probabilities for different values of house price appreciation.[21] 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. This difference is statitically significant.[22]

[20] These probabilities are average probability across individuals, holding age fixed at 35 and house price appreciation fixed at the indicated value. Predicted probabilities using no individual level controls other than age and year fixed effects are included in Figure 12 in the appendix.

[21] As above, these are average predicted probabilities holding age constant. Reported values in this paper are always average marginal effects or average predicted values unless noted otherwise.

[22] 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. The interpertation of this effect is less clear than for first-time home buyers. This can be interpreted as the wealth effect: as house prices increase, homeowners become wealthier and may want to increase their consumption of housing. However, it could also reflect relatively higher house price expectations in areas already experiencing higher house price growth. 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. Table 2 contains additional regression details, including the parameter estimates on the remaining controls and measures of goodness of fit.[23]

4 Consumption of Owner Occupied Housing Services

In this section, I ask how–conditional on purchasing a home–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.[24]

[23]Results that control for fiscal wealth are included Figure 15 in the appendix. Prior to 1999, information on financial assets is only acquired with the wealth supplements, so the sample sizes when controlling for financial wealth is more limited.

[24]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

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:

$$\begin{aligned} X_{it} =& \boldsymbol{\alpha} * f(\text{hpa}_{it}) + \beta_1 * \text{Income}_{it} + \beta_2 * (\text{Family Size}_{it}) \\ &+ \boldsymbol{\beta_3} * f(\text{Years of Education}) + \boldsymbol{\beta_9} * f(\text{age}_{it}) + \gamma_t, \end{aligned}$$

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. Dropping even years of data gives similar, although less precise, results. The covariates are similar to those described in Section 3, but do not include the number of months since the previous interview or the county level employment growth. The number of months since the previous interview is not included because I am not dropping even interview years prior to 1999. The months since previous interview picks up this change in survey frequency and affects the coefficients on the year dummies. The county level employment growth is removed because the national trend in employment also pulls from the coefficients on the year dummies. The results still hold if employment growth is included, but are slightly less precise. The exclusion of the county level employment growth is that I can use data going back to 1985, which includes the tail end of the 1980s housing boom.

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.[25]

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.

[25]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. Results are also similar when I use 2000 census tract values

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, 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.

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.

4.1 Results

Figure 4 contains the main results of interest. 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.

First-time home buyers on average purchase homes in census tracts with comparable house price levels to where they were renting. However, during the initial years of the boom, it appears there is a trend towards first-time buyers purchasing homes in areas slightly more expensive relative to their rentals, although the percent change in census tract median house value is never significantly above zero. However, 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 7 percent cheaper than those in which they were renting.

This appears to be driven by first-time buyers in the highest house price growth areas.

for all years after 2000. In other words, the results are not driven by gentrification, or house prices rising in areas households were more likely to move to.

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. 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.

Unlike first-time home buyers, continuing homeowners were increasing their housing consumption throughout the boom. They were purchasing homes in census tracts up to 9 percent more expensive than their current census tracts, whereas during the pre-boom, continuing homeowners purchased homes in census tracts that are on average 2 percent more expensive. As can be seen from the top middle to panel of Figure 4, this pattern is independent of local house price appreciation. Therefore, this increase in consumption of housing is not due to wealth effect. This rules out an increase in demand for housing due to increases in wealth and emphasizes that the fundamental change during the boom must have been experienced universally.[26]

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 results for different values of house price appreciation shows that this is consistent across areas with different rates of house price appreciation.[27]

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 5 contains results for the regressions of homeowners 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. About 13 percent of homeowners during the boom invested more than $10,000 in their primary residence. This compares to fewer than 6 percent prior to the boom, and the value fell to 10 percent during the bust. This is a statistically significant difference. However, unlike for homeowners purchasing new homes, these effects were magnified in areas with high house price appreciation. Fifteen percent of households in the areas with 15 percent house price appreciation made a significant financial investment in their homes, compared to 13 percent in areas with no house price growth.

[26]Results using the self-reported house values for continuing homeowners is included in Figure 17 in the appendix. Furthermore, while it is certainly feasible that households with higher expectations for future house prices were simply moving forward in time their decision to purchase a new home, the fact that they were purchasing *larger* homes than average indicates something beyond time dynamics.

[27]Results when controlling for financial wealth are included in Figure 16 in the appendix.

5 New York Consumer Credit Panel Analysis

Figure 6 contains plots for first-time home buyers in the CCP. My results corroborate my findings for first-time home buyers in the PSID. The regression specifications used to produce these plots parallel those for the PSID. The main difference is that the CCP contains no information on income or education. However, it does include the Equifax Risk Score, which is a credit score similar to a FICO score. The Equifax Risk Score should be correlated with income and education, so I include a quadratic of this credit score in both the hazard and conditional regression specification. I also cluster the standard errors by county.[28]

The top two panels in 6 contain results from the hazard specification. The left panel contains probabilities of transitioning into homeownership for the first time by year. I have plotted both the probabilities assuming no house price growth and the implied probabilities given actual house price growth to emphasize that had there been no house price growth during the boom, more people would have been able to afford to become homeowners. However, the overall picture the CCP is somewhat different than the results from the PSID: even after multiplying the probabilities in the CCP results by two to account for the yearly (as opposed to biyearly) hazard, the probability of transitioning into homeownership at any point in time is significantly lower in the CCP than in the PSID. The hazard of first-time homeownership in the CCP is also falling over the course of the boom as opposed to increasing in the early years. Despite that, the effect of house price appreciation is in the same direction as in the PSID: renters in higher house price growth areas were significantly less likely to transition into homeownership. The top right panel shows that renters in the highest house price growth areas are 0.075 percent less likely to transition into homeownership than renters in areas with no house price growth. There are a number of reasons why the probability of purchasing a first home is lower in the CCP than in the PSID. While the CCP is a larger sample, the identification of first-time buyers in the CCP is not as clean. Furthermore , the percent of people with a mortgage in the CCP is lower than other data sources, implying that the CCP has the number of people at risk of getting their first mortgage is too large in the CCP, which would lower the predicted probabilities.

The bottom two panels are from the conditional regression regression specification. There are close the PSID results both in terms of direction and magnitudes. On the left, I have again plotted the predicted percent change in "housing consumption" assuming zero house price growth along with the predicted percent change using the house price appreciation that actually transpired during the boom.[29] Had there been no house price growth, first-time home buyers would have purchased homes in census tracts that are four percent more expensive than those in which were renting. However, given the actual path of house prices,

[28] Clustering by state also works.

[29] I use each individual's count level house price appreciation, not the national house price appreciation.

by the peak of the boom first-time home buyers were moving to census tracts that were two percent cheaper than where they had rented. The bottom right panel shows how housing consumption varied by house price appreciation. In areas with 15 percent house price growth, first-time buyers purchased homes in census tracts that were 6 percent cheaper than those in which they were renting.

6 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:

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

The parameter of interest is the coefficient on lagged home equity (δ). In line with the previous literature, I limit the sample to homeowners who do not move to isolate the effects of home equity on non-durable consumption.

6.1 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. Because 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 (0.334 percent), followed by all food (0.0892 percent), and food eaten out (0.0785 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.

7 A Life Cycle Model of Homeownership

In this section I test whether optimistic expectations for future house prices or a significant drop in interest rates are more likely to explain my 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. This model also serves to help develop some intuition about how the user cost interacts with some of these realistic features of housing markets.

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.

7.1 The Model

7.1.1 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;[30] $1/\sigma$ 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.[31]

7.1.2 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 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:

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

where the latter

Households pay a fraction of the house value to purchase (κ) or sell (χ) a home, which

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

[31] 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.

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.[32] 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.[33]

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.

7.1.3 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:

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

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

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

[33] 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.

$\tilde{r}_a = r_a(1-\tau_y)$ 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.

7.1.4 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[34]; $B()$ 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 is subject to:

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

where I_d indicates whether a household defaults on their mortgage.

7.1.5 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.

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

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

$$q_t = \sum_{t=0}^{\infty} \left(\frac{1 - \delta_h - \delta_r}{1 + \tilde{r}_a} \right)^t E_t {r_{s,t}}^{35}$$

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).

To model house price expectations 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 2. The interest rate shock is modeled as a fall in both the mortgage and risk-free interest rate that occurs concurrently with an increase in house prices.

7.1.6 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)[36], 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

[35] 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, which decreases the user cost of homeownership, I lower the rent-to-price ratio by assuming that rental income is not taxed.

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

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:

$$\frac{u_s(c_t, s_t)}{u_c(c_t, s_t)} = \kappa I_m q_t + \frac{[\lambda_t / E_t\lambda_{t+1} - 1]q_t}{\lambda_t / E_t\lambda_{t+1}} - \frac{E_t(q_{t+1} - q_t)}{\lambda_t / E_t\lambda_{t+1}} + \frac{E_t q_{t+1}(\delta_h + \chi_j I_m - \delta_h \chi_j I_m)}{\lambda_t / E_t\lambda_{t+1}} - (1 - \theta)\frac{\mu_t}{\lambda_t} q_t - \xi_t.$$ [37]

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 future 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

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

(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.[38] If the household sells their home 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.[39]

7.2 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

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

[39]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.

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[40]) 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.[41]

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) estimated a replacement rate of 68 percent, which is slightly higher than that found in other literature.[42] 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 baseline 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. I follow Demyanyk et al. (2013) and set the exogenous moving shock equal to 2 percent annually.

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

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

[42]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.

7.2.1 House Prices, Interest Rates, and Simulating the Boom

The model is solved for three separate and independent house prices states—the base state, the boom state, and the post-boom state. For the house price shocks I set baseline rental rate 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.

In the boom state, future rents are expected to increase 50 percent annually between the current and next model period (for a period of 5 calendar years).[43] The post-boom state is the realization of the higher rents and the higher house prices that were expected in the boom state. In this state, households expect that rents will stay at their high level for the foreseeable future. In the simulations, the post-boom state is never reached. The boom is simulated by a transition from the base state to the boom state. The bust is a return to the base state.

During the boom, households expect that the increase in rents will occur 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.[44] The transition matrix for house prices is given by:

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

The value of house prices in the boom state is determined by the fraction of the increase in future rents that is passed through to the present.

In my main results I assume that there is a 50 percent rate of pass-through of expectations for higher future rents to present-day house prices.[45] A pass-through rate of 50 percent results in $q = [1\ 3.51\ 7.59]$, a five-year rent-to-price ratio of 6.53 percent during the boom,

[43] 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.

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

[45] The results are highly dependent on how much of this expected increase in rents is passed through to present-day house prices. In Figures 19 and 20 in the appendix, I report results for three different rates of pass-through: 25, 50, and 75 percent. 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.

and expected house price growth of 77 percent. There are a number of realistic reasons that the pass-through could be incomplete. For example, houses are transacted infrequently and the process of buying and selling a house takes time. Futhermore, optimistic beliefs could be held by only a portion of the population. People purchasing homes for reasons other than optimistic beliefs would keep the current price relatively low.

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 50 percent results in expectations of about 15 percent.

I also solve the model for two levels of interest rates: the initial values as described in the previous section and a 50 percent reduction relative to the baseline. I solve the model for the two interest rate states for each of the three house price states, which allows me compare the interest rate and belief shocks in situations with equal increases in house price levels.

7.3 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.[46] 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 25 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

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

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.

7.4 Model Results

Figure 10 contains plots of the probability of continuing homeowners purchasing a new home and of renters transitioning into homeownership. The left-hand side plots in Figure 10 contain the results when I model the boom as a combination of higher present-day house prices and a 50 percent drop in interest rates without any change in expectations (households always expect prices to remain at their current level). The middle panel are results from when I model the boom as an increase in prices and expectations. The right-hand side panels contain results from when I model the boom as an increase in house prices combined with both an increase in expectations and a drop in interest rates.

The first take away from these results is that a drop in interest rates alone cannot replicate two of the empirical facts about the boom: that during the boom continuing homeowners purchased larger homes and renters increased their probability of transitioning to homeownership. This is because of the higher house prices. However, higher house prices were a feature of the housing boom, so lower interest rates need to be strong enough to be able to overcome that.

The expectations shock can replicate these two facts. However, the results with both the expectations and interest rate shock are also very reasonable. While the effect is slight, the percent of homeowners purchasing a new home and renters transitioning into homeownership is slightly higher when hit with both an expectations and an interest rate shock as opposed to solely with higher expectations. With solely the interest rate shock, no continuing homeowners purchase new home and no renters transition to homeownership, so the interest rate shock alone also cannot replicate the housing consumption results (that continuing homeowners purchase larger homes and first-time home buyers smaller houses). However, Figure 11 shows the results for the price expectations shock and the combined expectations/interest rate shock. The price expectations shock alone can recreate the housing consumption facts in the PSID for continuing homeowners and first-time buyers. The results from the combined shock show that lower interest rates increase the size of homes purchased by first time buyers relative to the expectations shock alone. However, they still purchase smaller homes relative to the pre-boom period. Lower interest rates also result in a higher percentage of continuing homeowners purchasing larger homes. This is because lower interest rates further lower the user cost, increasing demand for housing services among all households.

The model does not match the non-housing consumption results in the PSID. Non-housing consumption among renters decreases as renters substitute away from non-durable consumption to fund the purchase of a now more expensive home. Homeowners on the other hand do spend some of their increase in wealth from higher house prices on non-durable goods.

8 Conclusion

The housing boom that preceded the Great Recession was characterized by an increase in demand for housing services. This is consistent with a story about optimistic expectations for house prices 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 fall in interest rates cannot explain the results. The narrative of a credit supply shock has emphasized that first-time home buyers and other marginal borrowers played an outsized role in housing markets during the boom. My results contradict that narrative and emphasize the role played by unconstrained households.

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 to the financial crisis. The focus of policy should be on increasing the resilience of the financial sector to fluctuations in *any* asset prices, not just housing. While regulating mortgage markets is important, limiting access to mortgage credit not only reduces foreclosure, but also limits the ability of households to access the benefits of homeownership. Any policy should take both of these effects into account.

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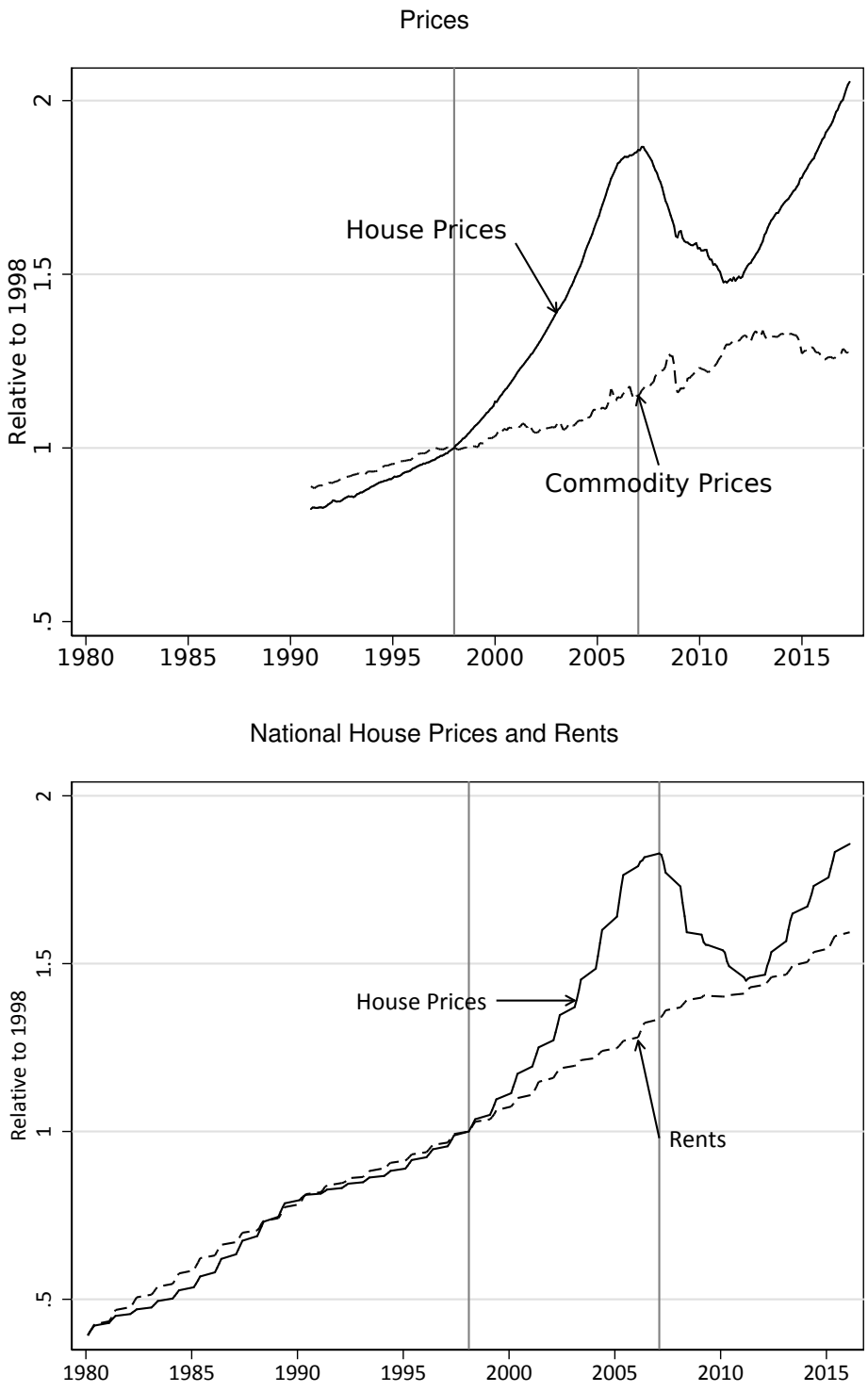

Figure 1. Characteristics of the Boom: *Note:* The two parallel lines mark beginning of 1998 and 2007 respectively. In the top panel, the prices for commodities are a component of the CPI-U series and the house price index is the national index from the FHFA. The rents and prices in the bottom panel were calculated by Davis, Lehnert, and Martin (2008) using data from the decennial censuses and indices on house prices and rents. *Source:* FHFA, BLS, and Davis, Lehnert, and Martin (2008).

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.

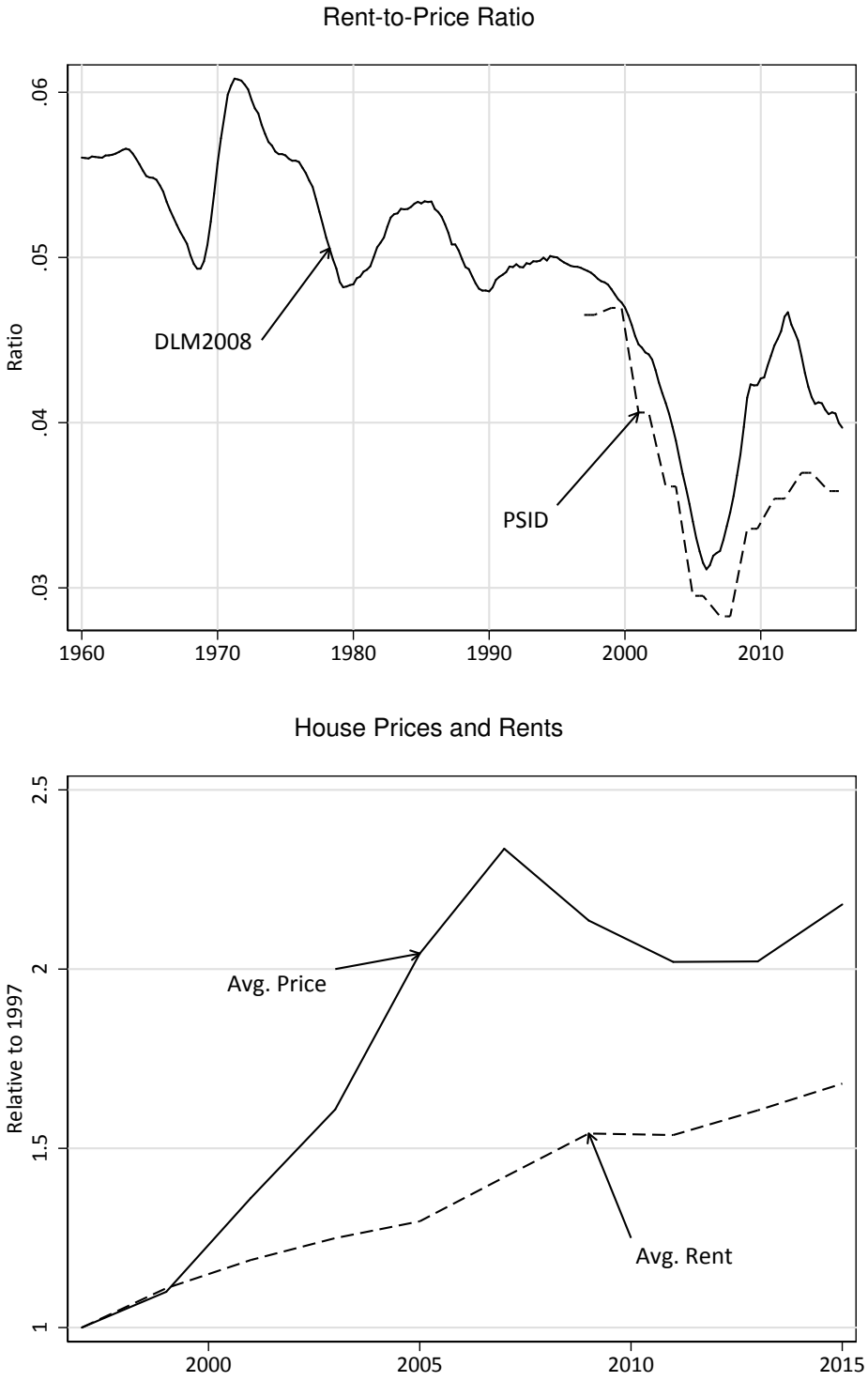

Figure 2. The Rent-Price Ratio in the PSID. *Note:* Data on rents and prices from the PSID are aggregated using PSID cross sectional weights, which become available in 1997. The rent-to-price ratio is calculated using the weighted mean of the annual expenditure on rent by renters over the weighted mean of house values reported by homeowners in the PSID. *Source:* PSID and Davis, Lehnert, and Martin (2008).

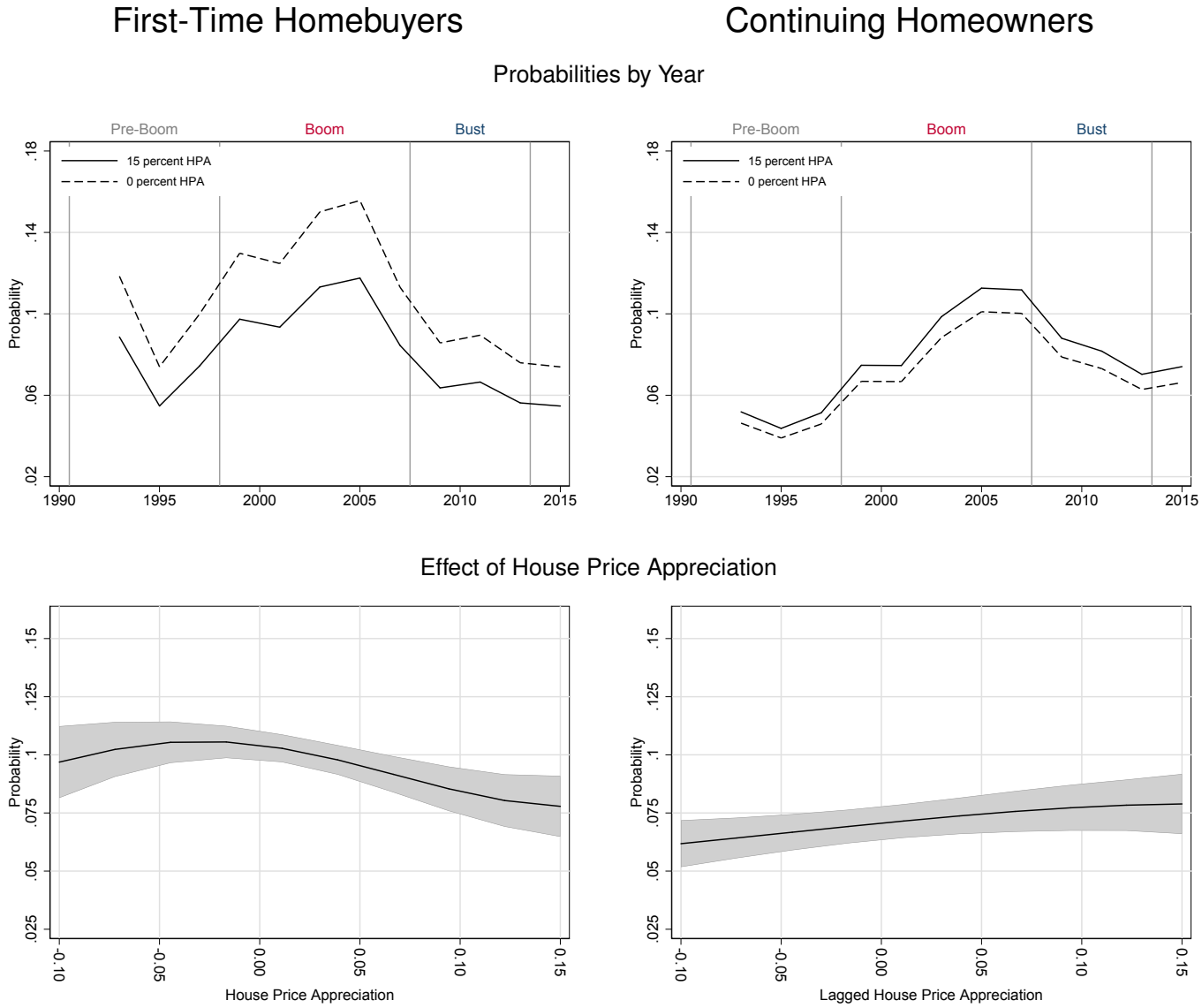

Figure 3. Effect of HPA on First Time Homeownership and Homeowners Purchasing New Home. *Note:* The probabilities for first-time home buyers are all estimated for a household whose head is 35 years old. The probabilities for continuing homeowners are all estimated for a household that purchased their 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 in $,000)	0.981***	0.338***
	(0.0537)	(0.0423)
Family Size	0.0803***	–0.00711
	(0.0147)	(0.0152)
Years of Education	–0.203***	–0.0702
	(0.0468)	(0.0506)
Years of Education × Years of Education	0.0115***	0.00492*
	(0.00184)	(0.00192)
Months Since Last Interview	0.0204*	0.00397
	(0.00931)	(0.00974)
Value of Previous Home ($,000)		–0.000402**
		(0.000135)
2000 Census Tract Median Home Value ($,000)	–0.00318***	
	(0.000318)	
Rooms in Previous Home	–0.00423	–0.0638***
	(0.0131)	(0.0114)
Δ ln(County Employment)	4.198***	3.393***
	(1.143)	(0.785)
Age		0.0521
		(0.129)
Age × Age / 100		–0.445
		(0.385)
Age × Age × Age /10,000		0.720
		(0.488)
Age × Age × Age × Age / 100,000		–0.0351
		(0.0223)
Year FEs	Yes	Yes
Chi-squared	8,884	17,162
Observations	22,428	40,738

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

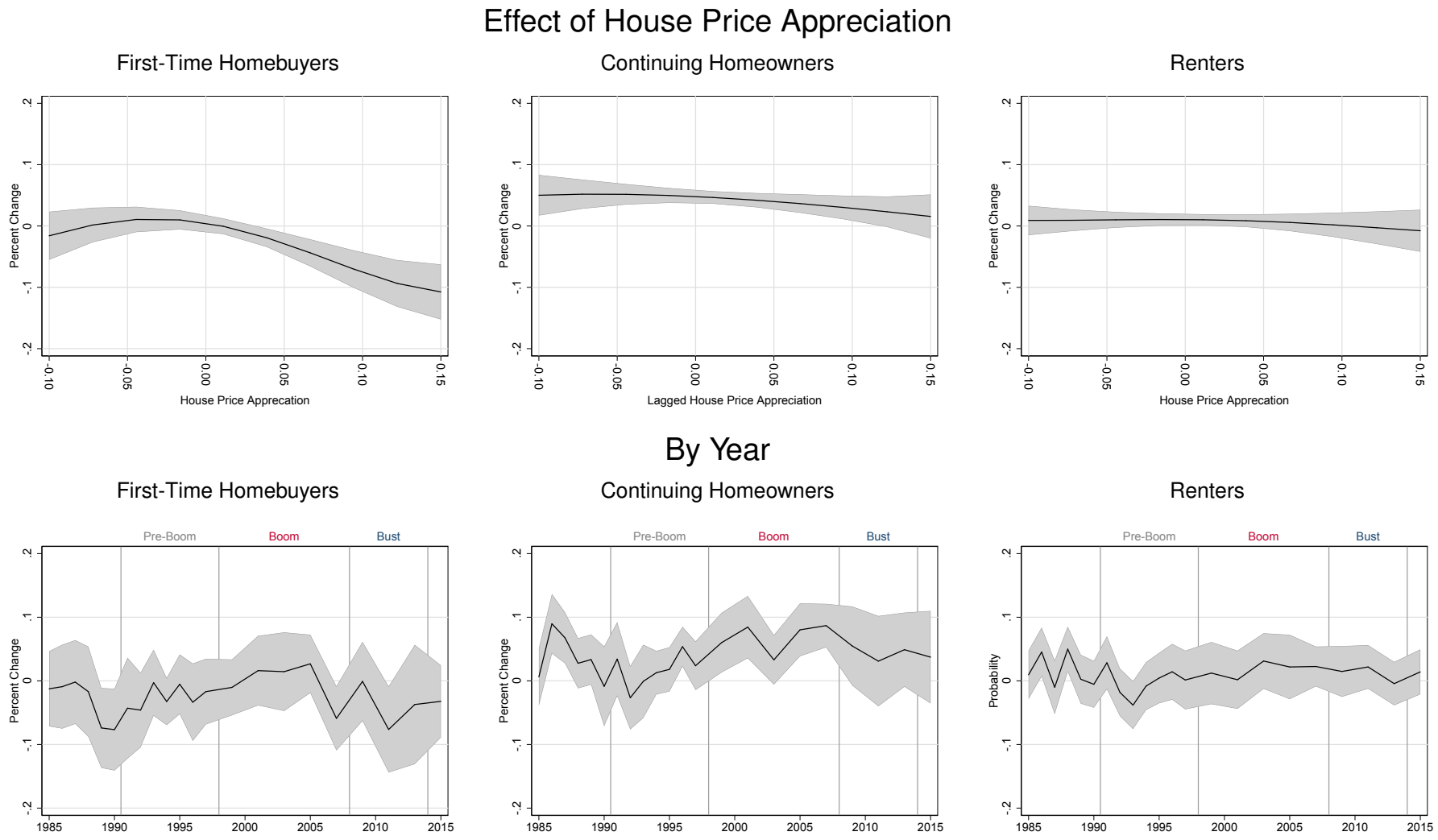

Figure 4. Percent Change in Census Tract House Value. *Note:* For first-time home buyers and renters, the house price appreciation is the concurrent annual house price appreciation. For continuing homeowners, it is the lagged house price appreciation. All are based on the location from which the households moved. *Source:* PSID, FHFA, decennial census, ACS.

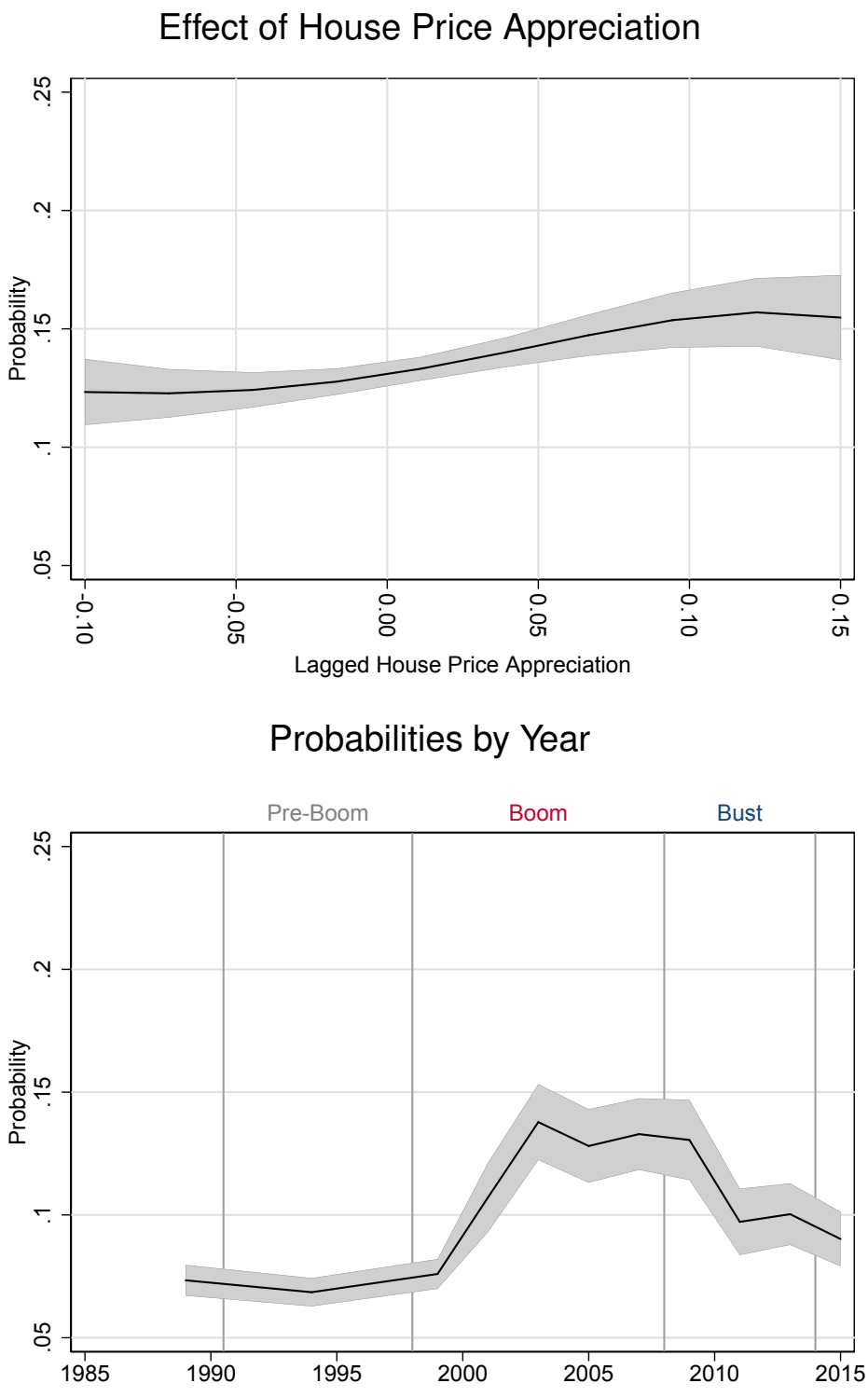

Figure 5. Investment in Current Primary Residence. *Note:* All probabilities are estimated from logistic regressions with the sample limited to homeowners. *Source:* PSID, FHFA, QCEW, Decennial Census.

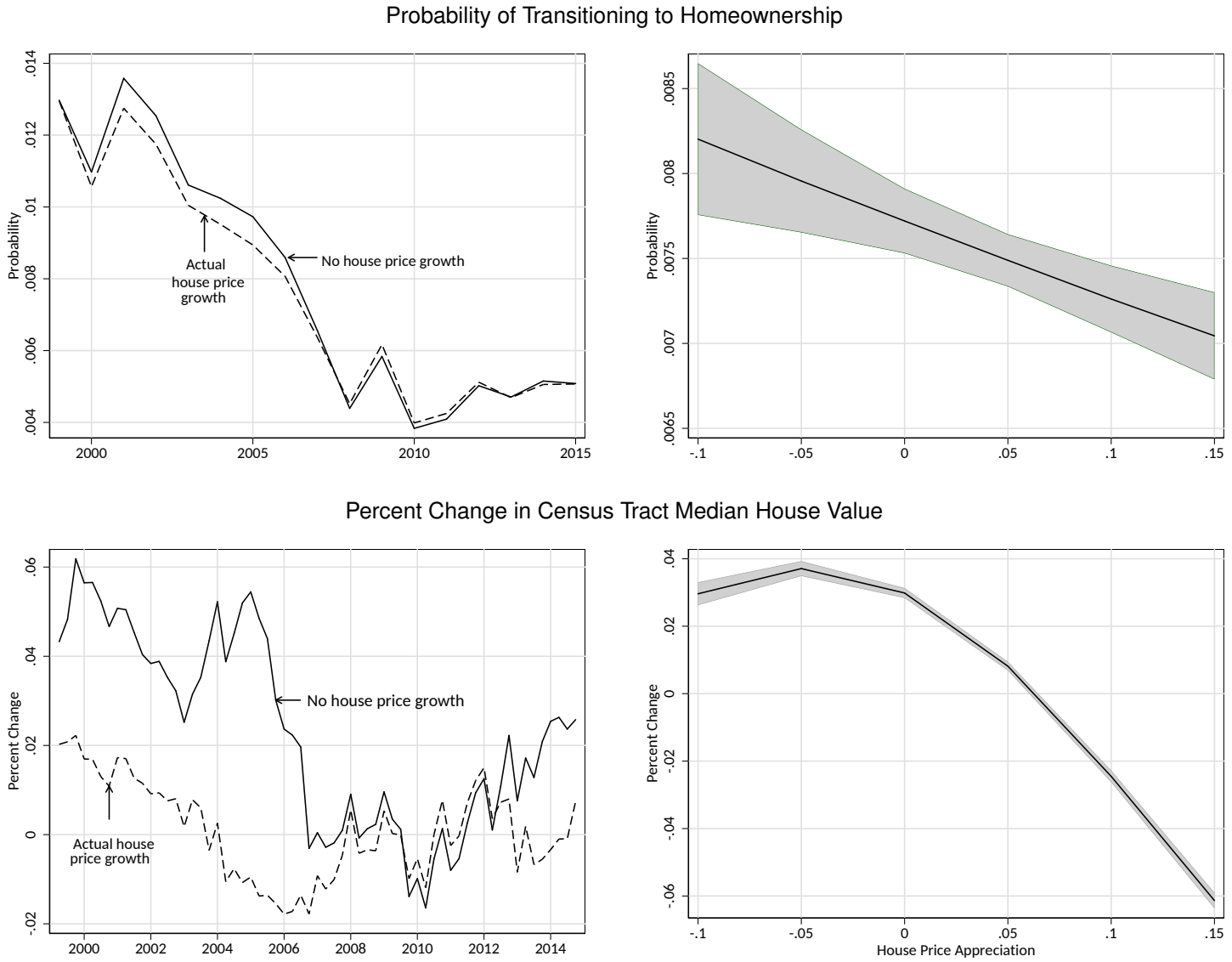

Figure 6. First-Time Homebuyers in the New York Consumer Credit Panel. *Note:* The top panel is the ratio of all people transitioning to homeownership for the first time in a given quarter to all the people at risk of transitioning the previous quarter. The bottom panel are the coefficients on the quarter dummies from a regression of the percent change in the census tract median house value of the census tract first-time homebuyers moved to relative to where they moved from. The regression also included age and the Equifax risk score. *Source:* New York Consumer Credit Panel.

	Households Moving			Homeowners
	FTHB	Homeowners	Renters	Additional Repairs
ln(Family Income in $,000)	0.00747	0.0136	–0.00284	0.643***
	(0.00710)	(0.00752)	(0.00437)	(0.0511)
Family Size	0.0109**	0.00690*	–0.00309	–0.00434
	(0.00391)	(0.00347)	(0.00246)	(0.0175)
Years of Education	0.00479	–0.00484	–0.00412	–0.0000913
	(0.0143)	(0.0108)	(0.00767)	(0.0698)
Years of Education × Years of Education	–0.000142	0.000130	0.000132	0.00186
	(0.000578)	(0.000425)	(0.000335)	(0.00258)
ln(Fiscal Wealth in $,000)				0.227***
				(0.0150)
Age	0.0740*	0.0498	–0.00771	–0.0971
	(0.0308)	(0.0339)	(0.0239)	(0.120)
Age × Age / 100	–0.210*	–0.122	0.0160	0.305
	(0.0869)	(0.0958)	(0.0688)	(0.312)
Age × Age × Age /1,000	0.0244*	0.0112	–0.00156	–0.0399
	(0.0101)	(0.0115)	(0.00829)	(0.0344)
Age × Age × Age × Age / 100,000	–0.00969e*	–0.00323	0.000688	0.0170
	(0.00408)	(0.00493)	(0.00355)	(0.0136)
Constant	–0.898*	–0.652	0.175	–4.260*
	(0.390)	(0.431)	(0.293)	(1.696)
Year FEs	Yes	Yes	Yes	Yes
R^2	0.016	0.021	0.002	
Chi-squared				1,623
Observations	4,337	5,833	13,830	24,318

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

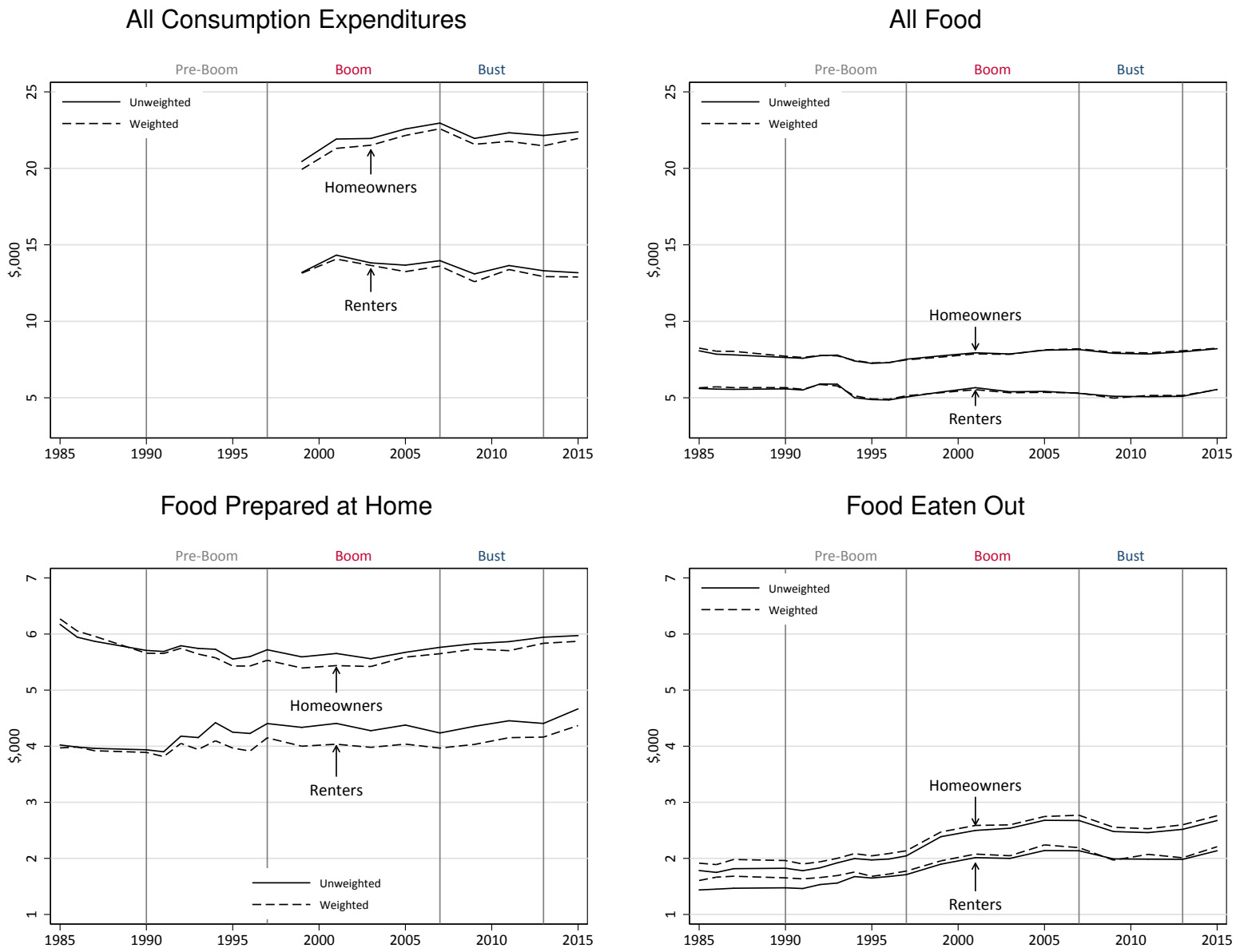

Figure 7. Average Expenditures By Type *Note:* No data on food expenditures is available in 1988 or 1989. "All food" includes food delivered, which is a separate category starting in 1994. In addition to food, "all consumption expenditures" include medical and dental expenditures, transportation including 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	0.00334*	0.000892*	0.000163	0.000785*
	(0.00167)	(0.000356)	(0.000173)	(0.000309)
ln(Family Income in $,000)	2.067***	0.507***	0.155**	0.290***
	(0.294)	(0.0693)	(0.0550)	(0.0305)
Family Size	1.556***	0.835***	0.911***	0.0118
	(0.165)	(0.0362)	(0.0282)	(0.0205)
Years of Education	–0.968	–0.428*	–0.348	–0.168
	(0.681)	(0.194)	(0.183)	(0.139)
Years of Education × Years of Education	0.0439	0.0182*	0.0131	0.00706
	(0.0280)	(0.00802)	(0.00703)	(0.00553)
Months Since Last Interview	0.0443	0.0228*	0.00170	0.0192**
	(0.0371)	(0.0106)	(0.00844)	(0.00640)
Δ ln(County Employment)	5.440	1.565	0.425	1.019**
	(3.399)	(0.842)	(0.724)	(0.378)
Age	–1.651	0.404*	0.354*	–0.213
	(1.643)	(0.188)	(0.146)	(0.127)
Age × Age / 10	0.913*	–0.0227	–0.0412	0.0905*
	(0.461)	(0.0513)	(0.0399)	(0.0353)
Age × Age × Age / 1,000	–1.48**	–0.0490	–0.000453	–0.128**
	(0.552)	(0.0604)	(0.0473)	(0.0422)
Age × Age × Age × Age / 100,000	0.753**	0.0411	0.0141	0.0588**
	(0.239)	(0.0260)	(0.0208)	(0.0183)
Constant	6.295	–5.102	–2.960	2.082
	(21.50)	(2.773)	(2.244)	(1.885)
Obs.	30,548	52,958	50,376	46,847
Adj. R^2	0.50	0.43	0.41	0.50
Year FEs	Yes	Yes	Yes	Yes
Household FEs	Yes	Yes	Yes	Yes

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): 0.15
	Elasticity of Substitution (η): 0.5
	Curvature parameter (σ): 1.5
	Discount rate (ρ): 3.5 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.

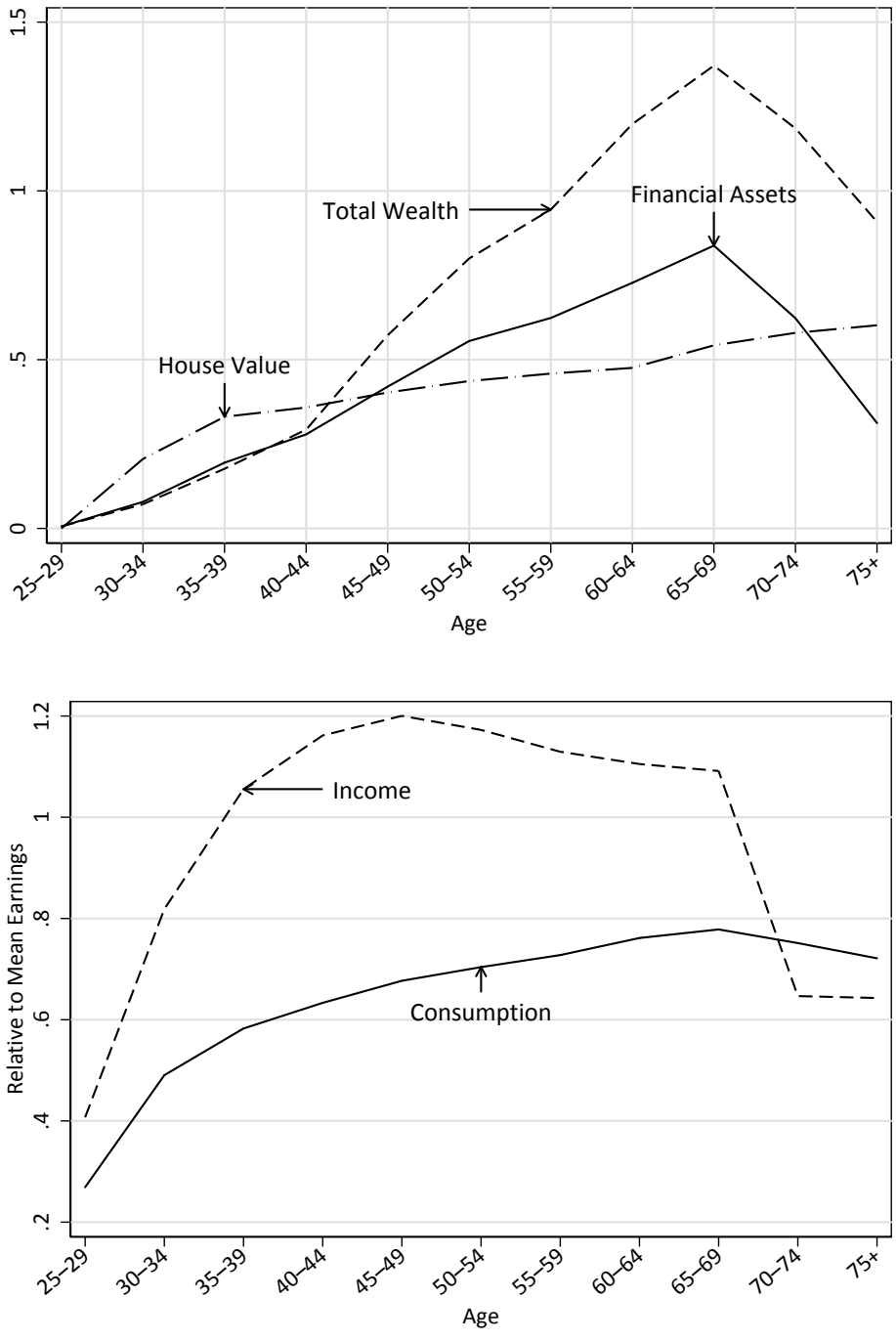

Figure 8. Life Cycle Profiles From Model *Note:* All variables are normalized by the mean earnings of the working aged population.

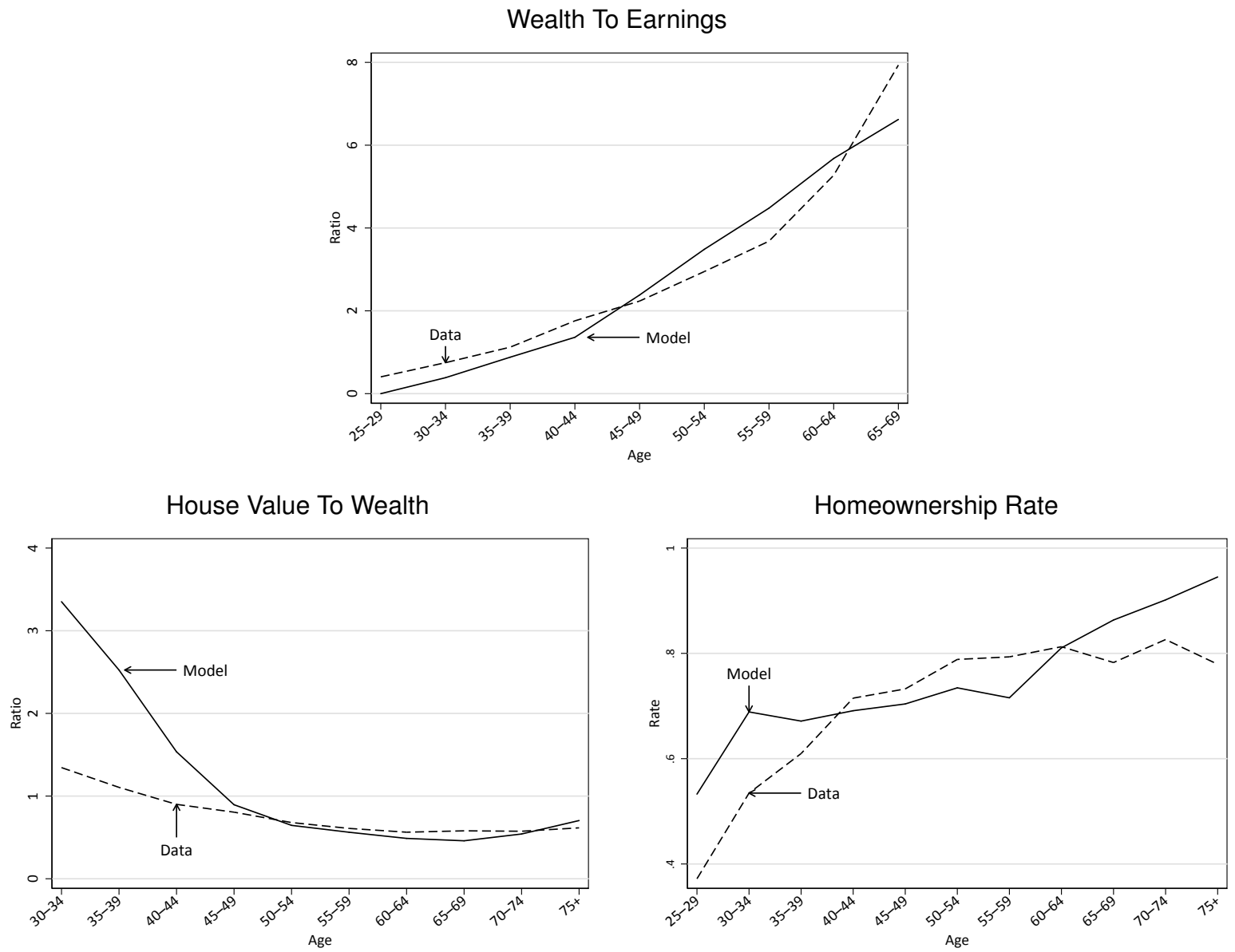

Figure 9. Model Calibration *Note:* The targets of the calibration were the median values of the wealth-to-earnings ratio and the house value-to-wealth ratio, and the mean homeownership rate, not the life cycle profiles. *Source:* SCF, author's calculations.

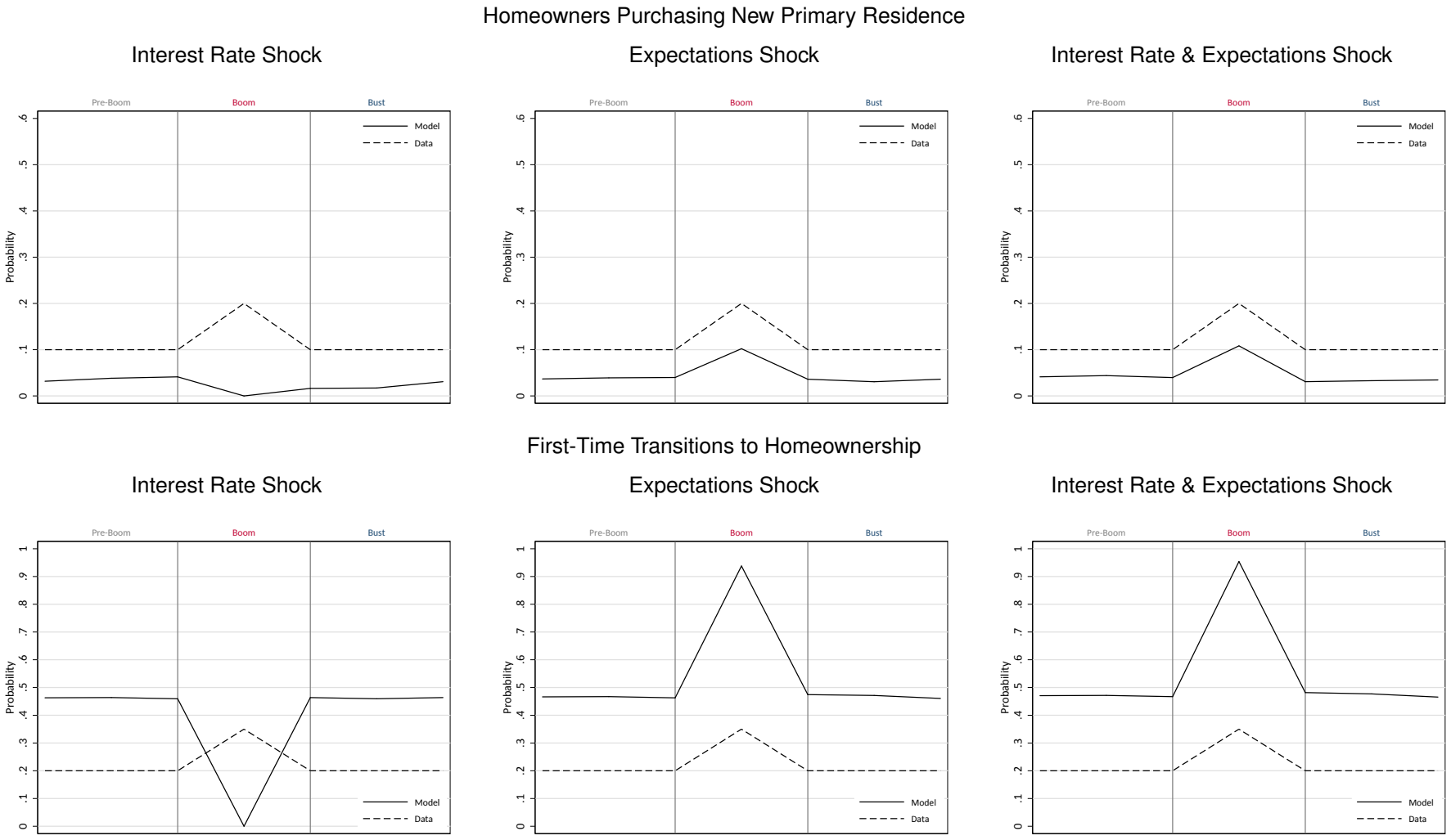

Figure 10. Model Results. *Note:* Plots for continuing homeowners are derived from a logistic regression of an indicator for having purchased a new home on time dummies. Probabilities for transitions to homeownership are calculated from estimates of a hazard model. The values from the data are implied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

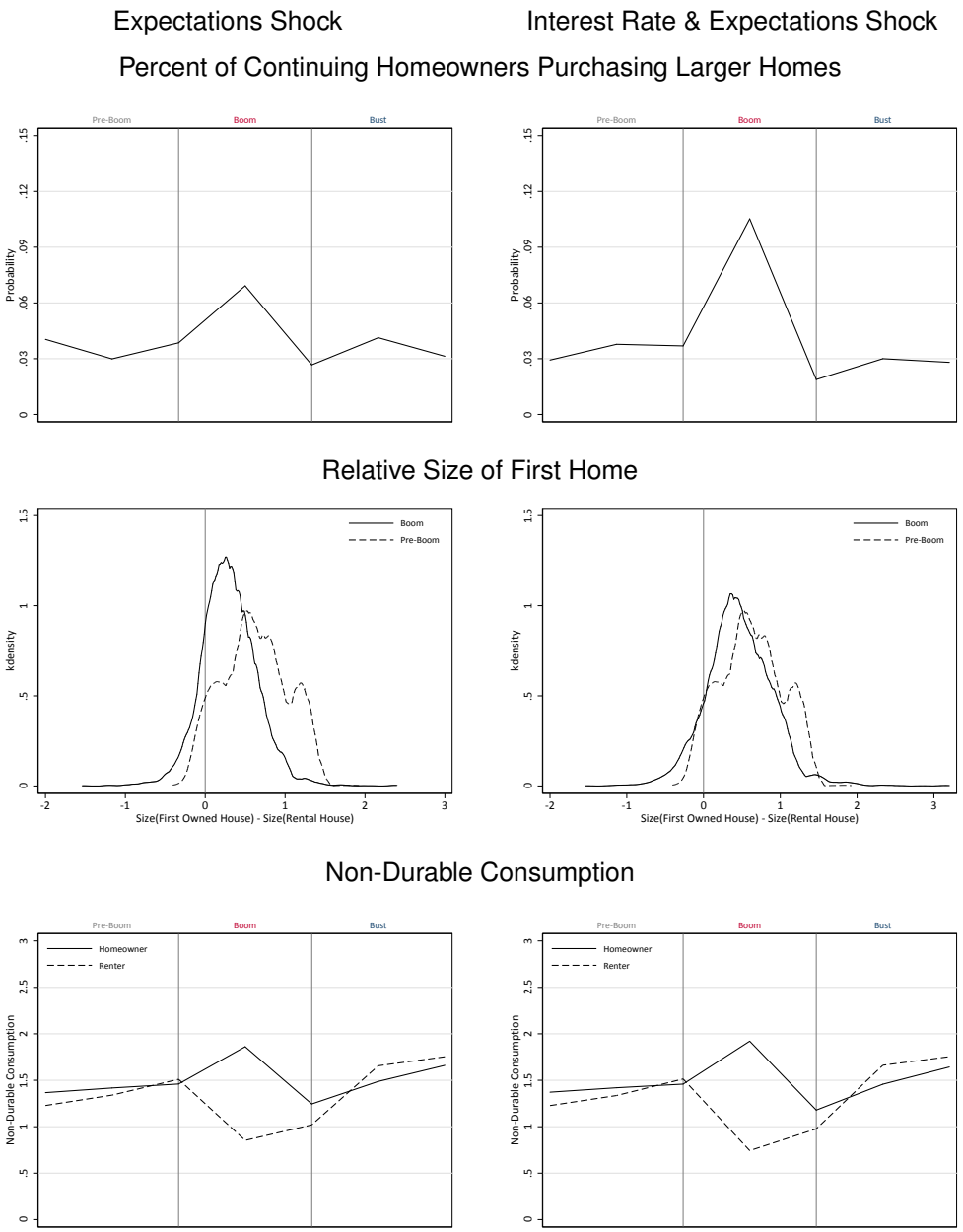

Figure 11. Model Results. *Note:* Values are from a logistic regression for continuing homeowners of an indicator of having purchased a larger home on time dummies. The paths for non-durable consumption are derived from a regression of consumption on time and household fixed effects.

A Identifying First-Time Home Buyers in the CCP

As mentioned in the main text, the CCP contains information on the age of each individual's oldest mortgage according to Equifax. This information allows me to back out the quarter in which an individual acquired their first mortgage. the CCP begins in 1999, and has information on mortgage originations. I identify first-time buyers as individuals whose first mortgage origination quarter according to the age of their oldest mortgages is within one quarter of the origination of a mortgage account in Equifax. This removes individuals who erroneously for whom the age of the first mortgage would imply that they became homeowners, but for whom there is no mortgage account originated in the CCP. To confirm that this is a reasonable identification, I compare the ratio of first-time home buyers in the CCP to all purchase mortgage originations in HMDA to the ratio of first-time home buyers in all home purchases according to the National Association of Realtors. The two shares are plotted in Figure 18.

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:

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

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:

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

The collateral constraint becomes:

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

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.

In Figures 19 and 20: A pass-through rate of 25 percent implies that the three house price states is given by $q = [1\ 2.26\ 7.59]$. Therefore, in the boom, house prices today increase from one to 2.26, the five-year rent-to-price ratio falls to 10.17 percent, and house prices are expected to increase 121 percent over five years (about 24 percent annually). Lastly, 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.

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.

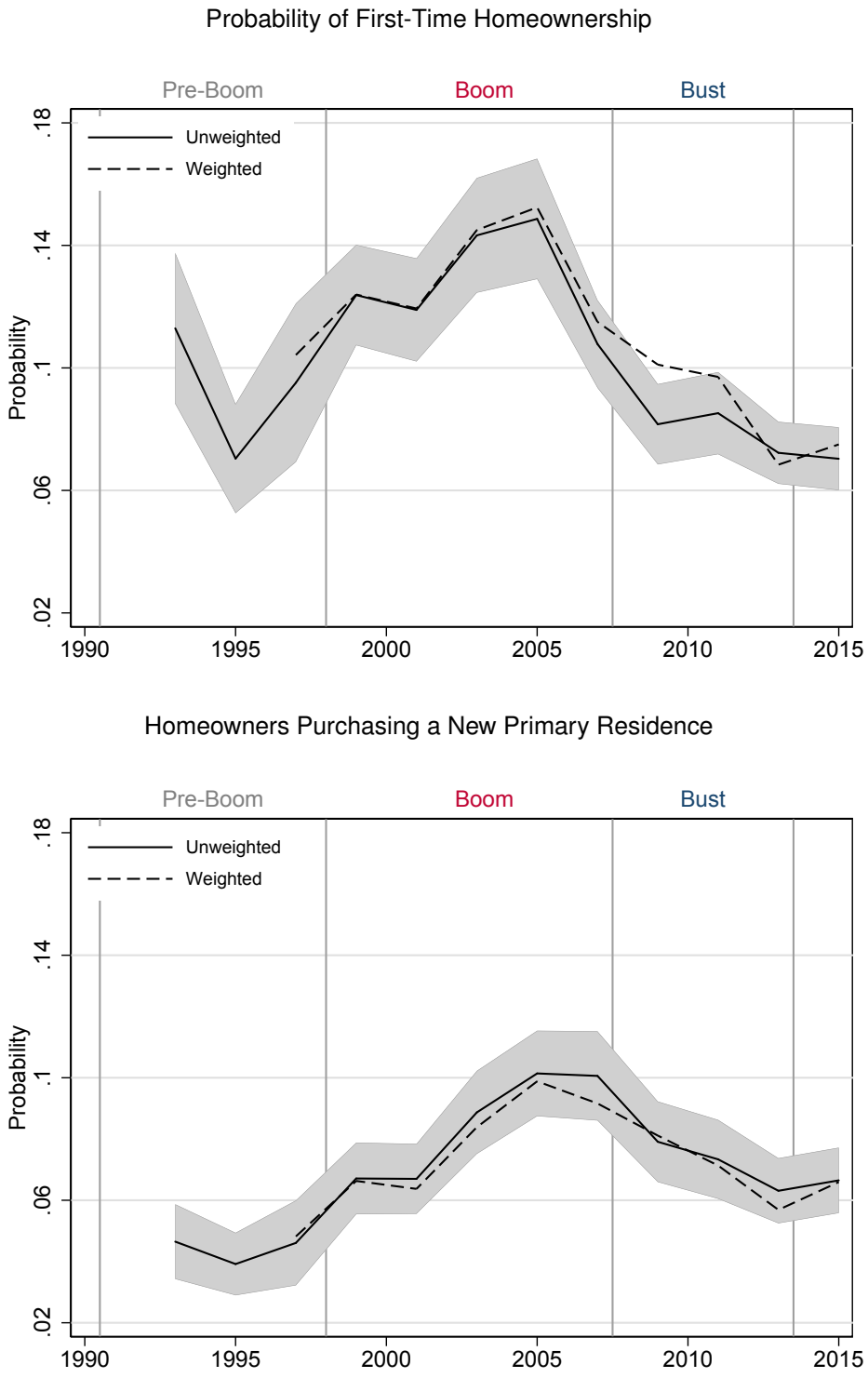

Figure 12. Probability of First-Time Homeownership or Purchasing a New Primary Residence. *Note:* Probabilities are calculated from the estimates of hazard model regressions with a baseline hazard, year fixed effects, and no individual controls. The probabilities of first-time homeownership are for a 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.

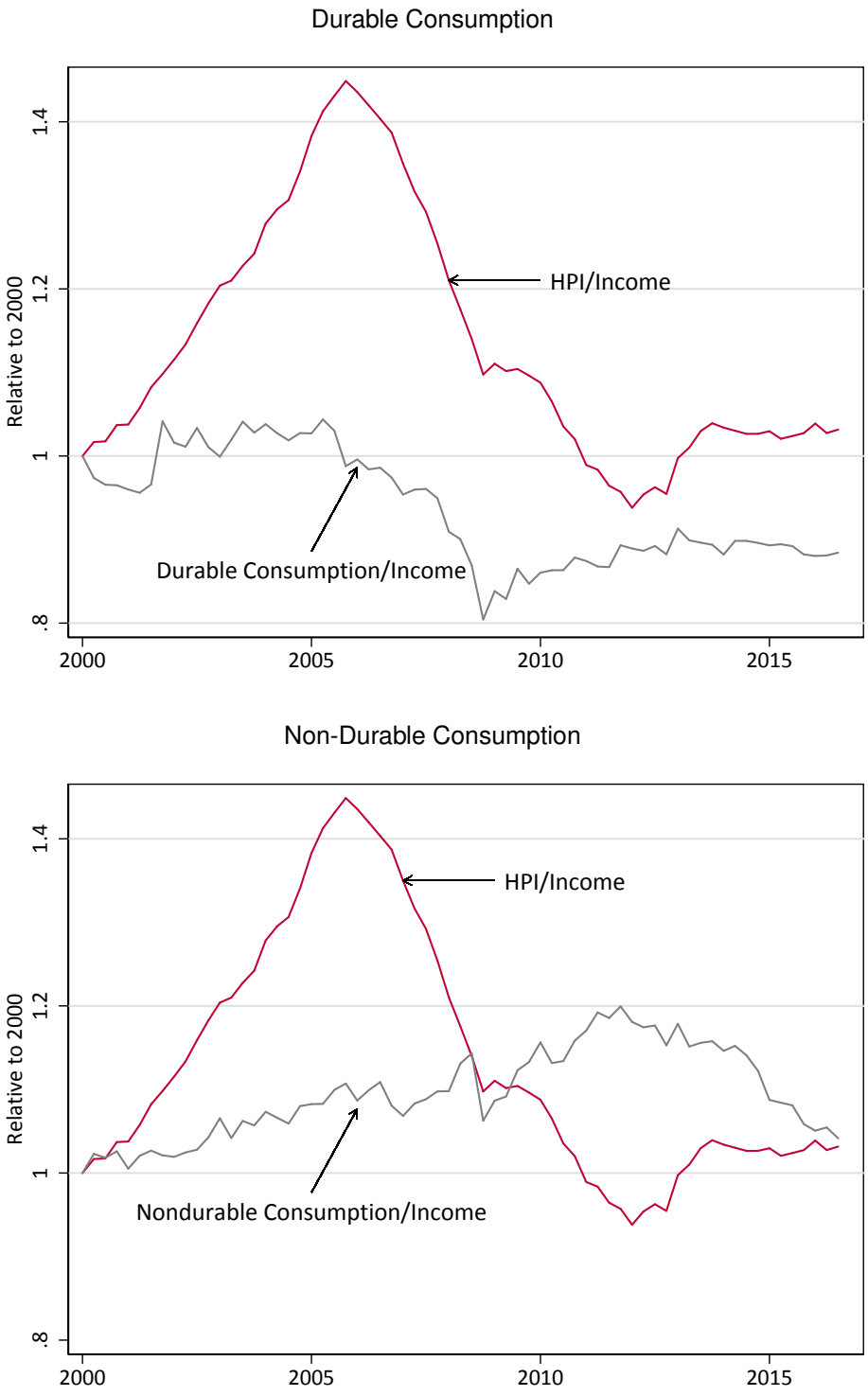

Figure 13. Consumption and HPI Relative to Income. *Note: Source:* Case-Shiller House Price Index, National Income and Product Accounts.

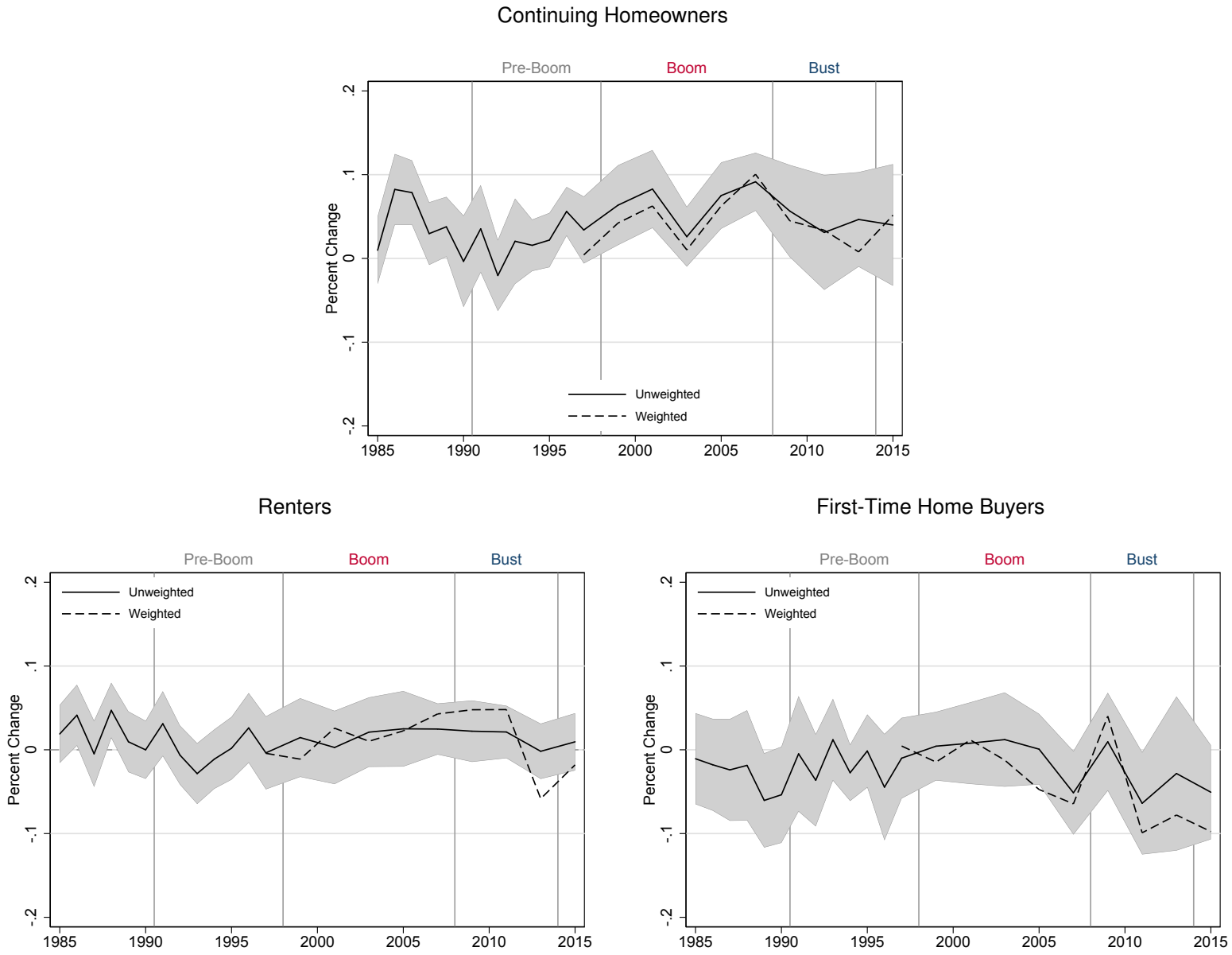

Figure 14. Percent change in census tract median house values by year. *Note:* From regressions of the log change in census tract median house values for continuing homeowners purchasing new homes, renters moving, and first-time home buyers respectively. *Source:* PSID.

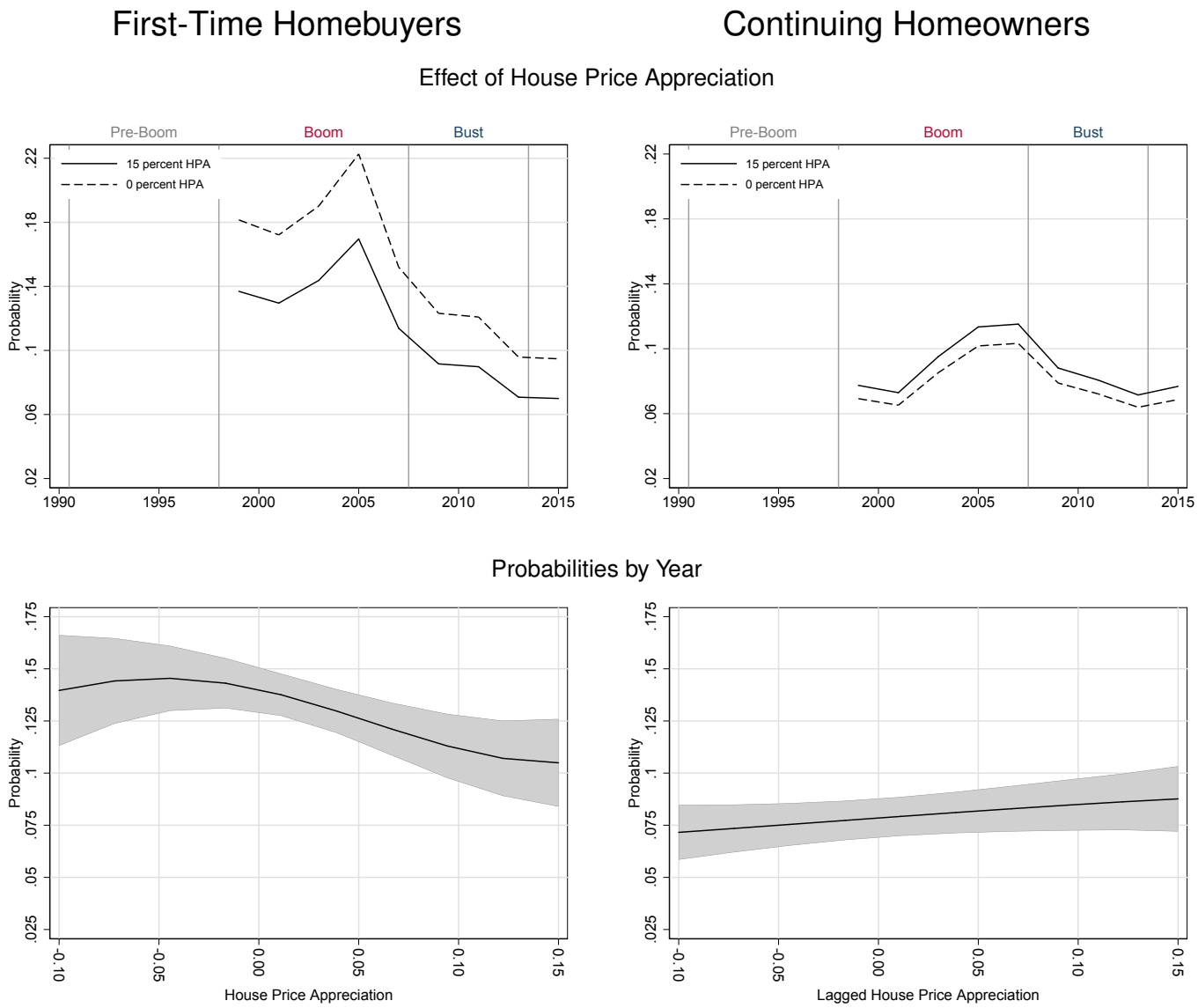

Figure 15. Effect of HPA on First Time Homeownership and Homeowners Purchasing New Home, Controlling for Fiscal Wealth. *Note:* The probabilities for first-time home buyers are all estimated for a household whose head is 35 years old. The probabilities for continuing homeowners are all estimated for 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. All regressions used to create these plots control for the fiscal wealth of households. *Source:* PSID, QCEW, FHFA, Decennial Census.

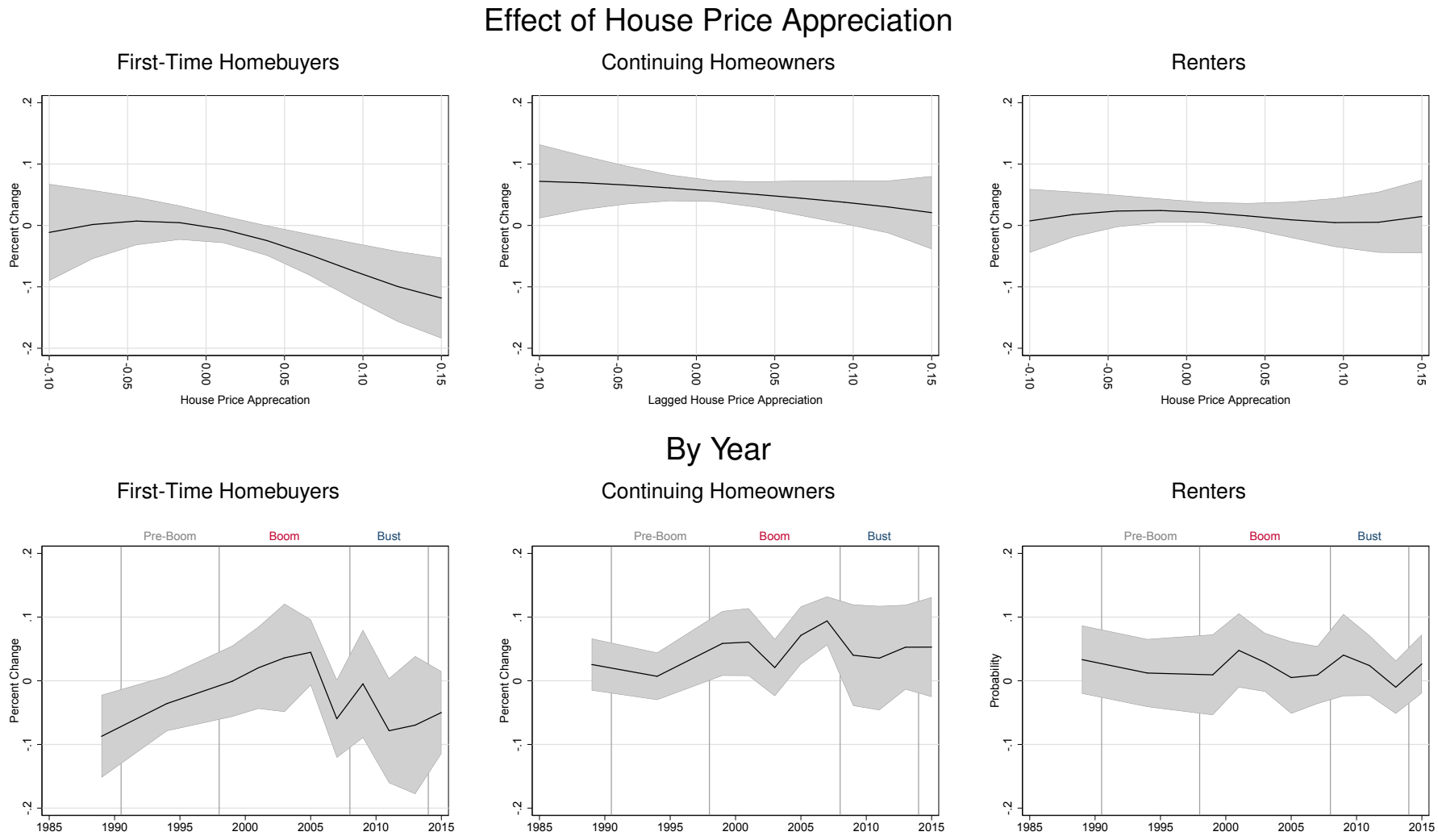

Figure 16. Percent Change in Census Tract House Value, Controlling for Fiscal Wealth. *Note:* For first-time home buyers and renters, the house price appreciation is the concurrent annual house price appreciation. For continuing homeowners, it is the lagged house price appreciation. All median home values are from the location from which the households moved. All regressions control for fiscal wealth. *Source:* PSID, QCEW, FHFA, decennial census, ACS.

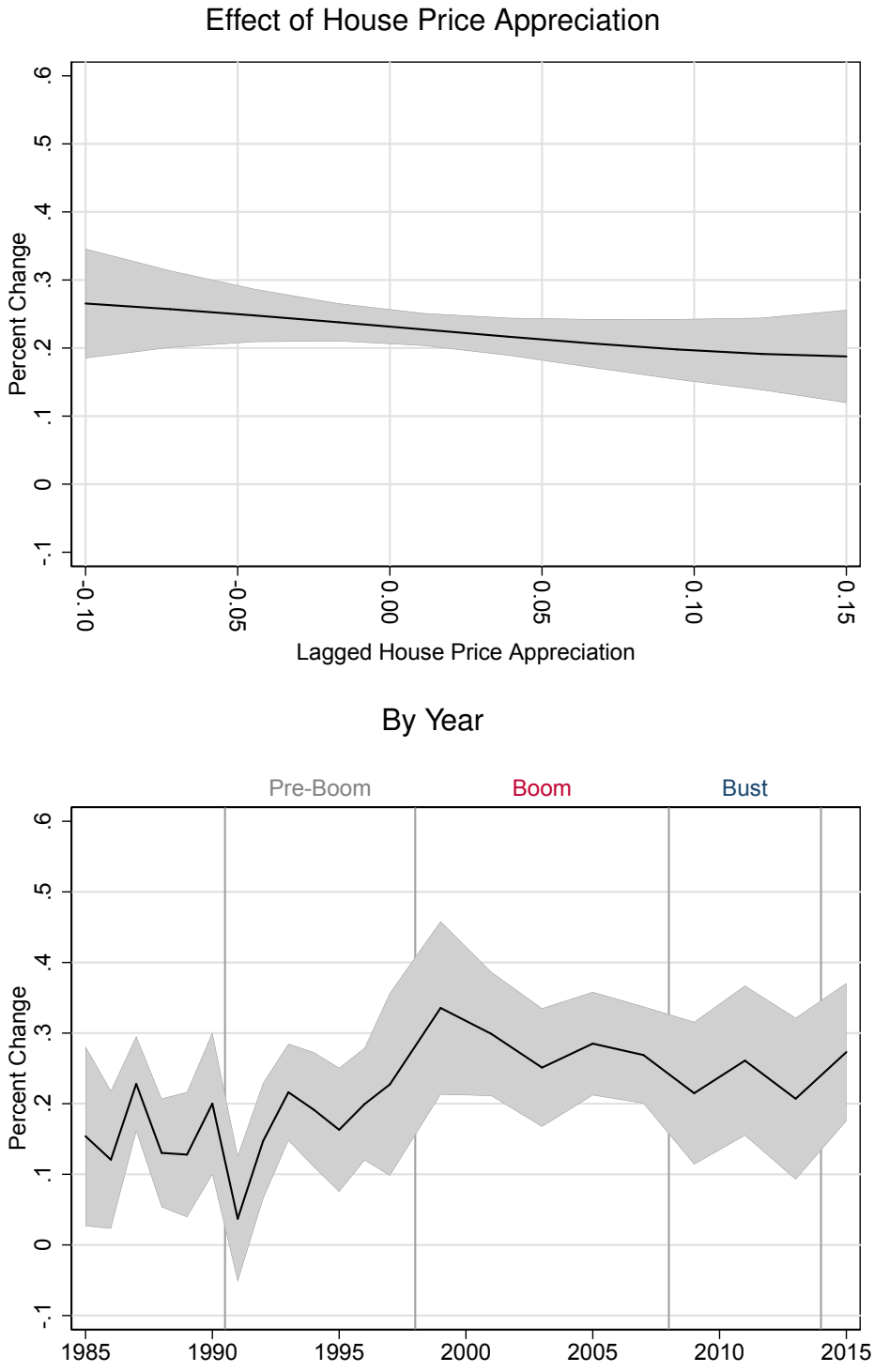

Figure 17. Percent Change in Self-Reported House Value for Continuing Homeowners. *Note:* These are plots of results with the percent change in median house value net of inflation on the left-hand side. Otherwise the regressions are the same conditional logits, with the same controls. *Source:* PSID, QCEW, FHFA, decennial census, ACS.

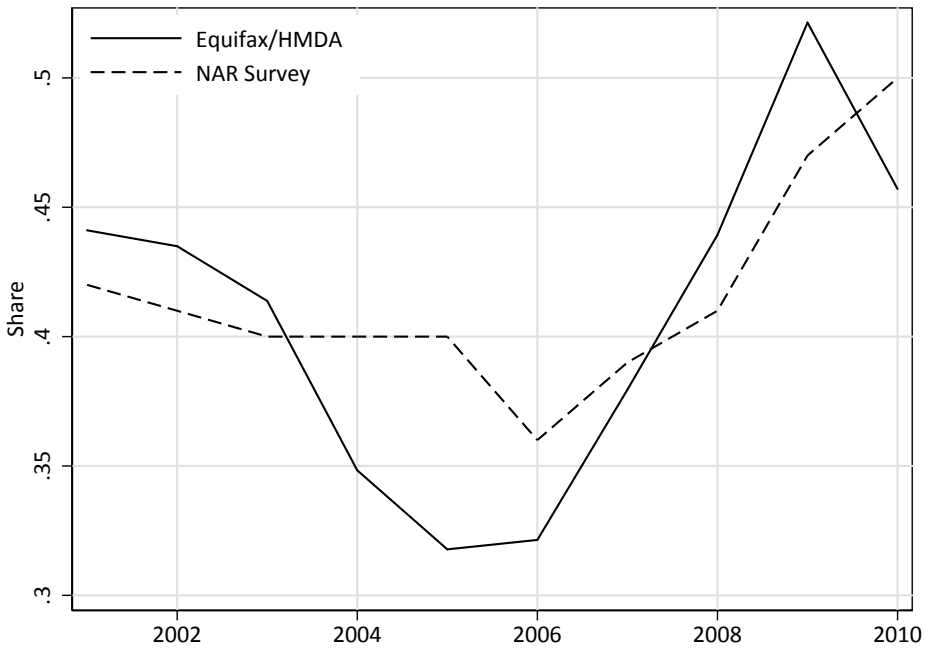

Figure 18. Comparison of First-Time Borrower Share using Equifax and HMDA Data with First-Time Homebuyer Share Reported in the National Association of Realtors Survey. *Note:* The black solid line is the number of first-time mortgage borrowers in Equifax divided by the number of owner-occupied purchase mortgage originations from HMDA. The blue line is the share of homebuyers who are first-time homebuyers according to the National Association of Realtors Annual Survey. *Source:* NY Fed Consumer Credit Panel/Equifax, Home Mortgage Disclosure Act, and the National Association of Realtors.

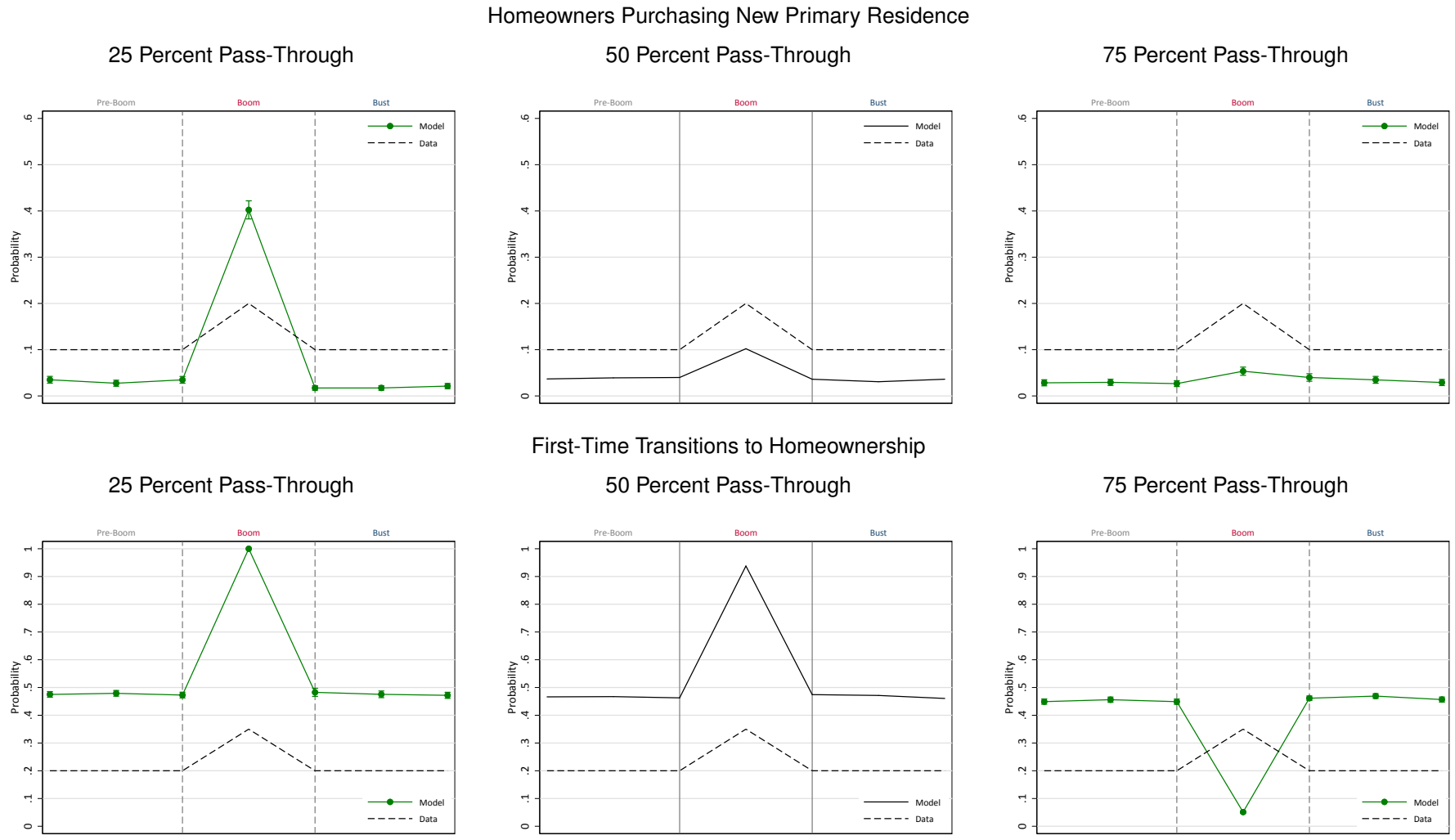

Figure 19. Model Results. *Note:* Plots for continuing homeowners are derived from a logistic regression of an indicator for having purchased a new home on time dummies. Probabilities for transitions to homeownership are calculated from estimates of a hazard model. The values from the data are implied five year probabilities based on results from the PSID.

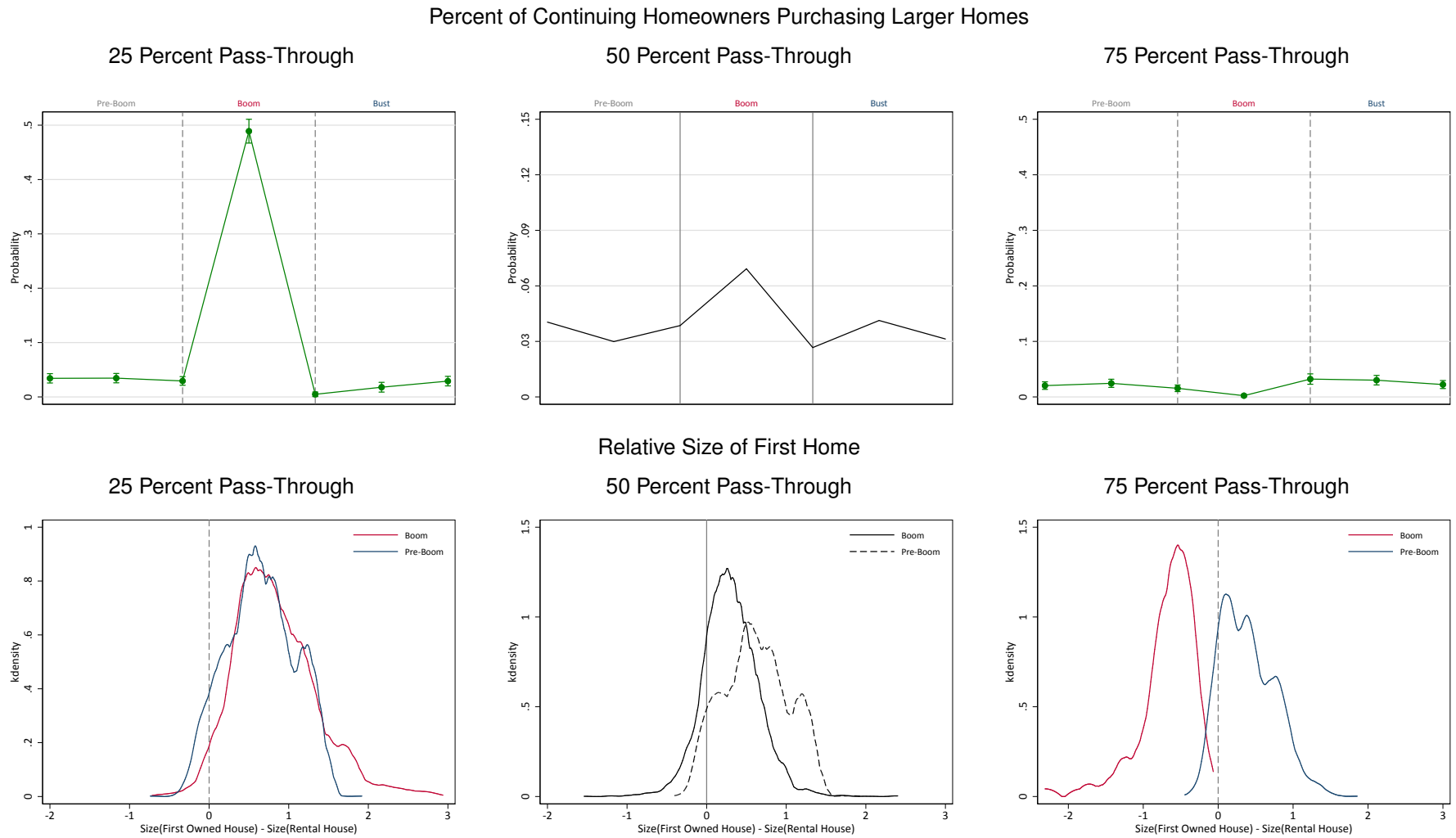

Figure 20. Model Results. *Note:* Values are from a logistic regression for continuing homeowners of an indicator of having purchased a larger home on time dummies.