Gauging the Influence of House-Price Expectations on Marginal Propensity to Consume Heterogeneity

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Abstract

This paper identifies a new determinant of household marginal propensities to consume (MPC): house-price growth expectations. We exploit a detailed and representative data set of Dutch households that allows us to link housing and savings decisions with house-price growth expectations and policy shocks. We document a positive empirical relationship between expected house-price growth and the propensity of households to move–both unconditionally and in response to monetary policy shocks. We explain this pattern using a structural life-cycle model of consumption and savings that features mortgage-financed owned- and rental-housing, and where households have subjective beliefs about future house prices. Due to the *housing capital gains channel*, households with higher expectations have a higher likelihood of moving. This leads to higher average and more dispersed MPCs, as housing is complementary to non-durable consumption. These results carry over to annual rebate coefficients (RC) from government stimulus transfers. Low-expectation households tend to have low RCs that are insensitive to stimulus size, while high-expectation households exhibit higher and more dispersed RCs that are decreasing in stimulus size.

Keywords: Marginal propensity to consume, housing, expectations, heterogeneous agent models, household finance and life-cycle, government stimulus policy.

JEL Classification: D15, D84, E10, E21, H31, R21.

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1 Introduction

The household's marginal propensity to consume, or MPC, plays a key role in the design of policies that aim to stabilize macroeconomic variables by working through household demand. As such, it is essential to understand the characteristics and determinants of this variable. In recent years, especially since the Great Financial Crisis, a large body of work has advanced this endeavor and robustly rejected the idea that aggregate household behavior can be accurately modeled by a representative permanent income consumer. Instead, an increased emphasis placed on the role of liquidity constraints in determining the consumption response, the detailed incorporation of heterogeneity into macroeconomic models, and their disciplining through strategies that exploit distributional moments of microeconomic data sets has produced estimates that reflect both a large magnitude and a high degree of heterogeneity in MPCs. Yet despite this heterogeneity, only about 25 percent of the variance of MPCs is explained by conventional observables (Lewis et al. (2019)). It is therefore important to further investigate the sources of this heterogeneity, as doing so would allow for a better design of stabilization policies and ideally, a better macroeconomic performance.

This paper adds to this project by focusing on heterogeneous expectations as a new explanatory variable of interest. In an environment where households have heterogeneous expectations regarding house prices, what is their effect on MPCs and on the propensity to adjust housing services? How does the heterogeneity in house-price expectations influence the shape of the distribution of MPCs? Are house-price expectations relevant for the effectiveness of stimulus policies? That is, do they matter beyond the conventional variables determining MPCs? We address these questions by exploiting a detailed and representative data set of Dutch households–i.e., the Dutch National Bank (DNB) Household Survey–that allows us to link households' housing choice to their reported house-price expectations. The data set is well-suited for addressing this research question as it contains a large list of variables relating not only to demographics and earnings but also to households' balance sheets. We find that (i) house-price expectations do indeed matter for household consumption decisions, both over the life-cycle and in response to policy shocks. (ii) Expectations influence the consumption of housing services and non-durable consumption even when controlling for a large set of demographic, economic, balance sheet, and aggregate variables. (iii) Policy makers would do well to take into account the whole distribution of expected house prices–as opposed to only the median/mean–since the relationship between expected house-price growth and household consumption is non-linear. (iv) This applies to both the consumption of housing services and non-durables.

We proceed in two steps. First, we document the empirical relationship between the house-price expectations that households report in the survey and their housing choices. The most

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relevant pattern in the data is that households with higher expectations exhibit a higher propensity to move (i.e., adjust their consumption level of housing services), as compared with low-expectation households. That is, households are more likely to move if they expect house prices to grow faster, whereas households that expect low house-price growth are relatively unlikely to adjust their level of housing. This pattern describes a non-linear relationship whereby the moving propensity of households expecting zero or negative growth is constant, but it is steeply increasing for households expecting positive growth. Further, household with high expected house-price growth are also more likely to switch houses *in response to expansionary monetary policy shocks* than other households.

Second, we combine the data with a structural life-cycle model of consumption and savings to explain the empirical relationship between the house-price expectations and to estimate the effects on non-durable consumption, which is not measured in the data. The model features mortgage-financed owned- and rental-housing, and subjective beliefs about future house prices. The model does a very good job of accounting for the data. Due to the *housing capital gains channel*, households with higher expectations have a higher likelihood of moving. This leads to higher average MPCs and more heterogeneous MPCs, as housing is complementary to non-durable consumption. These results carry over to the rebate coefficients, or RCs, from government stimulus transfers. An implication of this result is that policy makers should use expectations data to achieve a more accurate policy design, as the full distribution contains information beyond what is summarized by the mean or median.

Our quantitative results incorporate the key stylized facts of the empirical distribution of household expectations. (i) There is a high degree of heterogeneity in the responses of households. The range in reported expected house-price growth spans from -20 percent per annum to $+20$ percent per annum.[1] This statistic on its own shows the potential relevance of this dimension of heterogeneity, since analyses that adopt the full-information rational expectations framework do not account for the influence of idiosyncratic expectations on household behavior. (ii) There are broadly two groups of households: *attentive* and *inattentive*. Attentive households follow the housing market fairly closely, while inattentive households do not report expectations. (iii) The expectations of attentive households are "benchmarked" to realized house-price growth, and also have a fixed idiosyncratic component. The average expected house-price growth for attentive households follows the realized growth of house prices throughout the cycle but there is dispersion around it. Realized house-price growth accounts for about half of the variation in expectations data. The remaining half of the variation is due to a household fixed effect, accounting for around a quarter of the variation, and a residual term that is orthogonal to household characteristics and choices. Hence, house-price expectations can be statistically

[1] This statistic refers to the trimmed data set and so is not the result of outliers.

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decomposed into an aggregate benchmark, a time-invariant idiosyncratic component, and a time-varying idiosyncratic component.

In relation to housing choices, there is a positive empirical relationship between expected house-price growth and the propensity of households to move. Specifically, households in the bottom three quintiles of the expectations distribution exhibit a constant moving rate of about 2 percent, while this figure is around 3 percent for the third quintile and about 4 percent for the fifth quintile. The moving propensity of households with high house-price expectations responds differently to monetary policy shocks than for households with low house-price expectations. Households in the middle and top quintiles of the expectations distribution are more likely to switch housing in response to an expansionary monetary policy shock than households with low expected house-price growth. From a statistical point of view, expectations data is a significant and substantial predictor of house-adjustment behavior in itself and in response to monetary policy shocks. This result holds even when controlling for household demographic, economic, and balance sheet characteristics, as well as aggregate states.

With respect to MPCs, higher house-price expectations lead to greater heterogeneity in MPCs. This effect is the result of differences in house-adjustment rates between groups of households with different expectations. Higher expected house-price growth–through the *housing capital gains channel*–leads to an increased likelihood of moving. Positive expected capital gains provide an incentive to adjust the consumption of housing upward given a positive perceived wealth/endowment effect. By moving more often, these households are more likely to adjust their consumption level at the time of the move into larger housing. The following non-durable consumption pattern is locally steep, as liquid wealth is rebuilt and consumption returns to its pre-adjustment level. Similarly, households with high expectations have higher target levels of housing and non-durable consumption. For negative and low levels of expected house-price growth, house-adjustment is essentially flat at a level that is exogenous to the model. The reason is that these homeowners can limit the wealth effects of negative housing capital gains by not moving or by postponing a move. Hence, the empirical pattern found in the data of moving rates increasing with house-price expectations is explained by the household's optimal response to their *expected* housing capital gains. Heterogeneity in their expectations induces heterogeneity in their consumption choices.

To analyze the effect of household expectations on the effectiveness of stimulus policies, we model a government stimulus package based on the US CARES Act of March of 2020 and estimate the annual RCs for different expectation groups. The general pattern is analogous to that of the MPC estimates. Households that expect higher growth rates for house prices exhibit much more dispersion in the RCs associated with the stimulus. The average RC is also higher for households with high expected house-price growth. The average RC for the highest expectation group is roughly 30 percent. Additionally, the dispersion of RCs for this group is

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very large, with the 90^{th} percentile being around 80 percent. In contrast, households with low and negative expected house-price growth exhibit low RCs with low variance within the group. From the policy maker's perspective, a relevant takeaway is that house-price expectations may serve as an indicator of the effectiveness of direct payments as stimulus policies.

This carries over to the dispersion of RCs across different stimulus sizes. The implication of this analysis is therefore that government stimulus is most effective on households that hold high house-price expectations. Such households are prone to spending a high proportion of stimulus checks as they tend to be more frequently borrowing constrained. These households are also more likely to adjust their housing and in turn, spend more on non-durable consumption at the margin. However, high expectations households are also more sensitive to the size of the stimulus package; their RCs fall relatively steeply as the size of the stimulus checks increases. In contrast, low-expectations households tend to have low and insensitive RCs. Hence, the effectiveness of government stimulus is approximately constant for this group of households. An implication of the model is that the average RC of the economy is remarkably stable with regard to the size of the stimulus package. However, there is great heterogeneity between house-price expectations groups for a given stimulus package.

Our results are an important contribution to the literature for two principal reasons. First, the unique role played by housing in household consumption behavior. The importance of balance sheets when analyzing MPCs is well-established but housing has far less often been explicitly modeled, despite being the largest balance sheet item for most households. This stylized fact suggests an important role for housing in determining household consumption and savings. Furthermore, there are three characteristics of housing that make it an essential component of many models that explain empirical patterns of life-cycle household consumption. (i) Housing is a discrete asset. It cannot be bought in continuous amounts but is purchased in discrete quantities. (ii) Housing is an illiquid asset. The buying and selling of a house generates non-negligible transaction costs, such as the costs of searching and moving, taxes, lawyers' fees, etc. (iii) Housing generates a flow of non-financial benefits to the occupier. This is the utility they obtain from the benefit of having shelter and a private space.[2] These features of housing impose a discrete choice on households every period. As a result, models with housing are characterized by non-convex dynamic programming problems, stemming from the primary and secondary kinks that this structure induces. The resulting consumption functions display local concavity but also discontinuities as housing adjustments are accompanied by large shifts in non-durable consumption, since housing and consumption are complementary. The implications for the distribution of MPCs are non-trivial.

The second reason why our study is important is that we focus on the influence of arbitrary

[2]For a thorough review of this literature, see Piazzesi and Schneider (2016).

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subjective beliefs about house prices.[3] To the degree that house-price expectations play a role in the decision to adjust the level of housing, they are likely to play a non-trivial role in shaping the distribution of household MPCs as well. In this sense, it is fundamental that empirical analyses about this channel be disciplined by empirical measures of expectations.[4] Our use of the DNB Household Survey allows us to take empirical household expectations as given and to discipline our quantitative analysis with them in order to derive MPC estimates and policy implications while remaining agnostic about the expectation-formation process. This approach, beyond the theoretical implications obtained, should prove practically useful in the policy space where agencies routinely keep track of household survey expectations.

Literature This study is part of a large and growing literature about house-price expectations. Many papers have provided evidence of the causal link between house-price expectations and home-ownership decisions. Important studies focus on the effect of housing market investments (Bailey et al. (2017)), home sales (Bottan and Perez-Truglia (2020)), and housing search (Gargano et al. (2020)). Expectations about the risk and uncertainty of house prices have also been shown to affect home ownership (Adelino et al. (2018)) and housing investment decision (Ben-David et al. (2019)). Finally, housing expectation have been well-established as a determinant of mortgage choice; see Bailey et al. (2017), De Stefani (2021), and Kindermann et al. (2021), among others. For a thorough review of the literature, see Kuchler et al. (2022).

This study is also concerned with the effect of household house-price expectations on consumption and housing decisions. Hence, it is related to a number the areas of the literature. Papers on the marginal propensity to consume are many and include Yao et al. (2015), Carroll et al. (2017), and Gross et al. (2020), among many others. Two seminal papers that established reference measurements on the level of MPCs are Johnson et al. (2006) and Parker et al. (2013). Using a quasi-experimental methodology, they documented annual MPCs in the order of $0.1-0.4$; in contrast to the MPCs of an order lower implied the permanent-income household models of the previous generation, such as Carroll (1997) and Ríos-Rull (1995). Kaplan and Violante (2014) provided the structural analysis to rationalize this observation and developed the precise mechanism behind these measures, finding that the presence of poor and wealthy hand-to-mouth households is key. More recently, Kaplan and Violante (2022) analyze the impact of different modeling features and calibration strategies on the distribution of MPCs in models of heterogeneous agents with incomplete markets. Importantly, they document that achieving an empirically plausible level and distribution of MPCs requires the presence of at least two assets in the model. In a similar vein, Carroll et al. (2021) study the interaction of precautionary saving and liquidity constraints in shaping the consumption function and con-

[3] Throughout we use beliefs and expectations almost interchangeably.
[4] See Brunnermeier et al. (2021) for a discussion

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sequently, the MPC of households. Regarding heterogeneity, a relevant paper is Lewis et al. (2019). They provide a measure of the degree to which the full distribution of MPCs remains unexplained. Specifically, they employ a clustering regression methodology to recover the full distribution of MPCs and find that they are only able to account for around 25 percent of the observed heterogeneity using conventional observables, such as income, balance sheets, and demographic characteristics.

Life-cycle models of household consumption, savings, and portfolios are relevant given that we aim to provide reliable estimates; this is why we work within this class of models; see Fernandez-Villaverde and Krueger (2011), Gourinchas and Parker (2002), Carroll (1997). Housing choice and monetary policy shocks is a relationship that we will explore in establishing our results. Papers in this area that are close to this one are Wong (2018), Berger et al. (2015), Berger and Vavra (2015). The area of house-price expectations and housing choice is key to our analysis, and related to Adelino et al. (2018), Armona et al. (2019), Kaplan et al. (2020), Favilukis et al. (2017), Guren et al. (2021), and Kuchler et al. (2022), among others. Since we deal with heterogeneity in expectations, papers such as Coibion et al. (2019), Vellekoop and Wiederholt (2017), Case and Shiller (2003), Liu and Palmer (2021), and Roth et al. (2021), that depart from the full information rational expectations assumption are also related. Finally, we also make use of solution methods for non-convex dynamic programming problems, such as in Iskhakov et al. (2017).

The rest of the paper is structured as follows. Section 2 describes the survey data on household house-price expectations. Section 3 analyzes the empirical relationship between household expectations and house-adjustment behavior, both unconditionally and in response to expansionary monetary policy shocks. Section 4 presents the structural model, describes the calibration strategy, and provides estimates for household MPCs. This section also presents an experiment modeling household RCs as a function of government stimulus policies. Finally, Section 5 concludes.

2 Household Expectations Data

In this section we present the data on house-price expectations and describe their main statistical characteristics. Our choice of data is in part motivated by the ideas laid out in Piazzesi and Schneider (2016) and Brunnermeier et al. (2021). These discussions pertain to the importance for studies that analyze economic behavior in contexts where available information would reject the full-information and rational expectations assumption. One proposition is to use data on expectations without positing an explicit data generating process, but as an input for structural models. *"Recent years have witnessed a massive effort to collect expectational data. [...]*

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These data allow researchers to study the joint distribution of expectations, characteristics, and choices. [...] Will we be able to explain all the cross-sectional variation in household expectations? The answer to this question will likely be no. [...] A more humble approach, which is still very interesting, is to admit that we do not know how households get to their expectations. [...] These approaches may help us to make progress in our understanding of volume in asset [and housing] markets, [as well as household choices more broadly]" (Brunnermeier et al. (2021)). We heed this suggestion by taking the data on expectations as given and remaining agnostic regarding the expectation-formation process driving households' responses. Following this approach, we describe the main features of idiosyncratic household expectations.

The data set we employ is the panel survey from the DNB Household Survey, conducted annually since 1993. The survey is representative for the Dutch population. Households participate for several years, with the housing questionnaire introduced in 2003. However, the questions on households' expectations regarding house-price growth were not included in year 2006, and only added for renting households since 2010. Nevertheless, the survey offers a large and representative panel data set for a period that covers the mature period of the early 2000s housing boom and the following bust and recovery. In addition to questions about households' expectations regarding the national house-price growth, the survey registers several household variables that are useful to our study. These include income level, a variety of financial balance sheet items, house holdings, mortgages, and several demographic characteristics. Unfortunately, consumption is not a variable that is measured in the survey.[5]

The full path of house prices expected by a household can be represented by exploiting five key characteristics of the data. (i) The distribution of expected house-price growth exhibits a high degree of dispersion; that is, there is a lot of heterogeneity in households' reported expectations. (ii) The cross-sectional distribution of expectations is roughly centered around the realized value of real house-price growth, and deviations from the benchmark are best represented as household fixed effects. That is, the level household expectations for *future* house prices is explained by the *current* house-price growth and idiosyncratic components that are stable over time. (iii) The long-term household expectations of house-prices are more stable and less dispersed than short-run expectations, and they are bench-marked to their median of 2 percent per annum (iv) Long-term house-price expectations are relatively insensitive to movements in short-term house prices. (v) Short-term expectations are correlated with households' propensity to move and with the size of adjustment in housing value, conditional on moving. Below we present each of these features in detail.

[5]See Appendix A for a detailed description of the data and its sources.

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Heterogeneity in Short-Term Expectations In this section, we focus on the short-term expectations of aggregate house-price growth. In the survey, households are asked a general question about the change they expect for house prices in the short term. The specific form of the question is shown below, with bold letters preserved from the original.

DNB Household Panel Survey Questions on House-Price Expectations:[6]

Question 1:

> What kind of price movement do you expect on the housing market **in the next two years**? Will the housing prices increase, decrease or remain about the same?
>
> 1 the housing prices will increase.....
>
> 2 the housing prices will remain about the same.....
>
> 3 the housing prices will decrease.....
>
> -9 don't know.....

Question 2:

> How much percentage points a year will they increase/decrease on average?
>
> percentage.....
>
> -9 don't know.....

Households report their expectations for the average house-price growth of a two-year horizon. We will assume throughout that the average reported is representative of their one-year-ahead forecasts. Additionally, we assume that households' repossesses refer to the real growth rate; this follows from the fact that the real interpretation is more consistent with the survey responses once expectations regarding general consumer prices are accounted for. Figure 1 shows two overlapping histograms for national house price expectations. The histograms are for years when national house prices are increasing–i.e., 2003-2008 and 2014-2018, labeled the *boom* period–and for years when they are decreasing–i.e., the *bust* period, 2009-2013–; they are shown in gray and in white, respectively.[7] Notable from this figure are the range of reported expectations (spanning from ± 20 percent per annum), and the distinct wedge between the main mass of observations between the boom and the bust periods; respective averages are 1.7% and -1.3%. The latter feature implies fluctuating expectations over the period of study, while the former reveals a high degree of heterogeneity in households' expectations. Additionally, both periods present a substantial mass of observations at zero.

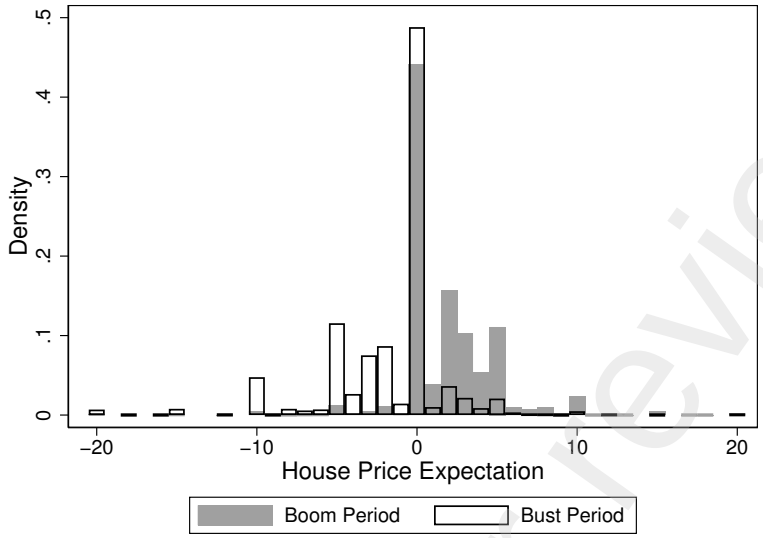
[6] The reported questions are from the Codebook for 2012 in english; the questions for other years are essentially the same.

[7] The distribution of expectations is trimmed by dropping the top and bottom 2.5% observations to eliminate extreme outliers.

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Figure 1: House Price Expectations Boom-and-Bust



Note: The bust period is defined as the years in which house-prices experienced negative growth; that is 2009 to 2013. The period outside those years is defined as the boom period. House price expectations are measured in percent.

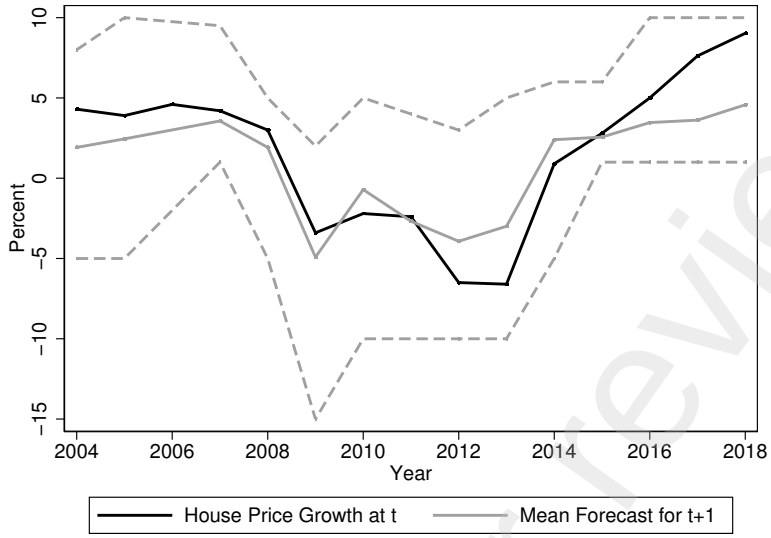
The large mass at zero reflects the fact that many households seem not to report well-defined expectations. Indeed, many of the reported zeros in the survey are in fact non-responses. The proportion of year-households that report a valid answer to the question of expected house-price growth is 0.654; this is a figure significantly higher than that of most other surveys on the expectations of house prices. The proportion of year-households that fail to respond is 0.291 and the proportion reporting an answer of "Don't know" is 0.055. We can therefore distinguish between year-households that hold precise and specific expectations about house prices–we will refer to these households as *attentive*–and those that prefer to remain somewhat aloof of the national housing market–i.e., *inattentive* households. Further, we will find it useful to refer to households that *always* report invalid responses as being *strictly inattentive*.

Benchmark to Realized House-Price Growth Figure 2 shows how the expectations of attentive households relate to actual national real house-price changes. The average expectation of *future* house price growth closely follows the *current* realized house-price growth rate. Note that the series for realized house-price growth is taken from the ECB's *Statistical Data Warehouse* and not contained in the household survey. Further, there is a wide range of forecasts, and realized house-price growth is within the 90 percent error band of expectations. This raises the natural question of weather or not households with different expectations behave differently with regard to their housing decisions. We explore this issue in detail in the next section.

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Figure 2: House Price Expectations and House-Prices



Note: Mean house-price expectation computed by omitting observations reporting zero growth. Error bands shown for 5% and 95%.

Next, we characterize the key longitudinal features of households' expectations. Table 1 presents a statistical model that decomposes house-price expectation for attentive households into an aggregate component, a time-invariant idiosyncratic component, and a time-varying random idiosyncratic component.[8]

The general form of this regression equation is:

$$E_{h,t}(\pi^H_{t+1}) = \alpha_0 + \alpha_h + \beta_0 \pi^H_t + \beta_1 E_{h,t-1}(\pi^H_t) + e_{h,t}$$

where $E_{h,t}(\pi^H_{t+1})$ denotes household h's expected house-price growth rate, α_h is the time-invariant idiosyncratic component, β_0 measures the aggregate component linked to realized house-price growth, π^H_t, and $e_{h,t}$ is the time-varying idiosyncratic component. A common constant term, α_0 and the first lag for expectations, $E_{h,t-1}(\pi^H_t)$ are included for completeness. Since we are interested in attentive expectations, we focus exclusively on households that participate for at least four consecutive surveys; all regressions are ordinary least squares with robust standard errors.[9] The expectations sample is trimmed by dropping the top and bottom one percent of observations to exclude extreme values. All growth rates are in percent.

[8]Random in that it is uncorrelated to observed household characteristics and to its own lag.

[9]The results below continue to hold if we implement the cutoff at five or six consecutive surveys as well.

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Table 1: House-Price Expectations, $E_t(\pi^H_{t+1})$

	(1)	(2)	(3)	(4)	(5)
Constant	-0.1110				
	(0.0717)				
House-Price Growth, π^H_t	0.5350***	0.5268***	0.3886***	0.5042***	0.4947***
	(0.0111)	(0.0082)	(0.0139)	(0.0193)	(0.0155)
$E_{t-1}(\pi^H_t)$			0.2910***	-0.0233	
			(0.0233)	(0.0303)	
Household Fixed Effects	No	No	No	Yes	Yes
Observations	3076	3076	3076	3076	3076
R^2	0.4697	0.5161	0.5608	0.7713	0.7712

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

In Table 1, regression (1) shows that on average the distribution of attentive expectations is centered around the realized house-price growth rate, π^H_t. This is seen by the fact that the constant term is insignificant, and confirmed in regression (2), with only house-price growth included in the regression and being significant at the 1% level. More notable, however, is the magnitude of R^2 in regression (2). That is, this suggests that by modeling attentive households' expectations as "bench-marked" to realized house-price growth, one can account for around half the variability in the data. Regression (3) provides a measure of the persistence in attentive households' expectations, showing that the first lag of short-term expectations is statistically significant. But regression (4) demonstrates that this persistence is fully accounted for by attentive households' time-invariant components. Specifically, regression (4) shows the result of regressing expected house-price growth on realized house-price growth, the first lag in expectations, and a full set of household dummies. Remarkably, the value of R^2 increases from 0.5608 in regression (3), where only the first lag is included, to 0.7713 in regression (4), where the idiosyncratic component is included. Further, the first lag in expectations is no longer statistically significant. Indeed, regression (5) confirms the explanatory power of the time-invariant idiosyncratic component as the R^2 is essentially the same when the first lag is dropped. This is the specification as stated previously: an aggregate or "bench-mark" component, a time-invariant idiosyncratic component, and a time-varying idiosyncratic component. The principal conclusion is that household expectations in the data are very responsive to house-prices in the aggregate and feature a high degree of idiosyncratic heterogeneity, with this component being stable over time.

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Long-term Expectations Long-term expectations play an important role in our analysis as they represent the end-point where households expect house-prices to settle. In the survey, the question posed to households regarding long-term expectations is the following:

In about a period of 10 years what do you think is a normal increase or decrease for property prices **per year**?
If it concerns a decrease of property prices, please enter a negative number.

percentage.....

-9 don't know.....

We interpret the responses to this question as representing where households estimate the growth rate of housing to be ten years in the future. Table 2 presents basic descriptive statistics for households' responses to both short- and long-term expectations. In contrast to short-term expectations, long-term expectations have a much lower coefficient of variation. For the full sample, the relevant figures are 5.28 and 1.21, while the corresponding numbers for attentive households are 3.81 and 1.16. This implies that long-term expectations are far more stable over time than short-term expectations. Indeed, this follows from the fact that long-term expectations are insensitive to both variations in realized house-price growth and to variations in short-term expectations, as shown below. The data on long-term expectations thus feature a narrow and stable longitudinal pattern, with a median and mode of 2.0 percent.

Table 2: Descriptive Statistics: Expectations

	Mean	St. Dev	Coeff. Var.
Short Term Market			
Full Sample	0.6	3.17	5.28
Attentive	1.11	4.23	3.81
Long Term Market			
Full Sample	2.85	3.44	1.21
Attentive	2.97	3.46	1.16

Note: Attentive denotes statistics computed using only well-defined responses. All variables are measured in percent.

Long-term and Short-term Expectations Table 3 presents regression results pertaining to the relationship between realized house-price growth and short-term expectations with long-term expectations. The general regression equation is:

$$E_{h,t}(\pi^H_{t+10}) = \alpha_0 + \alpha_h + \beta_0 E_{h,t}(\pi^H_{t+1}) + \beta_1 \pi^H_t + \epsilon_{h,t}$$

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where $E_{h,t}(\pi^H_{t+10})$ is household's long-term expectations, α_h is a time-invariant household component, $E_{h,t}(\pi^H_{t+1})$ is households' short-term house-price growth expectations, and π^H_t is realized house-price growth.

Table 3: Long-Term Expectations, $E_{h,t}(\pi^H_{t+10})$

	(1)	(2)	(3)	(4)	(5)
Constant	2.8422***	2.7566***	2.7918***	2.3357***	2.3333***
	(0.0499)	(0.0527)	(0.0556)	(0.5996)	(0.6062)
$E_t(\pi^H_{t+1})$		0.0976***	0.1255***	0.1129***	0.0883***
		(0.0141)	(0.0189)	(0.0246)	(0.0179)
House-Price Growth, π^H_t			-0.0343**	-0.0274*	
			(0.0135)	(0.0165)	
Household Fixed Effects	No	No	No	Yes	Yes
Observations	4741	4741	4741	4741	4741
R^2	0.0000	0.0146	0.0161	0.4182	0.4176

Robust standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

The main result is that the coefficient of interest, β_0, is estimated to be between 0.09 and 0.12 with a high degree of statistical significance. Additionally, the sensitivity of long-term expectations to variations in aggregate house-prices, as measured by coefficient β_1, is also low, both in the magnitude and the statistical significance of the estimate. These relationships indicate that long-term expectations are more stable over time than short-term expectations. This stylized fact will be relevant when incorporating households' expectations into the model for structural analysis in Section 4.3.

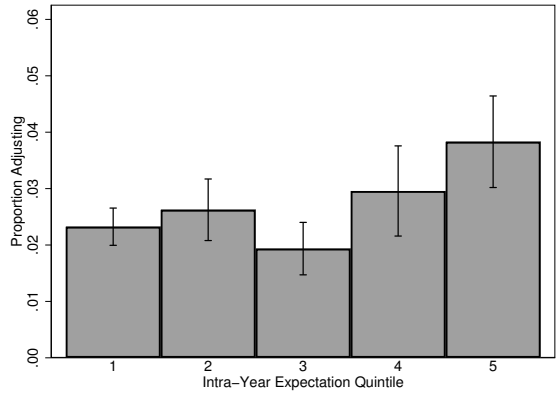
Short-term Expectations and the Propensity to Move In this section we present two key patterns about how short-term expectations relate to housing choices. We focus on the house-adjusting behavior of homeowners.[10] Figure 3 presents four graphs that show the general relationship between households' expectations and (i) the likelihood of adjusting or moving, and (ii) the size of the adjustment, conditional on moving. The likelihood of adjusting is approximated by the proportion of adjusting households. We plot the proportion of households that switch houses in the year following the answering of the survey (Panel (a)) and in the two years following the answering of the survey (Panel (b)). The variables are aggregated by intra-year house-price expectation quintiles. That is, each household-year is labeled by the

[10]Renters are excluded from the graphs due to the limited availability of data, as compared to that of homeowners.

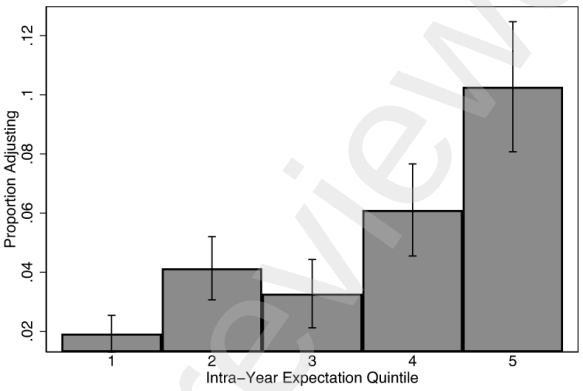
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Figure 3: Expectations and House Adjustment Behavior

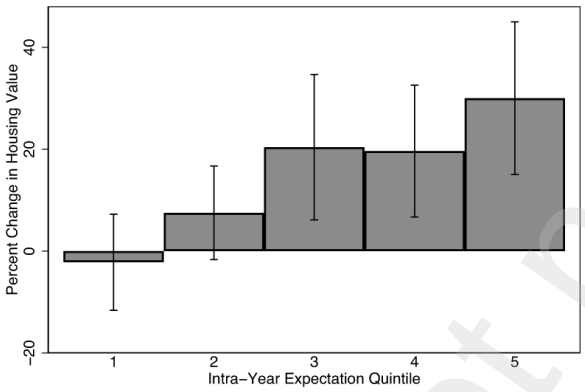
(a) House-Adjusting Rate, 1yr



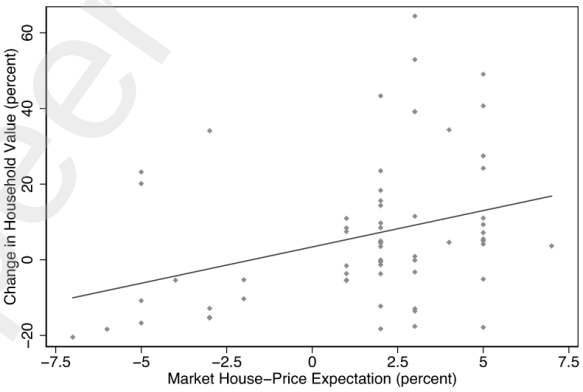
(b) House-Adjusting Rate, 2yr



(c) House-Adjusting Rate



(d) House-Adjusting Size



Note: This figure shows the fraction of homeowners adjusting within a 1yr and 2yr window by short-term expectations quintile in Panels (a) and (b), and the percent of real housing value adjustments by short-term expectations quintile and by reported expectation in Panels (c) and (d), respectively. Confidence intervals shown are at 90%. The slope of the fitted line shown in Panel (d) is 1.92 with an associated p-value of 0.006.

quintile of the cross-sectional distribution of the expectations they fall into. This yields a discrete variable that accurately represents the expectations type of attentive households while controlling for aggregate fluctuations throughout the period.[11] The size of the adjustment is measures in percent terms and conditioned on adjusting home-owners.[12] Panel (c) shows the adjustment averages with 90 percent error bands by expectation quintiles. Panel (d) shows the point values of real housing adjustments as a function of households' point expectations.

There is an increasing relationship between the likelihood of house adjustment in Panels (a)-(b) and expectation quintiles. This is most apparent in Panel (b), which presents the two-

[11] In the construction of these graphs, we employ current-period adjustment and beginning-of-period (i.e., *ex ante*) expectations. These measures are appropriate for capturing the correlation we wish to explore.

[12] In the graph, we show the magnitude of inflation-adjusted percent change in the house-holdings reported by households; the same pattern obtains when house-holdings are deflated using the aggregate house-price index.

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year window adjustments since it provides a better accounting of household choices that might be carried out with delay and/or that were reported with delay due to the frequency of the survey. In this case, the adjusting rate grows from about 2 percent for the first expectation quintile to about 10 percent for the fifth quintile. More importantly, however, is to note the pattern exhibited in Panel (a), which shows house adjustments in the year after responding to the survey. Here, the pattern represents a constant moving rate for quintiles 1-3 of about 2 percent, then a moving rate of about 3 percent for quintile 4, and 4 percent for quintile five. This 2-3-4 pattern will be used later on to provide validation to the structural model.

Panel (c) shows that the average change in housing value for the lowest quintile is not statistically significant, whereas households in the highest quintile on average increase the value of their housing by around 30 percent. Panel (d) registers all the housing adjustments and plots a linear regression confirming the positive correlation between expectations and the magnitude of adjustment. These facts suggest that house-price growth expectations play a role in house adjustment behavior. House-price growth expectations are correlated with households' rate of house adjustment, as well as the degree of that adjustment when it takes place. In the next section we explore these relationships in more detail by controlling for the demographic, economic and financial characteristics of households, as well as aggregate factors.

3 Expectations and Choices: Data

This section presents estimates of the relationship between house-price growth expectations and the moving propensity while controlling for other prominent determinants of household MPCs. We do not attempt to establish causality in a definitive sense, given the endogeneity issues inherent in the data; see Gorodnichenko and Weber (2016). However, we provide robust estimates that support the view in favor of different economic outcomes as a function of heterogeneous expectations. These results will also be employed in the next section to validate the structural model from which we compute the MPC estimates.

3.1 House Choices over the Life Cycle

The key underlying mechanism that provides a rationale for differing behavior between otherwise-identical households with different beliefs is that of *expected housing capital gains* (Kaplan et al. (2020)). The expectation of positive future capital gains provides an incentive for households to adjust their holdings. When expected house-price growth is positive, households are likely to upgrade their housing consumption as they expect to receive financial gains in the future and benefit from higher housing quality over time.

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This framework suggests the following linear probability model:[13]

$$\mathbb{1}_{\{\Delta H_{h,t+1}\}} = \mu + \alpha_h + \beta f\left(E_{h,t}(\pi^H_{t+1})\right) + \gamma_1 Y_{h,t} + \gamma_2 A_{h,t} + \gamma_3 M_{h,t} + \gamma_4 PH_{h,t} + \Gamma_1 X_{h,t} + \Gamma_2 X_{r,t} + \epsilon_{h,t}$$

where $\mathbb{1}_{\{\Delta H_{h,t+1}\}}$ is a house-adjustment indicator variable, α_h is a household fixed effect, $f\left(E_{h,t}(\pi^H_{t+1})\right)$ denotes a function of expected house-price growth, $Y_{h,t}$ denotes net income, $A_{h,t}$ denotes net financial assets, $M_{h,t}$ denotes mortgage mortgage, $PH_{h,t}$ denotes owned house value, $X_{h,t}$ denotes the household's demographic characteristics, $X_{r,t}$ denotes year, region and year-region fixed effects, and $\epsilon_{h,t}$ is a normally-distributed error term.

We are interested in testing if $\beta \neq 0$. Note that we do not investigate how households form their expectations but rather focus on measuring the extent to which they are correlated with their house-adjustment behavior, while controlling for the key components of their portfolios, and their economic and demographic characteristics, as well as unobserved factors common to their region and the aggregate economy. The house-adjusting indicator variable is the conceptual analogue of non-durable consumption in direct MPC estimates since it renders continuous the consumption of housing services–a discrete variable. Hence, by exploiting the panel dimension of the survey we are able to estimate the effect of expectations on the propensity to adjust housing.

We present three different specifications for the specification for $f(\cdot)$. Namely, (i) a baseline specification in which expectations do not play a role in house-adjustment behavior; regressions of this sort account for the conventional determinants of household MPCs. (ii) Households' reported house-price expectation are assumed to have a linear relationship to the propensity to move. (iii) A set of five expectation types that denote the household's quintile in the year-specific cross-sectional distribution of expectations; this specification follows from the pattern shown in Figure 3 and allows for some degree of non-linearity in the influence of expectations. In all cases, we include household, year, region and year-region fixed effects to account for aggregate and regional factors driving house-adjustment behavior.[14] We also include a number of household-specific controls that include economic and demographic variables. Finally, we try to control for any systematic behavior associated with non-response on part of households by including dummy variables for strictly inattentive households.

The demographic variables are the size of the household size, the age –and age squared–

[13]The choice to use a linear probability model is driven by three main considerations. Firstly, the estimates can be interpreted in a straightforward way, which is essential in order to provide clear statistics to guide the structural model's calibration. Secondly, a linear specification is consistent with estimations of MPCs in the literature that do not include expectations; hence for comparability. Finally, households' relative expectations are appropriately modeled as fixed types, following the results of Section 2. Therefore, comparing the effect of expectations between groups–as in case (iii)–is a more informative approach than looking at with-in group effects.

[14]In Appendix A1 we present estimates including cohort effects as a robustness exercise and include additional specifications for household expectations.

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of the household head, and the number of members in the household, as well as a dummy for college degree. Economic variables are net income and a dummy for retired status. Portfolio items include the household's net financial assets, its housing wealth, and the value of their mortgage. The timing of variables in the regressions is such that the housing decision on the part of households is regressed on beginning-of-period levels, i.e., before the adjustment decision has been made.[15] OLS estimation results for the linear probability model outlined above are reported in Table 4.

The estimations provide strong support for the hypothesis that household house-price growth expectations influence house-adjustment behavior, even while controlling for demographic characteristics (such as age and household size), economic characteristics (such as income level and retirement status), and the overall composition of their portfolios (i.e., their holdings of net financial assets, mortgage loans and housing wealth). This is an important result to stress since there is ample evidence on the importance of accounting for household portfolios in the estimation of MPCs, especially regarding their influence on the behavior of wealthy hand-to-mouth households; see Kaplan and Violante (2014). What the results of Table 4 show is that an additional dimension potentially influencing MPCs is households' idiosyncratic expectations, since non-durables and housing are complementary goods in household consumption.

Consider the baseline regression (1) which omits the responses on expectations altogether. In this column, virtually all of the household's variables have a significant correlation with respect to the probability of house adjustment. On the demographics dimension, note that the greater the age of a household head, the lower the probability of moving (by around 0.55 percent), though this effect is decreasing with age (as captured by the positive coefficient on the squared variable "Age of HH Head Sq.").[16] The same goes for the size of the household; the larger the household, the lower the likelihood of moving (about 0.44 percent). Net income, on the other hand, is positively correlated with likelihood of house adjustment. Increasing the household's annual income by one thousand euros increases the probability of moving by 0.05 percent. These are the economic variables which influence house adjustment behavior. A dummy for retirement is not found to be significant in this or any of the following regressions. Neither is the college dummy.

Regarding the household's portfolios, housing wealth and the mortgage value are highly

[15]House adjustment is identified in the survey through the questions "Since when (which year) have you (has your household) been living at the present address?" and "In which year did you buy your current house?" While a number of reporting errors had to be corrected, this was done so without recourse to any of the exogenous variables employed in the estimations.

[16]The significance and sign of coefficients higher than zero but smaller than 0.0001 in absolute value is noted but their precise value is omitted if not central to the analysis in order to preserve the readability of the estimations tables.

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Table 4: Home Adjustment Behavior and House-Price Expectations

	Baseline	Expectations	Expectation Quintile
House-Adjustment Indicator	(1)	(2)	(3)
House Price Expectation		0.0013*	
		(0.0007)	
Quintile 2			0.0238**
			(0.0096)
Quintile 3			0.0051
			(0.0096)
Quintile 4			0.0297***
			(0.0103)
Quintile 5			0.0417***
			(0.0126)
Strictly Inattentive		0.0061	0.0062
		(0.0080)	(0.0167)
Net Income	0.0006***	0.0006***	0.0003
	(0.0002)	(0.0002)	(0.0002)
Net Financial Assets	0.0000	0.0000	0.0000
	(0.0000)	(0.0000)	(0.0000)
Housing Wealth	-0.0002***	-0.0002***	-0.0002***
	(0.0000)	(0.0000)	(0.0001)
Mortgage Value	-0.0002***	-0.0002***	-0.0002***
	(0.0000)	(0.0000)	(0.0001)
Age of HH Head	-0.0055***	-0.0053***	-0.0092***
	(0.0014)	(0.0014)	(0.0022)
Age of HH Head Sq.	0.0000***	0.0000***	0.0001***
	(0.0000)	(0.0000)	(0.0000)
Household Size	-0.0044*	-0.0044*	-0.0069**
	(0.0023)	(0.0022)	(0.0035)
College	0.0053	0.0058	0.0069
	(0.0052)	(0.0052)	(0.0081)
Retired	-0.0082	-0.0080	-0.0070
	(0.0064)	(0.0064)	(0.0106)
Constant	1.2248***	1.2292***	1.4347***
	(0.0600)	(0.0654)	(0.0813)
Household FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Year × Region FE	Yes	Yes	Yes
Observations	8251	8251	3833
R^2	0.1783	0.1791	0.2096

Note: Robust standard errors in parentheses. House-Price Expectations are in percentage points. Quintile refers to the intra-year quintile of house-price expectations that attentive households fall into; inattentive household are not included in this regression. Strictly inattentive is an indicator variable for households that always report zero expected house-price growth or do not report expectations. Net income and household portfolio items are in thousands of euros; mortgage values are reported in positive figures. Household size is the number of members in the household. College and Retired are dummy variables.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

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significant and exhibit the expected negative sign. A higher level of housing wealth and a larger mortgage are both associated with a lower probability of house adjustment. To put the magnitude of the effect into perspective, consider that the unconditional mean of the probability of house adjustment is 0.0328 or 3.28 percent. Hence, one should interpret the coefficients on housing wealth (-0.0002) and mortgage value (-0.0002)–both measures in thousands of euros–as signifying that for an additional one hundred thousand euros in either variable, the probability of house adjustment would decrease by 2 percent. The effect of the household's net financial assets is insignificant. These partial effects are in line with the literature and are key controls in estimating the effect of expectations on housing adjustment, given the well-established role that they play in determining MPCs. These correlations will remain significant, for the most part, in the regressions that follow, where we look at the partial effect of households' expectation on aggregate house-price growth.

In regression (2) we estimate the partial effect of expected house-price growth on the probability of house adjustment. It is estimated over the full sample period and all households. The controls from regression (1) are included. Additionally, we include a dummy variable for strictly inattentive households. The main result is that the coefficient estimate on house-price expectations (i.e., 0.0013) is positive –as expected– and significant at the 90 percent level. This can be interpreted as estimating that a one-percent increase in expected aggregate house-price growth is associated with a 0.16 percent higher probability of moving. This is evidence in favor of the capital gains channel of expectations on housing and consumption. However, both the magnitude and significance of the estimated coefficient are moderate. This estimate measures the degree to which higher expectations correlate with a higher propensity to move *for a specific household*. However, given the results from 2, it is appropriate to ask if households with high expectations exhibit a higher moving propensity *in comparison to low-expectations households*.

In regression (3), we allow for non-linear effect in the form of dummy variables for households' expectations quintile. In this case, there is an even stronger and more significant effect of expectations on the likelihood of house adjustment. Particularly remarkable are the estimated coefficients for quintiles four and five, who exhibit a 2.97 percent and a 4.17 percent, respectively, higher probability of moving than the lowest quintile reference group's unconditional probability of house adjustment of 1.92 percent. This result confirms the positive correlation between expectations and house-adjustment propensity that was identified in Figure 3, Panel (a) and establishes this pattern as a key result. Further, it reaffirms the fact that expectations data are in fact a new and significant predictor of house-adjustment behavior.

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3.2 Response to Monetary Policy Shocks

This section investigates whether or not households with different expectations respond differently to policy shocks. Specifically, we study the influence of expectations on households' response to monetary policy shocks. This analysis provides an indication about the degree to which there is a correlation between expected house-price growth and household MPCs. This follows from the well-established fact that monetary policy shocks lead to changes in households' non-durable consumption. While we are not able to observe the consumption of non-durables for the households in our sample, we expect that changes in non-durable consumption are correlated to expectations if housing choices prove to be so.[17]

We follow the previous estimation strategy while additionally allowing for interaction effects between two key measures of household expectations and monetary policy shocks. Including the level effect of expectation groups–in addition to their interaction with monetary policy shocks–serves to isolate a higher degree of causality in the correlation between expectations and moving rates. The monetary policy shocks that are relevant to this analysis are the innovations that are unforeseen to the market, as identified by employing high frequency surprises around policy announcements; see Gorodnichenko and Weber (2016), Nakamura and Steinsson (2018), and Wong (2018). Specifically, we use the series computed by Gertler and Karadi (2015)[18] for the euro area, which has been shown to serve as an external instrument that can produce responses in output and inflation that are typical in monetary VAR analysis. As with realized house-price growth, the series of monetary policy shocks are exogenous to the survey and households.

The linear probability model is thus defined by:

$$\mathbb{1}_{\{\Delta H_{h,t+1}\}} = \mu + \alpha_h + \beta f\left(E_{h,t}(\pi^H_{t+1})\right) + \psi f\left(E_{h,t}(\pi^H_{t+1})\right) \times \epsilon^{MP}_{h,t} + \gamma \pi^H_t + \tilde{\Gamma}_1 \tilde{X}_{h,t} + \Gamma_2 X_{r,t} + \epsilon_{h,t}$$

where previous notation is preserved, with $\tilde{X}_{h,t}$ being the vector of all observable household characteristics, and where we have added realized house-price growth, π^H_t, and monetary policy shocks, $\epsilon^{MP}_{h,t}$, in percent as regressors.[19] Realized house-price growth serves as a relevant and highly significant variable to capture aggregate states. Later on, with a focus on inference, we will introduce a broad set of fixed effects. For now, we are interested in estimating ψ, i.e., the partial effect of expectations on the household's response to a monetary policy shock.

The monetary policy shocks variable is specified so that positive values represent an expansionary shock. They are indexed at the household level since housing decisions are regressed

[17] The near-ideal scenario would be to have data on the consumption and receipt of a one-time unexpected transfer with built-in exogenous variation in recipients; such is the data exploited by Johnson et al. (2006) in their now seminal paper. In the absence of such data, however, we reply on a sequence of monetary policy shocks, which are especially apt to our setting since the outcome variable is an indicator variable, better observed over several periods.

[18] Since this series is employed the sample available for estimations is 2003-2016.

[19] Note that only household fixed effects, α_h, and region fixed effect, $X_{r,t}$, are included, as year fixed effects are not admissible in this specification.

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on the cumulative sum of policy shocks in the year leading up to the date when the survey was answered.[20] In order to gauge the degree to which there is a heterogeneous effect of expectations, monetary policy shocks are interacted with the two main discrete measures discussed previously: (i) attentive vs. inattentive households, and (ii) households' relative position in the cross-sectional distribution of expectations. Households are grouped into Pessimistic, Neutral and Optimistic, which denote attentive households' position in the year-specific distribution of expectations, 1^{st}, $2^{nd} - 4^{th}$, and 5^{th} quintiles, respectively. This grouping is done to increase the sample size within each expectation type, following Wong (2018).

Table 5 shows estimates for (i) the effect of monetary policy shocks on house-adjustment, (ii) the effects interacted with households' attentiveness type, and (iii) the effect interacted with expectations types. The regressions confirm the key findings of the previous sections regarding the correlations of households' demographic, economic, and balance sheet characteristics on house adjustment. Additionally, realized house-price growth is significant at the 0.01 level and associated with an increase in the likelihood of house adjustment; for a one-percent increase in house prices, the probability of house adjustment increases by 0.2 percent.

Regression (1) further shows that an expansionary monetary policy shock of one percent increases the probability of house adjustment by 0.1 percent, with a significance level of 0.01. However, this effect is not the same for all groups of households. Regression (2) shows that while a one-percent expansionary monetary policy shock increases the likelihood of adjustment for attentive households by 0.1 percent, it does not significantly–in a statistical sense–affect inattentive households' adjustment behavior. An analogous result obtains for expectations types within attentive households. Regression (3) shows that while there is no significant effect of monetary policy shocks on households categorized as pessimists, a one-percent expansionary monetary policy shock is associated with an increase in the probability of adjustment of 0.12 percent in the case of expectation-neutral households and 0.32 percent in the case of optimistic households–both at a 0.01 significance level.[21]

[20] The main results of Table 5 continue to hold for regression (2) for a monetary policy shock horizon of six months as well; while the results of regressions (1) and (3) hold for horizons of six months, one year, eighteen months and two years.

[21] These findings continue to hold when one allows for cohort effects; see Table A3.

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Table 5: Home Adjustment in Response to Monetary Policy Shocks

House-Adjustment Indicator	Monetary Policy Shocks (1)	Attentive/Inattentive (2)	Expectation Type (3)
ϵ_MP	0.0011***		
	(0.0003)		
Attentive × ϵ_MP		0.0011***	
		(0.0003)	
Inattentive × ϵ_MP		0.0005	
		(0.0008)	
Neutral			0.0036
			(0.0049)
Optimist			0.0184**
			(0.0086)
Pessimist × ϵ_MP			0.0005
			(0.0004)
Neutral × ϵ_MP			0.0012***
			(0.0005)
Optimist × ϵ_MP			0.0032***
			(0.0011)
Strictly Inattentive		0.0034	0.0063
		(0.0083)	(0.0096)
House-Price Growth	0.0020***	0.0020***	0.0019***
	(0.0005)	(0.0005)	(0.0006)
Net Income	0.0005**	0.0005**	0.0005**
	(0.0002)	(0.0002)	(0.0002)
Net Financial Assets	0.0001**	0.0001**	0.0000
	(0.0000)	(0.0000)	(0.0000)
Housing Wealth	-0.0003***	-0.0003***	-0.0001***
	(0.0000)	(0.0000)	(0.0000)
Mortgage Value	-0.0004***	-0.0004***	-0.0001**
	(0.0000)	(0.0000)	(0.0001)
Age of HH Head	-0.0109***	-0.0109***	-0.0062***
	(0.0016)	(0.0016)	(0.0017)
Age of HH Head Sq.	0.0001***	0.0001***	0.0000***
	(0.0000)	(0.0000)	(0.0000)
Household Size	-0.0092***	-0.0092***	-0.0071**
	(0.0028)	(0.0028)	(0.0029)
College	0.0242***	0.0243***	0.0063
	(0.0060)	(0.0060)	(0.0060)
Retired	0.0056	0.0056	0.0011
	(0.0070)	(0.0070)	(0.0077)
Constant	0.4994***	0.4980***	0.2800***
	(0.0521)	(0.0521)	(0.0586)
Household FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Observations	8525	8525	6381
R^2	0.0612	0.0613	0.0361

Note: Robust standard errors in parentheses. Sample consists of 2003-2016. The variable for house adjustment is the change in housing wealth –in percentage points– of moving households. Monetary policy shocks are in percent and positive values denote expansionary shocks. Strictly inattentive –as well as Attentive/Inattentive variables– is an indicator variable for households that always report zero expected house-price growth or do not report expectations. Pessimistic, Neutral and Optimistic denote attentive households' position in the year-specific distribution of expectations: 1^{st}, $2^{nd} - 4^{th}$ and 5^{th} quintiles, respectively. Net income, home values and household portfolio items are in thousands of euros; mortgage values are reported in positive figures. Household size is the number of members in the household. College and Retired are dummy variables.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

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Table 6: Attention Groups Statistical Inference Tests

	(1)	(2)	(3)	(4)
Attentive - Inattentive	0.0006	0.0014	0.0016	0.0014
χ^2	0.49	3.71	4.43	5.50
p-value	0.4823	0.0541	0.0353	0.0190
Household FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
Year × Region FE	No	No	Yes	Yes
Cohort FE	No	No	No	Yes

Note: Headline numbers the difference in estimated coefficients. χ^2 are statistics from the pairwise tests of $H0 : \psi_i = \psi_j$, where $i \neq j$. A p-value of less than 0.1 rejects the null of equal probability of house adjustment in response to a one-percent expansionary monetary policy shock between attentiveness groups at a 0.1 significance level. The realized level of house-price group is dropped from regressions where year effects are included.

Lastly, we present inference tests for the equal response to monetary policy shocks between relevant groups. In each case, we present the difference between the point estimates for the partial effects of monetary policy shocks, i.e., $\psi_i - \psi_j$. We look to reject the null hypothesis $H0 : \psi_i = \psi_j$, where $i \neq j$. A p-value of less than 0.1 rejects the null of equal probability of house adjustment in response to a one-percent expansionary monetary policy shock between groups at a 0.1 significance level. Regressions (1) through (4) in Table 6 differ in the fixed effects that are, for robustness, included in the estimation, ranging from household and region fixed effects to household, region, year, region-year, and cohort fixed effects. The conventional set of regressors are included as well.[22]

Table 6 shows the results for the heterogeneous effect of monetary policy according to attentiveness. In addition to the difference in estimated coefficients, the estimated chi-squared coefficient and the p-values are reported for each regression. The main result is that for regressions (2)-(4) the equal-response hypothesis is rejected with a significance level of around 0.1. Hence, the likelihood of house adjustment of attentive households tends to respond to expansionary monetary policy shocks by 0.14-0.16 percent more than that of inattentive households.

[22]The realized level of house-price growth is dropped from regressions where year effects are included.

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Table 7: Expectations Groups Statistical Inference Tests

	(1)	(2)	(3)	(4)
Optimists - Pessimists	0.0027	0.0027	0.0026	0.0022
χ^2	5.37	6.61	5.90	6.22
p-value	0.0205	0.0102	0.0151	0.0127
Optimists - Neutral	0.0020	0.0007	0.0004	0.0006
χ^2	2.69	0.33	0.14	0.42
p-value	0.1012	0.5674	0.7100	0.5188
Neutral - Pessimists	0.0007	0.0020	0.0021	0.0016
χ^2	1.40	7.93	8.91	9.04
p-value	0.2365	0.0049	0.0028	0.0026
Household FE	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes
Year FE	No	Yes	Yes	Yes
Year × Region FE	No	No	Yes	Yes
Cohort FE	No	No	No	Yes

Note: Headline numbers the difference in estimated coefficients. χ^2 are statistics from the pairwise tests of $H0 : \psi_i = \psi_j$, where $i \neq j$. A p-value of less than 0.1 rejects the null of equal probability of house adjustment in response to a one-percent expansionary monetary policy shock between expectation groups at a 0.1 significance level. The realized level of house-price group is dropped from regressions where year effects are included.

Similarly, Table 7 presents the results for the pairwise comparison of expectation types. The regressions provide robust support for a heterogeneous response of house adjustment to monetary policy shocks between optimists and pessimists. Optimists tend to respond to a one-percent expansionary monetary policy shock with 0.22-0.27 percent more probability of house adjustment than do pessimists. Further, the null hypothesis of equal response across expectation types is strongly rejected at more than the 0.05 significance level. A similar result holds for the responses of neutral households over pessimist households, with an approximate difference of 0.20 percent. Only in the comparison of optimist and neutral households is the hypothesis of equal responses not rejected. Taken together, the results from the tables strongly suggest that households' house-price growth expectations do indeed influence their house-adjustment decisions, over and above what is explained by controlling only for demographic, economic, and balance sheet characteristics.

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4 Expectations and Choices: Structural Model

This section employs a structural model incorporating heterogeneous house-price expectations to compute household MPCs. As before, we proceed in two steps. First, we estimate household MPCs in the life-cycle context, as the change in non-durable consumption following a vanishingly small increase in cash-on-hand. Next, we estimate the variation in non-durable consumption following an unexpected stimulus transfer by the government, given an exogenous future path for taxes, i.e., households' RCs. These estimates measure the degree to which house-price expectations play a role in differentiating households' consumption responses to fiscal policy shocks. As a baseline, we model the stimulus transfers legislated in the US CARES Act.

The move to a structural setting serves two principal purposes. Firstly, since the DNB Survey data does not contain information on the consumption of non-durable goods, working with a structural model allows us to link the variables discussed above to non-durable consumption in a theoretically consistent way.[23] The second advantage of carrying out a structural quantitative analysis is that the equations from which the MPCs are obtained embody optimal behavioral relationships that can be used to rationalize the data. In this regard, this approach assumes a degree of causality in the relationship between expectations and MPCs. We therefore work with a model that is close to the standard life-cycle model of savings and consumption with housing; see Piazzesi and Schneider (2016) for a thorough presentation.[24]

This standard model does a good job of reproducing the positive correlation between expected house-price growth and house-adjustment rates. Following Carroll et al. (2017) and Kaplan and Violante (2022), we present results for two alternative calibrations to provide a broader range of estimates. Additionally, we present results for three different types of loan contracts, both to provide additional estimates and as robustness exercises showing that our findings continue to hold under different borrowing mechanisms. The main result is that households with higher expectations have a higher likelihood of moving due to the *housing capital gains channel*. This leads to higher average and more heterogeneous MPCs, as housing is complementary to non-durable consumption. This result carries over to the RCs from government stimulus transfers. Low-expectation households tend to have low and insensitive RCs, while high-expectation households exhibit higher and more dispersed RCs, both per stimulus package and across stimulus sizes.

[23] An alternative strategy would be to work with statistical models built upon assumptions regarding the budget constraints faced by households and the degree of measurement error that is prevalent in the data.

[24] The model is intentionally kept parsimonious in order to prioritize the clarity of conceptual interpretation over achieving an exact numerical fit in calibration.

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4.1 Model

The model extends the conventional consumption-savings problem as in Carroll (2006) by including a discrete housing choice. It is similar to the models of Kaplan et al. (2020), Berger et al. (2015) and Landvoigt (2017). The model features idiosyncratic income risk, access to housing services through home-rental or home-ownership with optional loan contracts.

The household sector is composed of a continuum of households that live for a fixed number of discrete-time periods, $j_{it} = \{1, 2, ..., J\}$, and are indexed at any period $t = \{0, 1, ...\}$ by the subscript i. This subscript will serve to particularize the households, beyond its state, by their idiosyncratic house-price expectation. They derive utility from non-durable consumption, C_{it}, and housing services, $S\left(H_{it}, \tilde{H}_{it}, j_{it}\right)$, according to the instant utility function $U\left(C_{it}, S\left(H_{it}, \tilde{H}_{it}, j_{it}\right)\right)$. Each household receives during its working life a stochastic income, and a deterministic pension after retirement at age J^{ret}. We denote by Y_{it} net earnings from either labor or pension payments. Subject to a no short-selling constraint, households can save in risk-free bonds that pay a real return, r_b, and in discrete housing units, $H_{it} \in \mathcal{H}$ where $\mathcal{H} = \left\{h^0, ..., h^{N_h}\right\}$ and $0 < h^0 < ... < h^{N_h}$, that sell at unit price P_t. In purchasing housing units, households have the option to finance part of the purchase through a loan contract at a fixed rate, r_m, that is subject to an intermediation spread such that $r_m = r_b + \zeta$, where $\zeta > 0$ denotes the spread. Finally, households can rent discrete housing, $\tilde{H}_{it} \in \tilde{\mathcal{H}}$ where $\tilde{\mathcal{H}} = \left\{\tilde{h}^0, ..., \tilde{h}^{N_{\tilde{h}}}\right\}$ and $0 < \tilde{h}^0 < ... < \tilde{h}^{N_{\tilde{h}}}$, at price $\tilde{P}_t$.

It is understood that the elements in $\mathcal{H}$ and $\tilde{\mathcal{H}}$ represent the size and quality of houses. Further, if a household decides to adjust the size of the house it owns or move into rental housing, it must incur a house-sales transaction cost linked to the size of the house being sold, $\kappa\left(H_{t-1}\right) = \theta\left(1 - \delta\right) P_t H_{t-1}$. Housing units are subject to a depreciation rate, δ. Households cannot simultaneously own and rent housing. Homeowners are subject to a moving shock, ξ_{it}, that if realized, forces them to sell their house; they are then free to choose the type and level of housing that they wish. The moving shock and the earnings process are the two sources of idiosyncratic risk that the household is subject to.

A household i born in period t wishes to maximize its expected lifetime utility:

$$E_t^i \left[\sum_{j=1}^{J} \beta^j U\left(C_{it+j}, S\left(H_{it+j}, \tilde{H}_{it+j}, j_{it+j}\right)\right) + \beta^{J+1} B\left(\tilde{W}_{it+J+1}\right)\right]$$

where $\beta \in (0, 1)$ is the household's subjective discount factor and $B\left(\tilde{W}_{it+J+1}\right)$ represents utility received from the wealth, $\tilde{W}_{it+J+1}$, it bequeaths to younger generations. We index the expectations operator with i to make explicit that the household's expectations with regard to house prices are allowed to be idiosyncratic. This is understood to denote the entire path of future house prices that a household might expect, from period-t onward. At this point, no

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restriction is placed on the process they expect, other than it be measurable and well-defined. In the empirical section, we will directly use the survey data to make this process specific.

Following Landvoigt (2017), note that given $\zeta > 0$, households will never choose to take out a loan and save in bonds at the same time. Therefore, we need only keep track of households' net non-housing (liquid) asset position, which we denote by A_{it}. Loan contracts are such that at origination, a *house-adjusting household* is subject to the following borrowing constraint:

$$-A_{it} \leq \lambda_m P_t H_{it}$$

After the loan contract has been entered into, a *non-adjusting household* is subject to a borrowing constraint that may be a function of the household's asset position, housing value, and/or demographics:

$$A_{it} \geq \phi\left(P_t, r_M, j_{it}, A_{it-1}, H_{it}\right)$$

This borrowing constraint is specified in a relatively general form because three distinct technologies will be specified in the empirical analysis below.

Renting households are subject to a no-borrowing constraint $A_{it} \geq 0$. Hence, there are three types of households: (i) adjusting households, (ii) non-adjusting households, and (iii) renting households.[25]

The Budget Constraint This timing convention implies that we can write the general budget and borrowing constraint faced by any household at the middle of period t as (dropping the subscript i)

$$\begin{aligned} C_t + A_t + P_t H_t \quad + \quad & \mathbb{1}_{\{H_t \neq H_{t-1}\}} \theta\left(1-\delta\right) P_t H_{t-1} + \mathbb{1}_{\left\{\tilde{H}_t > 0\right\}} \tilde{P}_t \tilde{H}_t = \\ & Y_t(\eta_t, j_t) + \left(1 + r_b + \mathbb{1}_{\{A_{t-1}<0\}}\zeta\right) A_{t-1} + \left(1-\delta\right) P_t H_{t-1} \end{aligned}$$

$$-A_t \leq \begin{cases} \lambda_m P_t H_t & \text{if} \quad H_{t-1} \neq H_t > 0 \\ -\phi\left(P_t, r_M, j_{it}, A_{it-1}, H_{it}\right) & \text{if} \quad H_{t-1} = H_t > 0 \quad \text{and} \quad A_{t-1} < 0 \\ 0 & \text{else} \end{cases}$$

Where $\mathbb{1}_{\{\cdot\}}$ denotes the indicator function.

The Income Process Idiosyncratic labor income, Y_{it}^w, is given by

$$\begin{aligned} Y_{it}^w &= w_t^L g\left(j_{it}\right) \chi_{it} \varepsilon_{it} \\ \chi_{it} &= \chi_{it-1}^{\rho} \nu_{it} \end{aligned}$$

where $\rho \in [0, 1)$, w_t^L is the aggregate wage rate, $g\left(j_{it}\right)$ is a deterministic age-dependent parameter, ε_{it} is a transitory income shock, and ν_{it} is a shock to the persistent component of income,

[25] We abstract from default as this option is essentially not observed in the Netherlands; see Geis and Luca (2021).

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χ_{it}. Pension income, Y_{it}^{ret}, is assumed to be constant and equal to some percent, rr, of the household's after-tax labor earnings at the age of retirement.

In what follows, let the process defining χ_{it} be approximated by a first-order Markov process and ϵ_{it} be discretized my means of the Gaussian quadrature rule. Then, we define the first-order Markov process $\eta_{it} = \chi_{it}\varepsilon_{it}$ and, hence, $Y_{it}(\eta_{it}, j)$ as

$$Y_{it}(\eta_{it}, j_{it}) = \begin{cases} (1-\tau)\, w_t^L g(j_{it})\, \eta_{it} & \text{if} \quad j_{it} \leq J^{ret} \\ rr\,(1-\tau)\, w_{t-(j_{it}-J^{ret})} g(j_{it})\, \eta_{it-(j_{it}-J^{ret})} & \text{if} \quad j_{it} > J^{ret} \end{cases}$$

where we define $\Upsilon_j(Y' \mid Y)$ as the age-specific transition matrix of the first-order Markov process representing Y. Note that we have made explicit the household's age. Finally, denote the cross-sectional distribution over individual household characteristics by $\Phi_t(Y_t, A_t, H_t, j_t)$.

Recursive Formulation We can now state the household's problem in recursive form. To simplify notation, let $X_t = (\eta_t, A_t, H_t, j_t, P_t)$ denote the vector of state variables. We assume a constant rent-to-price ratio, so that the only price included in the vector of state variables is the price of owner-occupied housing.[26] Similarly, the real aggregate wage is assumed to be constant and equal to one in equilibrium. Finally, as we are abstracting from aggregate risk at the moment, we have omitted dependence on the cross-sectional distribution $\Phi_t(Y_t, A_t, H_t, j_t)$. Thus, the household's problem is given in the following definition.

Definition 1 *Given the environment and vector of state variables defined above, X_t, the household's dynamic programming problem is given by:*

$$V_t(X_t) = \max\left\{V_t^{own}(X_t), V_t^{adj}(X_t), V_t^{rent}(X_t)\right\}$$

where

$$V_t^{own}(X_t) = Prob(\xi_t = 1)V_t^{adj}(X_t) + Prob(\xi_t = 0)V_t^{noadj}(X_t)$$

$$\begin{aligned} V_t^{adj}(X_t) &= \max_{\{C_t, A_t, H_t\}} \left\{U(C_t, S(H_t)) + \beta E^i\left[V_{t+1}(X_{t+1}) \mid \eta_t, P_t\right]\right\} \\ s.t. \quad C_t + A_t + P_t H_t &= Y_t(\eta_t, j_t) + \left(1 + r_b + \mathbb{1}_{\{A_{t-1}<0\}}\zeta\right) A_{t-1} + (1-\theta)(1-\delta) P_t H_{t-1} \\ A_t &\geq -\lambda_m P_t H_t \end{aligned}$$

[26] Berger et al. (2015) also assume a constant price-to-rent ratio, while Landvoigt (2017) assumes that the rental price is pegged to house prices but allows the ratio to vary through time in a deterministic way.

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$$
\begin{aligned}
V_t^{noadj}(X_t) &= \max_{\{C_t, A_t\}} \left\{ U\left(C_t, S\left(H_{t-1}\right)\right) + \beta E^i\left[V_{t+1}\left(X_{t+1}\right) \mid \eta_t, P_t\right] \right\} \\
s.t. \quad C_t + A_t + \delta P_t H_{t-1} &= Y_t(\eta_t, j_t) + \left(1 + r_b + \mathbb{1}_{\{A_{t-1}<0\}}\zeta\right) A_{t-1} \\
A_t &\geq \begin{cases} \phi\left(P_t, r_M, j_t, A_{t-1}, H_t\right) & if \quad A_{t-1} < 0 \\ 0 & if \quad A_{t-1} \geq 0 \end{cases}
\end{aligned}
$$

$$
\begin{aligned}
V_t^{rent}(X_t) &= \max_{\left\{C_t, A_t, \tilde{H}_t\right\}} \left\{ U\left(C_t, S\left(\tilde{H}_t\right)\right) + \beta E^i\left[V_{t+1}\left(X_{t+1}\right) \mid \eta_t, P_t\right] \right\} \\
s.t. \quad C_t + A_t + \tilde{P}_t \tilde{H}_t &= Y_t(\eta_t, j_t) + \left(1 + r_b + \mathbb{1}_{\{A_{t-1}<0\}}\zeta\right) A_{t-1} + (1-\theta)(1-\delta) P_t H_{t-1} \\
A_t &\geq 0
\end{aligned}
$$

with the terminal value of the household's value function (at period $T+1$) given by:

$$V_{T+1}\left(X_{T+1}\right) = B\left(\tilde{W}_{T+1}\right)$$

where

$$\tilde{W}_{T+1} = (1 + r_b) A_T + (1 - \delta) P_{T+1} H_T$$

since at T the relevant borrowing constraint is $A_T \geq 0$ and where income follows the process specified above. Note that we have labeled the expectations operator with a superscript i, as households are allowed to hold subjective expectations about future house prices.

4.2 Functional Forms and Calibration

In this section, we specify the functional forms relating to households' preferences and discuss calibration.

4.2.1 Functional Forms

Households' instantaneous utility function, following Landvoigt (2017) and Berger et al. (2015) is given by:

$$U\left(C_t, S\left(H_t, \tilde{H}_t, j_t\right)\right) = \frac{\left[C_t^{1-\sigma} S\left(H_t, \tilde{H}_t, j_t\right)^{\sigma}\right]^{1-\gamma} - 1}{1-\gamma}$$

where $S(\cdot)$ is linear in its first two arguments and given by:

$$S\left(H_t, \tilde{H}_t, j_t\right) = \omega_{j_t} H_t + \tilde{H}_t + \varpi \qquad \text{where} \quad \varpi \geq 0 \quad \text{and} \quad \omega_{j_t} = 1 + e^{\omega_{P(0)} + j_t \omega_{P(1)} + j_t^2 \omega_{P(2)}} \geq 1$$

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where ϖ captures social housing and ω_{j_t} represents an ownership premium that is a polynomial in age.

The specification for utility due to bequests is taken from Kaplan et al. (2020), who follow De Nardi (2004),

$$B\left(\tilde{W}\right) = \vartheta_1 \frac{\left(\tilde{W} + \vartheta_2\right)^{1-\gamma} - 1}{1-\gamma}$$

We analyze the data under three different cases of borrowing constraints faced by homeowners or *non-adjusting households*: (i) home equity line of credit (HELOC) loans that may be refinanced at no cost; (ii) long-term mortgages that may be refinanced at a fixed cost; and (iii) constant-amortization long-term mortgages. The first case, i.e., HELOC loans, is used to calibrate the model and is specified as follows,[27]

$$\phi\left(\cdot\right) = \lambda_m P_t H_t$$

Hence, under HELOC loans, *non-adjusting households* are allowed to borrow at rate r_m at any period up to a λ_m proportion of the current value of their home. The only requirement is that they pay back their loan in full by the end of their fixed lifetime.

With mortgages that may be refinanced[28] *non-adjusting households* can increase the size of their home loan at a fixed cost F^{Refi} that enters the budget constraint specified as follows,

$$F^{Refi} = F^{Fixed} \mathbb{1}_{\{A_t < A_{t-1} < 0\}}$$

Lastly, constant-amortization long-term mortgages are such that after the mortgage contract has been entered into, a *non-adjusting household* must only make a minimum payment while the mortgage is outstanding, according to the constraint

$$A_t \geq \left[1 + r_M - \Xi\left(r_M, j_t\right)\right] A_{t-1}$$

The function $\Xi\left(r_M, j_t\right)$ is be defined by the constant-amortization formula

$$\Xi\left(r_M, j_t\right) = \frac{r_m \left(1 + r_m\right)^{J+1-j_t}}{\left(1 + r_m\right)^{(J+1-j_t)} - 1}$$

That is, if a *non-adjusting household* pays the minimum amount of the mortgage contract every year since entering the contract, they will own the house outright by the end of their life.

[27] Given the structure of mortgage lending that was predominant in the Netherlands, this case if likely to be the best-suited to serve as a benchmark. The general pattern of households' balance sheets leading up to and throughout the housing cycle is that they kept their outstanding principal largely unchanged and there were few costs associated with increasing their loans; see Geis and Luca (2021).

[28] This case is studied in detail in the context of it's effect on the conduct of monetary policy by Wong (2018).

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4.2.2 Subjective Expectations

Households' subjective expectations, as reported by households in the survey data, are assumed to be the certain point forecasts of the house-price growth rate. This assumption is driven by data limitations but also finds support in the literature on attention to macroeconomic variables. Subjective expectations enter the household's optimization problem through the law of motion of wealth, W_{t+1}. That is, in the presence of movements in house prices, a household must account for potential *housing capital gains* since the law of motion of W_{t+1} is given by earnings, savings, and the value of undepreciated housing:

$$\begin{aligned} W_{t+1} &= Y_{t+1} + (1+r_b)\,A_t + (1-\delta)\,P_{t+1}H_t \\ &= Y_{t+1} + (1+r_b)\,A_t + (1-\delta)\,P_tH_t\left(1+\pi^H_{t+1}\right) \\ &= Y_{t+1} + (1+r_b)\,A_t + (1-\delta)\,P_tH_t + \underbrace{(1-\delta)\,P_tH_t\pi^H_{t+1}}_{\text{Housing Capital Gains}} \end{aligned}$$

where π^H_{t+1} denotes house-price inflation.

Thus, conditional on current-period housing and saving choices, households take into account their *expected housing capital gains* when computing their forecast of future beginning-of-period resources:[29]

$$E^i\left(W_{t+1} \mid Y_t, \pi^H_t, A_t, H_t\right) = E\left(Y_{t+1} \mid Y_t\right) + (1+r_b)\,A_t + (1-\delta)\,P_tH_t + \underbrace{(1-\delta)\,P_tH_tE^i\left(\pi^H_{t+1} \mid \pi^H_t\right)}_{\text{Expected Housing Capital Gains}}$$

where expected housing capital gains vary according to household i's expectation.

The *housing capital gains* channel is the mechanism through which subjective beliefs about house prices affect consumption and savings decisions in the model. Importantly, whether or not the household receives next-period housing capital gains depends on its *current period housing choice*. Hence, the mechanism through which differing expectations influence consumption and savings decisions works through a wealth/endowment effect due to future capital gains.[30]

Longitudinally, we think of households' forecasted house-price growth as being fixed at period t and then expected to gradually converge to a level of two percent in the long term. This feature is consistent with the main featured of the data; specifically, the high persistent of short-term expectations–after controlling for aggregate movements–and the stable and narrow longitudinal shape of long-term expectations, as well as their insensitivity to changes in short-

[29] Note that we assume, for simplicity of exposition, that the distributions of household earnings and house prices are orthogonal to one another.

[30] Recall that in solving its dynamic programming problem, the household will compare choice-specific (with regard to housing) value functions in order to select its optimal discrete choice. Thus, the expected capital gains, being a function of the current discrete choice (H_t), directly affect the household's current decision on housing.

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term expectations.[31]

Computationally, we approximate the household's expected path for house-prices through the incorporation of the randomization of expectations; given the absence of data on the full path of expected house-price growth. The implementation is as follows: at period t, households know their expected house-price growth but they anticipate that in the next period they will hold their same expectations with some probability λ_E, and with probability $1-\lambda_E$ they will expect the long-term house-price growth level of two percent. This approach allows the state space to remain at a tractable size while still incorporating the horizon effects of expectations in a realistic way. More specifically, in solving the household's problem with short-term expectation e, an approximate Bellman equation of the following form is employed:

$$V_j^e(X) = max\left\{U(C, S(H)) + \beta \tilde{V}_{j+1}^e(X')\right\}$$

where

$$\tilde{V}_{j+1}^e(X') = \lambda_E V_{j+1}^e(X') + (1-\lambda_E) V_{j+1}^{LT}(X') \qquad \text{where} \quad \lambda_E \in [0,1]$$

where V_{j+1}^{LT} denotes the age-$j+1$ value function for a household with expected house-price growth fixed at two percent.[32] The precise value of λ_E will be pinned down by targeting the pattern of moving rates and expectations in the short term, as documented in Section 2.

4.2.3 Solution Method

The model is solved using the discrete-continuous endogenous gird method (DC-EGM) as in Iskhakov et al. (2017). This procedure builds on the EGM of Carroll (2006) and consists in using an exogenous end-of-period (i.e., post-decision) savings grid and the household's Euler equation to back out an endogenous grid for beginning-of-period financial wealth. Secondary kinks in choice-specific value functions are handled by eliminating segments that fall below the upper envelope of the correspondence. For a full outline of the algorithm see Appendix C.

4.2.4 Calibration

Table 8 lists the parameters of the model and their interpretation. Parameters set in the first stage are chosen outside the model, with reference to the data and/or literature. Parameters chosen in the second stage are calibrated using the model. We present results for two calibration strategies given that each has specific implications for the level and distribution of household

[31] The median for this variable is two percent and although there is some dispersion, it is dwarfed when compared to the heterogeneity found in short-term expectations; among attentive households, the coefficient of variation for short-term expectations is larger than that of long-term expectations by a factor of 3.25x; see Section 2.

[32] There exist several studies which employ this solution method in the consumer, firm, bank, and sovereign default literature, where horizon effects are present; see Yamaguchi et al. (2014).

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MPCs that the model generates; see Carroll et al. (2017) and Kaplan and Violante (2022) for a detailed discussion. The first calibration strategy aims to equalize the data and model averages of net financial assets, while the second strategy targets average net worth.

4.2.5 First-Stage Parameters

Demographics The model is specified at an annual frequency, with households starting their working life at age 25, retiring at age 65, and dying at age 80.

Preferences The risk aversion parameter is fixed at 2, in line with much of the macroeconomic literature. The share of housing services is set to 0.3 in order to match the empirical average rental expenditure of 30 percent of income.

Income Process The estimation of the income process follows Storesletten et al. (2000, 2004).[33] The replacement rate is set to 0.85,[34] in accordance with the data.

Housing Sector We assume that there is no house-price growth, we fix the rent-to-price ratio at 0.07 as per the Nijskens et al. (2017), and normalize the rental rate to one.[35] All variables are measured in terms of the median real net annual income. We follow Kaplan et al. (2020) in fixing log-linear housing grids with four and six points for rental and owner-occupied housing, respectively. The minimum and maximum owner-occupied housing grid points correspond to 10^{th} and 80^{th} percentiles of the empirical distributions, with the minimum rental grid point set according to the 10^{th} percentile of the rental housing distribution, and all other points overlapping with the owner-occupied housing grid. Specifically, the grids are:

$$\begin{aligned} \mathcal{H} &= \{0.243, 0.373, 0.571, 0.874, 1.338, 2.048\} \\ \tilde{\mathcal{H}} &= \{0.098, 0.243, 0.373, 0.571\} \end{aligned}$$

Following Fernandez-Villaverde and Krueger (2011), the value is social housing is treated as a computational parameter and set to a level low enough so that it does not have a noticeable impact in the implications of the model, 0.00001.[36] We take from the literature the house depreciation rate, $\delta = 0.04$, and the house sales transaction cost, $\theta = 0.07$.

[33] See Appendix D for details.

[34] Recall that this does not refer to income received from a government-managed pension system but captures all of the non-interest income households receive after retirement.

[35] See Appendix H for a justification of the rental rate's normalization.

[36] In practice, this implies that only about one percent of households choose to not consume positive levels of rental or owner-occupied housing.

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Table 8: Parameter Values

Parameter	Interpretation	Stage	Value (NFA/NW)
	Demographics		
J	Age of death (years)	1^{st}	80
J^{ret}	Age of retirement (years)	1^{st}	65
J^{born}	Age of birth (years)	1^{st}	25
	Preferences		
β	Discount factor	2^{nd}	0.934/0.965
γ	Risk aversion	1^{st}	2
σ	Weight on housing services	1^{st}	0.3
$\{\omega_j\}$	Additional utility from owning	2^{nd}	$\widehat{P}(2)$
ϑ_1	Strength of bequest motive	2^{nd}	1744.725/1915.104
ϑ_2	Luxuriousness of bequests	2^{nd}	23.356/30.945
λ_E	Relative weight of short-term expectations	2^{nd}	0.950/0.950
	Income Process		
$\{g(j_t)\}$	Deterministic age profile	1^{st}	$\widehat{P}(4)$
ρ	Autocorrelation of persistent component	1^{st}	0.967
σ^2_χ	Variance of persistent shock	1^{st}	0.089
σ^2_ε	Variance of transitory shock	1^{st}	0.291
rr	Pension replacement rate	1^{st}	0.853
	Housing Sector		
π^h	Housing price growth	1^{st}	$\emptyset$
P	Owner-occupied housing price	1^{st}	$\tilde{P}/\varrho$
$\tilde{P}$	Rental housing rate	1^{st}	1
ϱ	Rent-to-Price ratio	1^{st}	0.07
$\mathcal{H}$	Owner-occupied house sizes	1^{st}	6
$\tilde{\mathcal{H}}$	Rental house sizes	1^{st}	4
ϖ	Value of social housing	1^{st}	1/100,000
δ	House depreciation rate	1^{st}	0.040
θ	House sales transaction cost	1^{st}	0.070
ξ	Moving Shock Hazard Rate	2^{nd}	0.018/0.018
	Financial Instruments and Aggregates		
r_b	Risk-free rate	1^{st}	0.032
ζ	Mortgage loan markup over risk-free rate	1^{st}	0.010
λ_m	Maximum LTV ratio on mortgage loans	1^{st}	0.900
F^{Fixed}	Mortgage Refinancing Fixed Cost	1^{st}	0.090

Note: NFA denotes the net financial assets calibration and NW denotes the net worth calibration. The 1^{st} stage of calibration refers to parameter values computed without recourse to the model. The 2^{nd} stage of calibration refers to parameter values computed within the model.

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Financial Instruments and Aggregated The risk-free rate is set to 3 percent per annum. The mortgage loan mark-up is set to the period average of 1 percent per annum, and the maximum LTV ratio is set to 0.90 equal to the estimated average in the data. Finally, the fixed cost of mortgage refinancing is set to 0.09, which is equivalent to roughly 2,000 euros; this is in line with Wong (2018).

4.2.6 Second-Stage Parameters

We calibrate the model at the steady state of the economy. In the absence of aggregate price fluctuations, the distribution of households over state variables is stable and the demand for housing and consumption are satisfied at fixed prices, consistent with the long run allocation. This represents the ergodic distribution of the economy and the empirical counterpart is the distribution of the pooled dataset, which provides an approximation to the long run distribution of the Dutch economy. Hence, we proceed by pooling all data and target the moments of the resulting distribution, while assuming constant prices and fixed expectations.[37] In order to compute the model-implied moments for the household sector, we use explicit aggregation to construct the measure of households over expectations and states, Φ. Specifically, we define the transition function of the economy to construct the density function of households over the state space of the economy according to the following definition, where we have assumed for simplicity that households are born with zero financial assets and housing.[38]

Let $\mathcal{E}$ be the set of possible income realizations, $\mathcal{A} = \mathbb{R}$ the set of possible non-housing assets held by the household, $\mathcal{H}$ the set of possible housing assets, as defined above, and $\mathcal{J}$ the set of possible ages. Let $X = (Y, A, H, j)$ and $\mathcal{X} = \mathcal{E} \times \mathcal{A} \times \mathcal{H} \times \mathcal{J}$, where it is understood that the timing convention for X is as described in the recursive formulation of the household's problem. Further, let $\mathcal{P}(\iota)$ and $\mathcal{B}(\iota)$ denote the power set and the Borel σ-algebra of ι, respectively. Finally, let $\mathcal{M}$ be the set of all probability measures on the measurable space $(\mathcal{X}, \mathcal{B}(\mathcal{X}))$.[39]

Definition 2 *Given interest rates r_b and r_m, and prices P and $\tilde{P}$, and a set of functions $V^i : \mathcal{X} \to \mathbb{R}$, $c^i : \mathcal{X} \to \mathbb{R}_+$, $a^i : \mathcal{X} \to \mathcal{A}$, $h^i : \mathcal{X} \to \mathcal{H}$, and $\tilde{h}^i : \mathcal{X} \to \tilde{\mathcal{H}}$, where the superscript $i \in I$ denotes agents' idiosyncratic expectations, associated with the household dynamic programming problem of definition 1, and the transition function $Q : \mathcal{X} \times \mathcal{B}(\mathcal{X}) \to [0, 1]$, the joint distribution*

[37] This procedure included the estimation of a common growth trend in the data, but the estimate is not statistically significant.

[38] In the model aggregation, we approximate the initial holdings of assets and housing using the empirical distribution of holdings for twenty-five year-olds.

[39] Where $\mathcal{B}(\mathcal{X}) = \mathcal{P}(\mathcal{E}) \times \mathcal{B}(\mathcal{A}) \times \mathcal{P}(\mathcal{H}) \times \mathcal{P}(\mathcal{J})$.

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of household incomes, assets, housing, and ages, Φ, evolves according to the functions:

$$\begin{aligned}\Phi\left(\mathtt{y},\mathtt{a},\mathtt{h},\mathtt{j}\right) &= \int Q\left(\left(Y,A,H,j\right),\left(\mathtt{y},\mathtt{a},\mathtt{h},\mathtt{j}\right)\right)d\Phi \\ \Phi\left(\mathtt{y},\mathtt{a},\mathtt{h},\{1\}\right) &= \sum_{y\in\mathtt{y}}\Upsilon_1\left(y\mid 0\right)\mathbb{1}_{\{0\in\mathtt{a},0\in\mathtt{h}\}}\end{aligned}$$

for all $\left(\mathtt{y},\mathtt{a},\mathtt{h},\mathtt{j}\right)\in\mathcal{B}\left(\mathcal{X}\right)$, and where Q is the transition function induced by $\Upsilon_j\left(Y'\mid Y\right)$, ξ, a^i and h^i, and where ϕ^i denotes the mass of households with expectations i, which is specified as follows,

$$Q\left(\left(Y,A,H,j\right),\left(\mathtt{y},\mathtt{a},\mathtt{h},\mathtt{j}\right)\right)=\sum_{i\in I}\phi^i\sum_{\xi\in\{0,1\}}Pr^{\xi}\sum_{y\in\mathtt{y}}\Upsilon_j\left(y\mid Y\right)\mathbb{1}_{\{a^i(Y,A,H,j)\in\mathtt{a},h^i(Y,A,H,j)\in\mathtt{h},j+1\in\mathtt{j}\}}$$

for all $\left(Y,A,H,j\right)\in\mathcal{X}$ and all $\left(\mathtt{y},\mathtt{a},\mathtt{h},\mathtt{j}\right)\in\mathcal{B}\left(\mathcal{X}\right)$.

The parameters to be chosen within the model are (i) the discount factor, (ii) those defining the second-order polynomial determining additional utility from home-ownership, (iii) the strength of the bequest motive, (iv) the degree of luxuriousness of bequests, and (v) the moving shock hazard rate. We work with two calibration of the model; one where the discount factor is set to match the average level of net financial assets, and one where household net worth is targeted. We adopt this approach in order to provide a robust range for our estimates but will refer to the version of the calibration that targets net financial assets as the benchmark.[40]

The home-ownership utility premium parameters are chosen to match the model-implied age polynomial for home ownership with its empirical counterpart, estimated controlling for time and cohort effects. The strength of bequests parameter is set targeting the median net worth ratio of eighty to fifty year-old households. The luxuriousness of bequests is set according to the percent of bequeathing households at the bottom half of the net worth distribution.[41] Finally, The hazard rate of the moving shock is set to target the average moving rate of homeowners.[42]

The version of the model used in calibration is the model with flexible HELOC loans; we keep parameters constant across the three versions of the borrowing constraint so we may attribute differences across them to the different borrowing constraints. In order to pin down the value of λ_E, we employ the net financial assets calibration to minimize the sum of squared errors between the moving rates of different expectation groups in the model as compared to the data.[43] We employ a nested-fixed-point algorithm to obtain the parameter values. Data

[40]This follows Carroll et al. (2017) who note that holdings of liquid financial assets are more left-skewed.

[41]Note that here we allow for some flexibility since we are unable to measure actual bequests in the data. Rather, we approximate this indicator by the percent of eighty year-old households that own a home.

[42]Since out model abstracts from moving cost for renters, we do not target this rate. With respect to homeowners, the moving shock adds additional ownership risk, which remains even after retirement.

[43]See Appendix E for confirmation that the essential relationship between house-price expectations and household MPCs and moving rates continues to hold for different values of λ_E. As to the working of the capital gains mechanism for inattentive households, it could be argued that it should be shut down altogether–both in the long- and short-term. While this position has some merit, the data rejects setting $\lambda_E^{Inattentive}=1.0$, which is what that approach calls for.

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moments and model-implied moments are reported in Table 9.[44]

Table 9: Target & Additional Data Moments

Targeted Moments	Data	Net Financial Assets Calibration	Net Worth Calibration
Average NW / NFA	-0.298 / 7.254	-0.311	6.722
Home-ownership rate	0.731	0.743	0.782
Median $NW_{j=80}$ / Median $NW_{j=50}$	1.391	1.170	1.320
Bequests below median $NW_{j=80}$	0.354	0.359	0.580
Polynomial Coefficient (1)	0.031	0.058	0.067
Polynomial Coefficient (2)	-0.0002	-0.0006	-0.0006
Homeowner's Moving Rate	0.019	0.019	0.018

Additional Moments	Data	Net Financial Assets Calibration	Net Worth Calibration
Ownership Rate per Wealth Quantile			
Homeownership Rate for Quantile 1	0.104	0.070	0.122
Homeownership Rate for Quantile 2	0.584	0.720	0.828
Homeownership Rate for Quantile 3	0.950	0.944	0.969
Homeownership Rate for Quantile 4	0.986	0.986	0.994
Homeownership Rate for Quantile 5	0.994	0.998	0.994
Net Worth Age Ratios			
Med NM(80) / Med NM(55)	1.215	1.146	1.138
Med NM(80) / Med NM(60)	1.168	0.933	1.000
Med NM(80) / Med NM(65)	1.045	0.786	0.892
Average Earnings per Housing State			
Average Earnings for Renters	0.884	0.666	0.758
Average Earnings for Owners	1.125	1.195	1.143
Ratio Owners/Renters	1.272	1.795	1.508
Average Quality of Rental and Owned Houses			
Average Rental House	0.221	0.206	0.228
Average Owned House	0.726	0.323	0.336
Ratio Owners/Renters	3.292	1.568	1.475
Moving Rates per Ownership Status			
Moving Rate for Renters	0.048	0.208	0.147
Moving Rate for Owners	0.019	0.019	0.018
Aggregate Moving Rate	0.027	0.067	0.046
Quantiles for Rental Housing Expenditures			
Rent / Income 10th percentile	0.198	0.211	0.206
Rent / Income 50th percentile	0.347	0.319	0.319
Rent / Income 90th percentile	0.802	0.471	0.489
Gini Coefficents			
Income	0.257	0.275	0.275
Housing Wealth	0.423	0.362	0.334
Net Worth	0.489	0.544	0.516
Average Rental Expenditure over Incomes			
All Age Cohorts	0.328	0.323	0.336
Excluding Retired Households	0.320	0.306	0.315

Note: All measures of household wealth and earnings are expressed in terms of median annual income (i.e., numeraire of the model). House sizes are represented by the housing grids. All other variables and statistics are self-described.

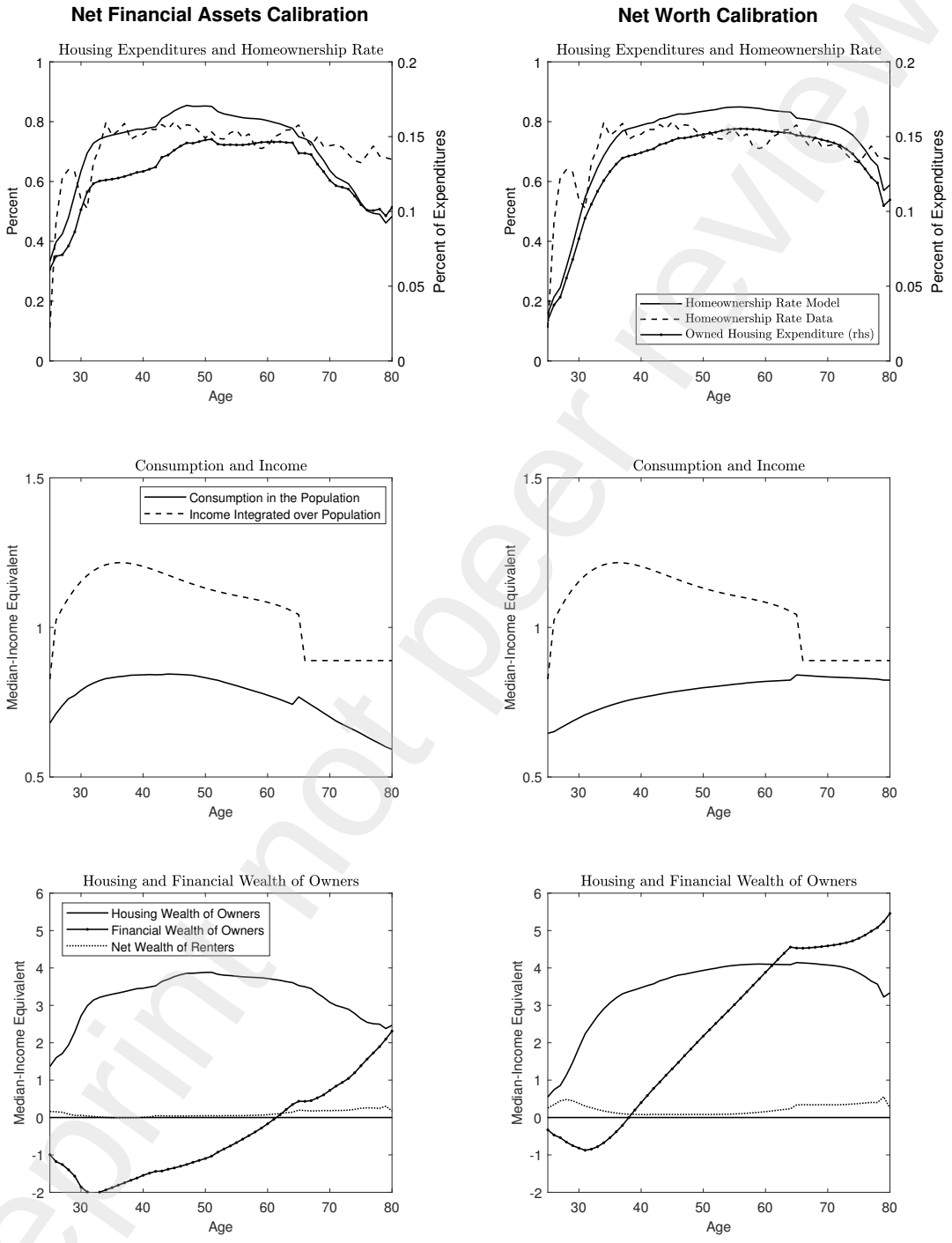
Finally, the life-cycle profiles of the baseline calibrations targeting net financial assets and net worth are presented in Figure 4. The takeaway from Table 9 and the top panels of Figure 4 is that the model does a pretty good job at matching the data.

[44]See Appendix F for the moments implied by the versions of the model that assume long-term mortgages and fixed refinancing costs.

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Figure 4: Life-Cycle Profiles



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4.3 MPCs Throughout the Life Cycle

In this section, we estimate the distribution of MPCs conditional on expected house-price growth. We fist validate the model's informative power by testing its ability to reproduce and account for the pattern characterizing the relationship between house-price expectations and house-adjustment rates. We then employ the model to compute the distribution of household MPCs as a function of short-term expectations and characterize the mechanism underlying the observed pattern to rationalize the empirical results of Sections 2 and 3.

Recall that in Section 3 we established that the most prominent and consistent pattern characterizing owners' house-adjustment rates is the non-linear relationship with expectations. Households in the bottom three expectations quintiles of the distribution exhibit a constant moving rate of about 2 percent, while this figure is around 3 percent for the third quintile and about 4 percent for the fifth quintile. Figure 5 shows that the "Flexible HELOC Loans" model– i.e., the calibrated version of the model–for both calibrations is able to replicate this empirical pattern.[45] Most importantly, under heterogeneous expectations, the model reproduces the 2-3-4 pattern strikingly well; despite not being explicitly targeted. Rounding to single digits, the model-implied moving propensities under the net financial assets calibration are 2 percent, 3 percent, and 4 percent.

Note that while we did not seek to establish causality between expectations to moving rates in the regression analysis of Section 3–where a version of the left-most graph of Figure 5 was identified–, the pattern implied by the model *should* be interpreted as a causal relationship from expectations to moving rates. In reading the center and right graphs of Figure 5, one should note that the only difference between the households belonging to each expectation group is their expected short-term house-price growth rate. Furthermore, as the plotted statistics are computed from the model's ergodic distribution, they are directly comparable to the long-term data averages included in the graph. In this sense, it is the difference in expectations that causes the difference in moving rates over the households' life cycle. The the mechanism underlying this pattern is the *expected housing capital gains channel*. This serves as a test of external validation of the model.[46] We are, therefore, confident in using the model to rationalize this behavioral pattern.

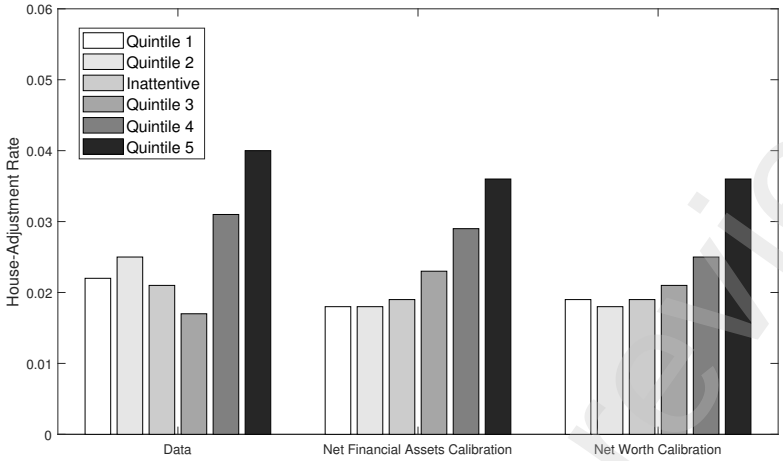
[45] While there is some variation in the adjustment-rates in the data for the first three expectations quintiles, we discount this feature somewhat as they are only occasionally significantly different between each other in the regression analysis.

[46] Although this pattern was influenced by the choice of λ_E, the qualitative pattern is a result of housing capital gains mechanism, rather than the randomization of expectations.

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Figure 5: Owner House-Adjustment Rates by Expectation Quintile



Note: Flexible HELOC Loans model calibrated to data.

The model-implied relationship between house-price expectations and house-adjustment rates is shown in Table 10. It is noteworthy that the empirical house-adjustment rates are matched quite well by all versions of the model. This provides additional evidence that the model does not misrepresent the underlying mechanism at work in the data. For negative and low levels of expected house-price growth, house-adjustment is essentially flat at the exogenous moving shock hazard rate. The reason is that homeowners can limit the wealth effects of negative housing capital gains by not moving or postponing moving. However, households that expect strong capital gains going forward have both an incentive to move up planned house-adjustments, and a strong perceived wealth effect that motivates higher target levels of housing consumption.

We use both calibrations and the three versions of the borrowing constraint for homeowners to estimate the effect of heterogeneous house-price expectations on the distribution of household annual MPCs. We focus on the six key groups that proved to be most relevant for analysis in Section 3. Namely, inattentive households, who expect that house prices will stay the same, and attentive households indexed by their expectation quintile. In order to compute the distribution of MPCs in the household sector, we integrate over the model-implied measure of households over expectations and states, Φ. Further, we define MPCs as the partial derivative of the household's consumption function over liquid wealth or beginning-of-period cash-on-hand.[47]

[47] Generally, MPCs are defined as the difference in consumption levels over a period of time owing to a purely-transitory windfall monetary gain. The definition we employ here is a specific version of this where the windfall gain is vanishingly small and the period in question is a calendar year.

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Table 10: Owner House-Adjustment Rates by Expectation Group and Borrowing Constraint

Net Financial Assets Calibration

Expectation Group	Data	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	0.022	0.018	0.017	0.018
Quintile 2	0.025	0.018	0.018	0.021
Inattentive	0.021	0.019	0.022	0.022
Quintile 3	0.017	0.023	0.023	0.022
Quintile 4	0.031	0.029	0.023	0.028
Quintile 5	0.040	0.036	0.023	0.035
Overall Average	0.026	0.024	0.021	0.024

Net Worth Calibration

Expectation Group	Data	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	0.022	0.019	0.019	0.019
Quintile 2	0.025	0.018	0.019	0.019
Inattentive	0.021	0.019	0.019	0.019
Quintile 3	0.017	0.021	0.023	0.023
Quintile 4	0.031	0.025	0.023	0.026
Quintile 5	0.040	0.036	0.025	0.037
Overall Average	0.026	0.023	0.021	0.024

Note: The values reported in the second column are computed from the data. All other values are computed from the models.

Definition 3 *The household's marginal propensity to consume, $MPC(\cdot)$, is defined as the change in consumption that is optimal in response to a vanishingly-small increase in the position of their liquid wealth, W:*

$$MPC\left(Y, A, H, j, E(P)\right) = \frac{\partial c\left(Y, A, H, j, E(P)\right)}{\partial W\left(Y, A, H, j, E(P)\right)}$$

where $c(\cdot)$ is the household's consumption function.

The marginal propensity to consume for any subset $\mathcal{E} \in \Omega$ is given by the integral of marginal propensities to consume with respect to the measure of that subset over the state space.

$$MPC^{\mathcal{E}}\left(\mathtt{y}, \mathtt{a}, \mathtt{h}, \mathtt{j}, \mathtt{E(p)}\right) = \int_{e \in \mathcal{E}} \frac{\partial c\left(Y, A, H, j, E(P)\right)}{\partial W\left(Y, A, H, j, E(P)\right)} \, d\Phi$$

We approximate the MPCs by numerically differentiating expectation-specific consumption functions. The mean estimates for MPCs are shown in Table 11; all reported figures are in annual terms. The estimates obtained are well within the range of the literature. For the net financial assets calibration, the mean estimates are around 0.17. This is greater than the mean estimates for the net worth calibration, where the average MPC is around 0.10. This owes to the fact that the empirical distribution of net financial assets is more left-skewed as compared to that of new worth. This results in a lower value for the discount factor which in turn, leads to higher propensities to consume. For reference, we offer the estimates for average MPC obtained by Krusell and Smith (1998)– between 0.05 and 0.09–,[48] Carroll et al. (2017) –who find 0.16 and 0.33, depending if there is heterogeneity in households' discount factors–, and Kaplan and Violante (2014), Kaplan et al. (2020)–both of which obtain an annual MPC

[48] As reported by Carroll et al. (2017), for consistency.

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of around 0.20. The range of average MPCs across different expectation groups varies from 0.063 to 0.327, which in terms of magnitude is also consistent with the literature. However, whereas the literature has found a high degree of heterogeneity without reference to subjective expectations, our results establish that some measure of this empirical heterogeneity is the result of heterogeneous expectations. Indeed, the MPCs exhibit the same pattern as house-adjustment rates–as documented in Section 3 for the data.

Table 11: Mean MPC by Expectation Group and Borrowing Constraint

Net Financial Assets Calibration

Expectation Group	$E_t(\pi^P_{t+1})$	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	-0.073	0.123	0.136	0.136
Quintile 2	-0.015	0.116	0.136	0.137
Inattentive	0.000	0.118	0.134	0.132
Quintile 3	0.020	0.161	0.169	0.145
Quintile 4	0.033	0.215	0.204	0.184
Quintile 5	0.063	0.327	0.245	0.263
Overall Average	0.005	0.177	0.171	0.166

Net Worth Calibration

Expectation Group	$E_t(\pi^P_{t+1})$	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	-0.073	0.063	0.063	0.065
Quintile 2	-0.015	0.064	0.063	0.064
Inattentive	0.000	0.064	0.070	0.070
Quintile 3	0.020	0.082	0.101	0.089
Quintile 4	0.033	0.114	0.131	0.128
Quintile 5	0.063	0.218	0.196	0.200
Overall Average	0.005	0.101	0.104	0.0103

Note: The values reported in the second column on house-price growth expectations, $E_t(\pi^P_{t+1})$, are computed from the data. All other values are computed from the models. MPCs are derived from annual variables.

Table 11 also has implications for the effect of borrowing constraints on household MPCs. Note that the least restrictive borrowing constraint from the set is the flexible HELOC loan contract, since it imposes no forced repayment schedule and it can be increased with no cost. Long-term mortgages are more restrictive in that they require a minimum payment every period and cannot be increase without paying the transaction cost associated with home-adjustment. Fixed refinancing also implies more stringent borrowing since increasing a loan requires paying a fixed cost. These features of a more stringent borrowing constraint have the effect of reducing the variance of MPCs across expectation groups. Specifically, both for the net financial assets and net worth calibrations, the MPCs for lower expectations quintiles are higher relative to the flexible HELOC loans case, while the MPCs for the highest quintiles are smaller. Hence, the dispersion of MPCs across expectations groups is reduced by tighter borrowing constraints.

Regarding the influence of house-price expectations on MPCs, our results show a clear and positive correlation between expected house-price growth and average MPCs. The lowest MPCs, around 0.12 and 0.06 for the net financial assets and new worth calibrations respectively,

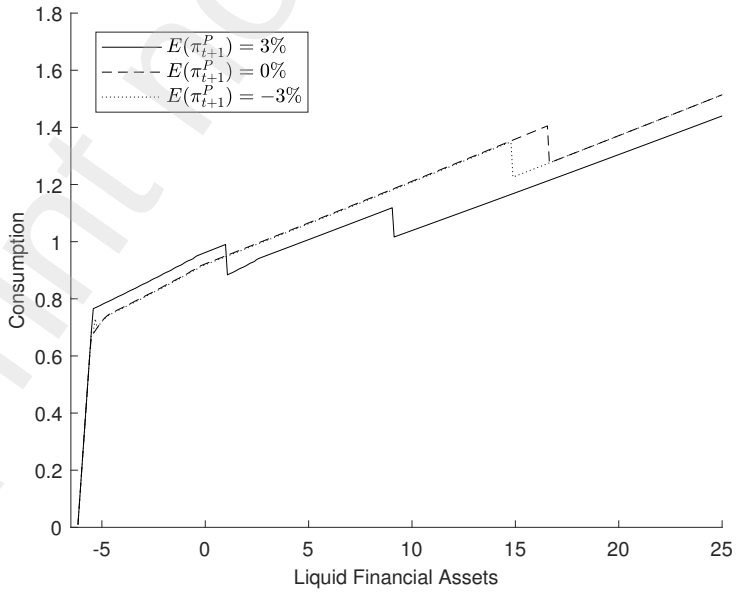
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are associated with strongly negative expected future house-price growth, at -7.3 percent. The average MPC increases steadily to a maximum of around 0.33 and 0.22 for the average expectation of quintile 5, at 6.3 percent. That is an increment of roughly 3x. These stylized facts owe to the perceived wealth effects that high-expectations household have, which results in a steeper consumption function on average, and on a higher house-adjustment rate–as shown in Table 10.

By moving more often, households in quintiles three through five–all of which have positive house-price growth expectations–are more likely to be in steeper areas of their consumption functions. Recall that the presence of a discrete choice in the form of housing in the households' dynamic programming problem induces kinks in their value functions and in turn, downward discontinuities in the consumption function. This is shown in Figure 6, where the consumption function for the same household (i.e., with the same states) has been graphed at three different levels of expected house-price growth. Households adjust on average their consumption level downward at the time of the move, as initial housing expenses are realized. Subsequently, the following consumption pattern is locally steeper, as liquid wealth is rebuilt and consumption returns to its pre-adjustment level. However, the household with $E(\pi^P_{t+1}) = 3\%$ will on average adjust more frequently and have a globally-higher level of consumption–given the presence of positive wealth effects–, yielding a higher slope throughout. Finally, notice that the effect of expectations on MPCs and house-adjustment rates is highly non-linear. These patterns are consistent with and complementary to the statistical analysis of Section 3.

Figure 6: Expected House-Price Growth and the Consumption Function



Note: The measures for consumption and liquid financial assets are specified in median net household income. The consumption functions plotted are identical in all states except for expected house-price growth.

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The effect of house-price expectations on the distribution of MPCs is shown in Figure 7, which further details the data from Table 11 and which shows box plot graphs for household MPCs by expectations group and borrowing constraint.[49] In contrast to the similarity of house-adjustment rates across borrowing constraints, for MPCs we find that homeowners' borrowing constraints do have a significant effect. The box plots denote by their bottom and top extreme lines the 1^{st} and 99^{th} percentiles of their distribution. The boxes are defined by the 10^{th} and 90^{th} percentiles, and so contain 80 percent of the distribution's mass. The line in the boxes is the mean MPC for the expectation group.

It is important to note that within an expectation group, all agents have the same belief. Similarly, all agents are subject to the same exogenous processes of age, earnings, and moving shocks. Therefore, the difference in the dispersion of MPCs between expectation groups is the result of endogenous household choices with regard to consumption, savings and housing. Given the complementarity between housing and non-durable consumption, the shape of the distribution of MPCs is similar to that of moving propensities. Low-expectation households have an average MPC of around 0.12; households in the 4^{th} quintile–$E(p) = 3.3$ percent–have an average MPC of 0.22; and households in the 5^{th} quintile–$E(p) = 6.3$ percent–have an MPC of 0.33. The standard deviation of high-expectation MPCs is 3.5x that of low-expectation households.

So, the picture is one of relative stability at the lower end of the expectations distribution, with a lot more action at the top end of the distribution. The mechanism driving this pattern is the *expected housing capital gains channel*. When house prices go up, homeowners experience a positive wealth and endowment effect. Similarly, households that expect positive house-price growth estimate a higher present value of their net worth. This boosts their demand for consumption of both non-durables and housing services. Over the life-cycle, they move into larger houses, they move more frequently, they are more likely to take on a mortgage, and hence more likely to be borrowing-constrained or wealthy hand-to-mouth households. Contrast this with households that are otherwise similar, but expect negative house-price growth. They have little incentive to move. They perceive a negative wealth effect. They holding on to their house for longer, accumulate more liquid assets, and end up consuming far away from the borrowing constraint and in the flatter area of the consumption function.

Essentially, what is happening is that households with higher expectations are fanning out more broadly over the grid of available housing, and spanning a greater area of the state space. This leads to a heavier mass on the very concave regions of the consumption function; and a greater variance as well, for the same reason. Low-expectations households remain within a narrower region of the state space. This is the mechanism shaping the relationship between

[49] See Appendix G for additional distribution graphs.

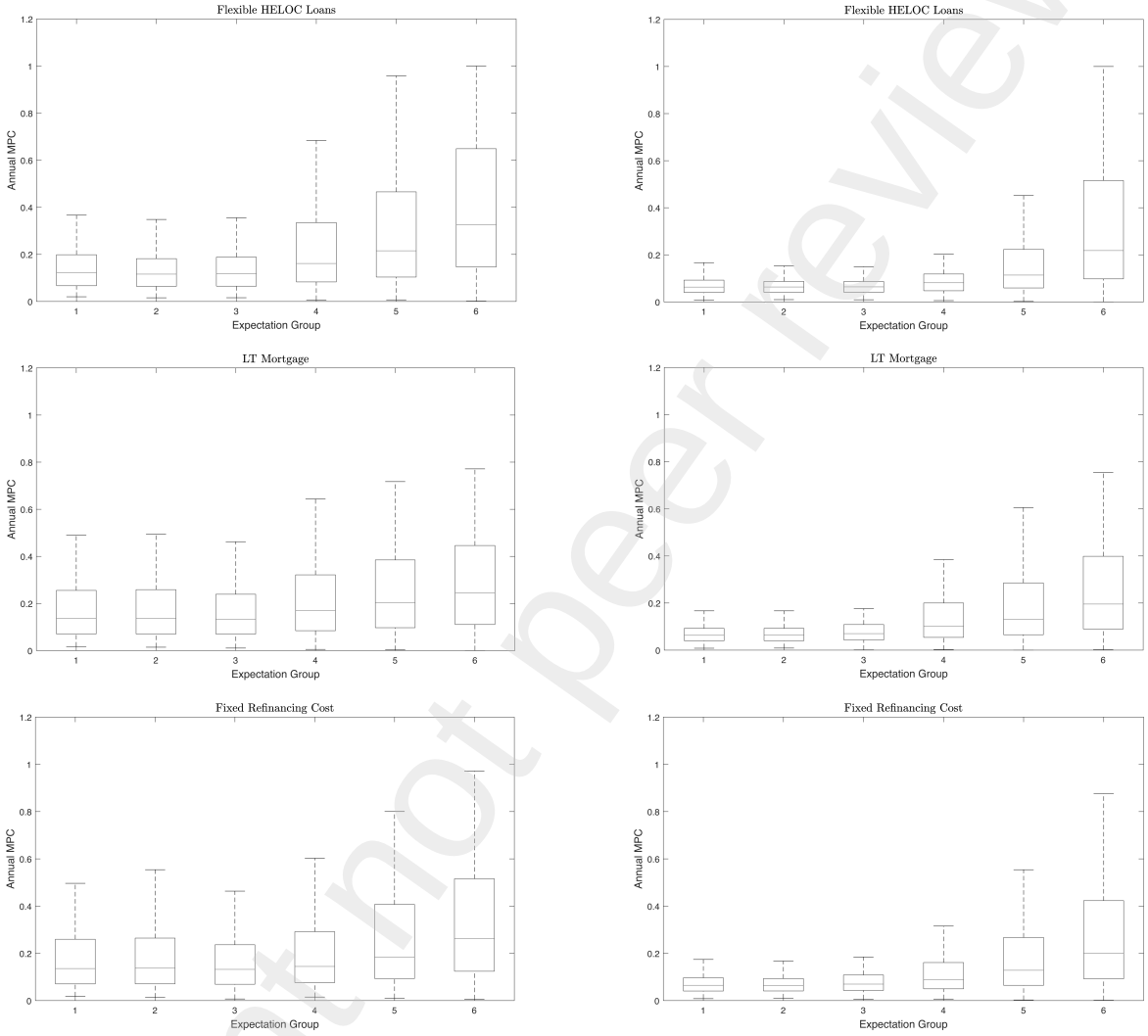
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expectations and MPCs. The model shows that it is very powerful and explains why it is identified it in the data with a high degree of robustness.

Figure 7: MPC Box Plots by Borrowing Constraint and Expectations

Net Financial Assets Calibration **Net Worth Calibration**



Note: Groups 1 and 2 are quintiles 1 and 2 of attentive households, respectively. Group 3 is inattentive households. Groups 4, 5 and 6 are attentive expectations' quintiles 3 through 5, respectively.

Finally, consider the effect of borrowing constraints. As before, in comparing the same expectation group between borrowing contracts, the difference is entirely attributable to this change in technology. Keep in mind that expectation groups 4-6 hold positive expectations, whereas groups 1-3 expect negative or no house-price growth. While the dispersion of MPCs for the first three groups is similar across the different borrowing constraints, it is increasing–together with the average–in the top three groups as one moves from the fixed refinancing cost function, to the long-term mortgage function, to the flexible HELOC loans function. The

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reason is that, while homeowners that expect positive house-price growth have (on average) the desire to increase consumption and/or housing, they are limited from doing so to varying degrees by the constraint they face. HELOC loans, from this perspective, are the most lax constraint and enable households to draw on a large share of their home equity, in order to finance higher non-durable consumption, at any given time. The result is a wide dispersion and a higher average of MPCs. while it is not clear if long-term mortgage contracts or fixed refinancing costs are more restrictive from the household's perspective, the results show that fixed refinancing costs have the greater effect in limiting the dispersion of MPCs. Households are still able to extract equity from their house values but at a high cost; it may be that the expected capital gains that are associated with these expectation groups are not high enough to justify that adjustment, or possibly the current cost of refinancing is prohibitively expensive.

4.4 Response to Government Stimulus Shocks

In this section we study the effect of household house-price expectations on the effectiveness of government stimulus in the form of cash transfers, a.k.a. stimulus checks. We focus on impact of heterogeneous expectations on the efficiency of government transfers in supporting aggregate consumption. The relevant measure for this question is the RC, which is similar to the MPC but not identical. Recall that we have defined the MPC as the response of consumption to an infinitesimal relaxation of the household's liquid resources. RCs, in contrast, are defined as the total change in consumption over a period of time in response to a fixed government transfer, and given a fiscal policy.

We model the government's stimulus package directed to households on the United States CARES Act that was passed in March of 2020. This stimulus was directed to households and directly mailed or deposited payments of $ 1,200 USD per adult plus $ 500 USD per child-dependent. The policy was not means tested. As to the headline figure, Misra et al. (2022) estimate an average household payment of $ 1,628 USD. Hence, we employ as our benchmark case a government stimulus policy that directly provides to all households a money transfer of $ 1,628 USD, or in euro terms € 1,428 EUR.

The experiment we carry out is as follows. The government unexpectedly provides all households with a check for € 1,428 EUR. This payment is financed in its totality by taking on debt at the exogenous, international interest rate of r_b. Simultaneously, it announces that in ten years time it will permanently increase the tax on labor earnings to pay off the debt plus interest. This policy is common knowledge, and the following government budget constraint at period t is imposed.

$$\int_{x\in\mathcal{X}} g_t \, d\Phi_t = \sum_{s=t+10}^{\infty} \left(\frac{1}{1+r_b}\right)^s \int_{x\in\mathcal{X}} \tau Y_s(x) \, d\Phi_s$$

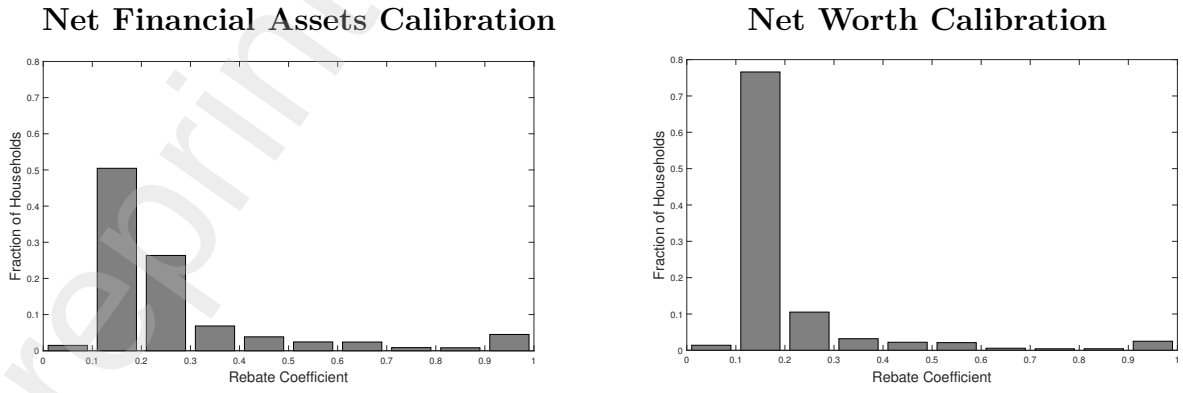
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where g_t is the stimulus payment and τ is the tax on labor earnings.

Households optimize and realize their consumption and savings decisions for the year, $C(X_g)$. We compute in parallel households' choices in the comparable steady state economy, where no government policy takes place, $C(X_{ss})$. The difference between the two choices for consumption is defined as the model-implied RC, $RB(g) := C(X_g) - C(X_{ss})$.[50]

A few words of clarification are in order. As our data is in annual terms, we are only able to compute annual measures of RCs. For this reason, we do not need to be as nuanced in defining the informational structure in which households operate. Similarly, a differentiation between households that have received payments and those that have not does not show up in our data set. Thus, we cannot compare these two types of households in measuring the RC implied by our model. However, the underlying definition between our measurements and those of Kaplan and Violante (2014) is the same, for both seek to isolate the impact of stimulus payments on otherwise identical households; in our case, they just happen to be the *same* household, in a different state of the world. Lastly, it should be noted that throughout this analysis all prices are kept constant. Therefore, this study cannot speak to second- and higher-order effects. The main reason for this is that there is not yet a well-established framework for dealing with the relationship between expectations and general equilibrium prices once economic agents are allowed to deviate from rational expectations. Since we take expectations from the data as given, we consider the derivation of such a relationship as being outside the scope of our study. Our results are greatly relevant, nonetheless, since they describe in detail the first-order effects on the part of households. This, along with the characterization of the underlying mechanism, is the driving force behind the relationship between house-price expectations and household consumption; additional features are a function of supply-side market structures that vary from country to country.

Figure 8: Rebate Coefficient Histogram



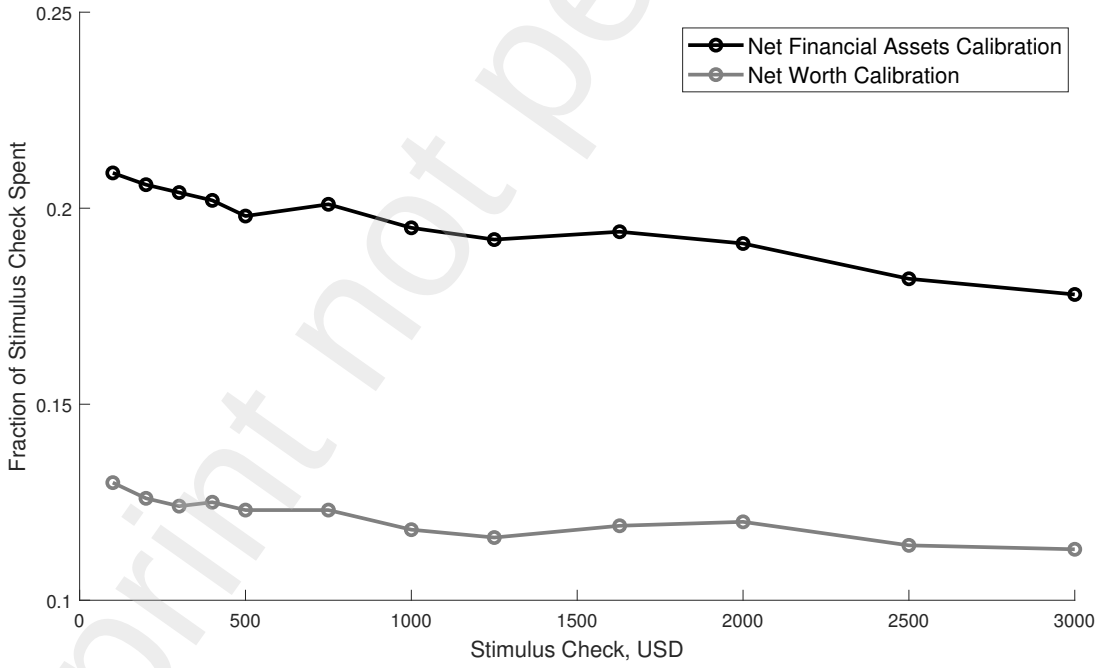
[50] We follow Kaplan and Violante (2014) both in the structure of the experiment and in adopting the label *rebate coefficient*, or RC.

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Turning now to the results, Figure 8 depicts from the stimulus policy experiment, the histograms for the RCs from both the net financial assets and net worth calibrations. We see that the general shape implied by the model, even under heterogeneous expectations, is consistent with the findings in the literature. There is a large mass of households –around 80 percent– that spend less than a fourth of the stimulus payment in the year after receiving it. These households are generally not borrowing constrained and, as detailed below, more likely to have low expected values of house-price growth. The net financial assets calibration is more right-skewed than the net worth calibration. This is mainly due to the lower discount factor on the part of households, which induces more front-loaded short-term consumption–all else being equal. The result is not only a stronger preference for immediate consumption but also a higher fraction of these households being borrowing constrained, regardless of their expectations with respect to house prices. While only about 6 percent of households in the net worth calibration spend at least half of the government stimulus in the first year, it is almost double this figure, at 11 percent, in the net financial assets calibration.

Figure 9: Rebate Coefficients by Stimulus Size



Note: The fraction of stimulus check spent is measured in annual terms.

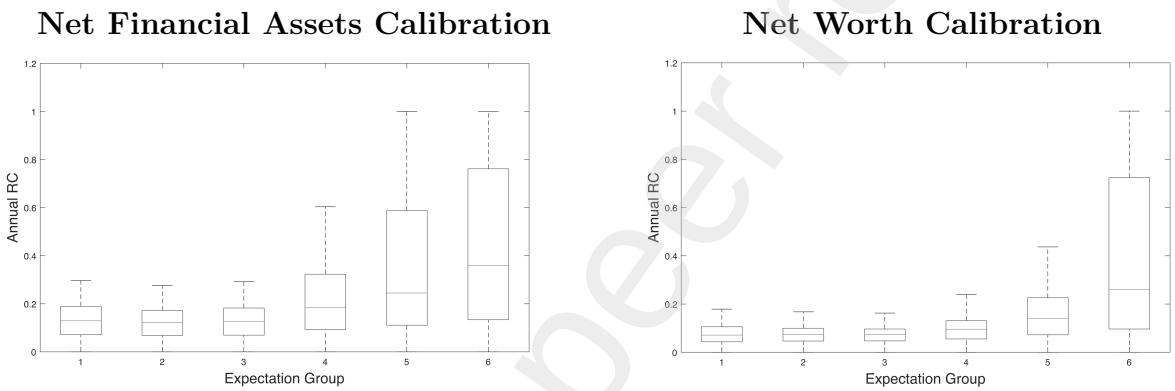
While we think of the net financial assets calibration as being the benchmark case for analyzing our experiment, these measures together provide a robust estimate of the RCs that are consistent with the data. An additional implication of our model is that the average RC of the economy turns out to be remarkably stable with regard to the size of the stimulus package.

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Consider Figure 9 below. This graph presents the average RC for both calibrations under different values of household checks. The minimum stimulus check presented is $ 100 USD and the maximum check is fro $ 3,000 USD. The model produces curves for the average RCs that broadly decline as the amount of the check grows, which is consistent with the literature. This implies diminishing returns–in terms of efficiency–to stimulus from the government's perspective. However, it is remarkable how flat the cures are. While the net financial assets calibration falls from 21 percent at $ 100 USD to 18 percent at $ 3,000 USD, the equivalent decline for the net worth calibration is from 13 percent to 11 percent. Those are differences of only 2 to 3 percent.[51]

Figure 10: Rebate Coefficient Box Plot by Expectations



Note: Groups 1 and 2 are quintiles 1 and 2 of attentive households, respectively. Group 3 is inattentive households. Groups 4, 5 and 6 are attentive expectations' quintiles 3 through 5, respectively.

In Figure 10 below, we present the box plots for the two calibrations under the US CARES Act experiment. These graphs yield a good representation of the heterogeneity in RCs that exists between expectation groups; indeed, they are complementary to the analogous graphs presented in Section 4.3. The main takeaway, in contrast to the relative stability of the *average* RC across stimulus package sizes, is that there is great heterogeneity between house-price expectations groups, for a given stimulus package. The general pattern is analogous to the box plots of the MPC estimates reported previously. Households that expect higher growth rates for house prices exhibit much more dispersion in the RCs associated with the stimulus experiment. The average RC is also higher for households with high expected house-price growth. The average RC for the highest expectation group, for example, is roughly 30 percent for the net financial assets and net worth calibrations. Additionally, the dispersion of RCs for this group is very large, with the 90^{th} percentile being around 80 percent. In contrast, households with low and negative expected house-price growth exhibit low RCs with low variance within the group.

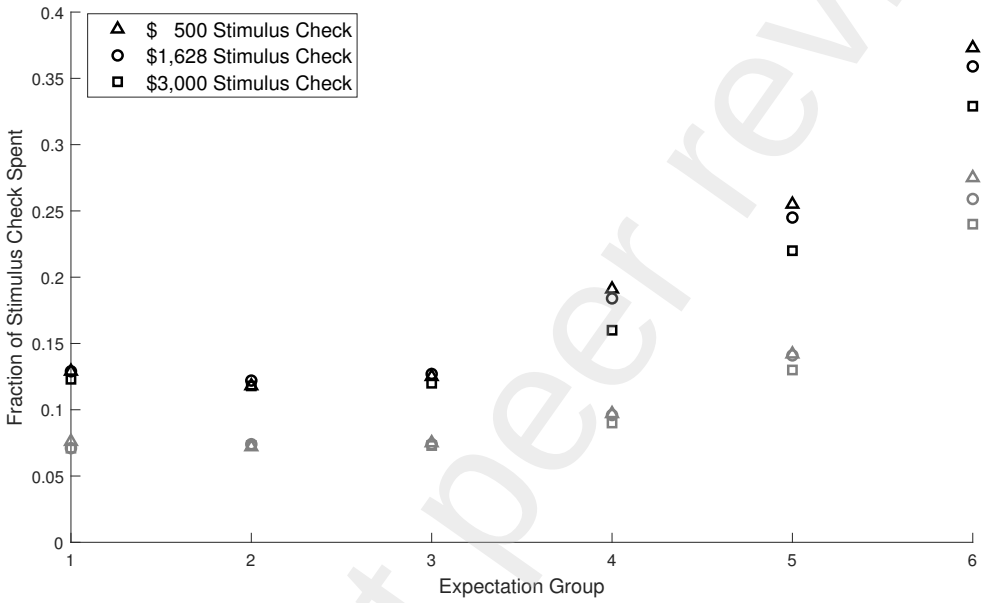
[51] For comparison, the analogous statistic estimated by Kaplan and Violante (2014) is a decline from 40 percent for $ 100 USD to about 23 percent for $ 3,000 USD; a variation of 17 percent.

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These features follow from the analysis of Section 4.3. Households with high expectations tend to be more constrained in terms of their desired level of consumption and more prone to adjusting their level of housing. These features result in a higher average and more dispersed RC. From the policy maker's perspective, house-price expectations serve as an indicator of the effectiveness of direct transfers as stimulus policies for household consumption.

Figure 11: Rebate Coefficients by Expectation Group



Note: Markers in black are for the net financial assets calibration and markers in gray are for the net worth calibration. Groups 1 and 2 are quintiles 1 and 2 of attentive households, respectively. Group 3 is inattentive households. Groups 4, 5 and 6 are attentive expectations' quintiles 3 through 5, respectively. The fraction of stimulus check spent is measured in annual terms.

Finally, we show that the relative dispersion of RCs across expectations groups carries over to the dispersion over stimulus sizes. In Figure 11 we plot the average RC per expectation group for three different stimulus package sizes; both calibrations are included in the graph. Firstly, note that the RCs for the net worth calibration are in all cases lower than those of the net financial assets calibration. This is consistent with Figure 8 but additionally demonstrates that the relation between the two calibrations extends to all expectation groups. Secondly, it is important to note that the average RC for groups 1, 2, and 3–all of whom expect non-positive short-term house-price growth–do not vary across stimulus package sizes. Indeed, the average RCs of 7 and 13 percent seem to be almost independent of the stimulus size. Finally, in contrast to low-expectations households, the RCs for expectations groups 4, 5, and 6 exhibit variation both between each other and across the stimulus package sizes. For instance, the RCs for expectations group 6 declines from 38 percent for a stimulus check of $ 500 USD to 33 percent

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at $ 3,000 USD, in the net financial assets calibration. The analogous numbers for the net worth calibration are 28 percent and 24 percent. These are relatively steep declines of 5 and 4 percent.

Table 12: Average Homeowner Leverage and Percent of Constrained Households

Net Financial Assets Calibration

Expectation Group	Average Homeowner Leverage	Constrained Households
Quintile 1	17.1	10.7
Quintile 2	26.0	9.1
Inattentive	27.7	9.9
Quintile 3	46.5	8.0
Quintile 4	55.3	11.2
Quintile 5	64.4	17.3
Overall Average	39.5	11.0

Net Worth Calibration

Expectation Group	Average Homeowner Leverage	Constrained Households
Quintile 1	0.0	3.4
Quintile 2	6.9	3.4
Inattentive	9.6	3.3
Quintile 3	24.8	2.6
Quintile 4	35.7	4.7
Quintile 5	52.2	7.0
Overall Average	21.5	4.1

Note: Homeowner leverage and constrained households are specified in percent.

The implication of this analysis is therefore that government stimulus is most effective on households that hold high house-price expectations. Such households are prone to spending a high proportion of stimulus checks as they tend to be more frequently borrowing constrained; see Table 12. These households are also more likely to adjust their housing and in turn, spend more on non-durable consumption. However, high expectations households are also more sensitive to the size of the stimulus package; their RCs fall relatively steeply as the size of the stimulus checks increases. In contrast, low-expectations households tend to have low and insensitive RCs. The effectiveness of government stimulus is approximately constant for this group of households.

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5 Conclusion

This paper has studied the relationship between households' expectations about future house prices–as measured through survey responses–and their consumption choices, both in housing and non-durable goods. We have shown that there exists a robust relationship between the heterogeneity in the expectations of house-price growth and the size and dispersion of household MPCs. The survey data on housing choices and expectations bears this out. Using a large and representative sample of Dutch households, we established that households that expect higher growth rates for house prices exhibit a greater propensity to adjust their level of housing. Analogously, the propensity to move of households with higher house-price expectations reacts more strongly to monetary policy shocks. Employing a structural life-cycle model, this pattern is explained by the influence of heterogeneity on the house-adjustment rate through the housing capital gains channel.

Higher expected house-price growth leads to higher MPCs on average and, through the housing capital gains channel, an increased likelihood of moving. Positive expected capital gains provide a reason to adjust the consumption of housing upward given a positive perceived wealth/endowment effect. By moving more often, households that have positive house-price growth expectations are more likely to adjust their consumption level downward in the shape of a step function, as initial housing expenses are realized. The following consumption pattern is locally steep, as liquid wealth is rebuilt. Further, high wealth effects imply globally-higher consumption levels, leading to a higher average slope in consumption functions.

For negative and low levels of expected house-price growth, house-adjustment is essentially flat. The reason is that homeowners can limit the wealth effects of negative housing capital gains by not moving or postponing moving. However, households that expect strong capital gains going forward have both an incentive to move up planned house-adjustments, and experience a strong perceived wealth effect that motivates higher levels of housing. This behavior with regard to house adjustment has a direct effect on non-durable consumption. The result is higher average MPCs and a greater dispersion. Heterogeneity in households' expectations induces heterogeneity in their consumption choices.

We also explored the effect of house-price growth expectations on the effectiveness of government stimulus policies. We modeled the government's stimulus package directed to households on the United States 2020 CARES Act and computed the associated RCs. The main finding is akin to that of the MPC analysis. Households that expect higher growth rates for house prices exhibit much more dispersion in the RCs associated with the stimulus experiment. The average RC is also higher for households with high expected house-price growth. Additionally, the dispersion of RCs for this group is very large. In contrast, households with low and negative expected house-price growth exhibit low RCs with low variance within the group. From the

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policy maker's perspective, house-price expectations serve as an indicator of the effectiveness of direct payment as stimulus policies for household consumption. This result carries over to the dispersion over stimulus sizes. The implication of this analysis is therefore that government stimulus is most effective on households or states that exhibit high house-price expectations. Such households are prone to spending a high proportion of stimulus checks as they tend to be more frequently borrowing constrained. These households are also more likely to adjust their housing and in turn, spend more on non-durable consumption. However, high expectations households are also more sensitive to the size of the stimulus package; their RCs fall relatively steeply as the size of the stimulus checks increases. In contrast, low-expectations households tend to have low and insensitive RCs. Hence, the effectiveness of government stimulus is approximately constant for this group of households.

Finally, it is important to note that a number of extension would be useful to further develop our understanding of the influence of household expectations on their consumption and savings decisions. As noted throughout, we have abstracted from aggregate uncertainty in analyzing the structural model. The reason is that there is currently no consensus framework for modeling the interaction between expectations and aggregate prices that does impose restrictions that are inconsistent with the data. This implies that our estimates must be understood as measurements of the first-order; going forward it would be useful to extend the model by appending an explicit specification for the supply of housing. Analogously, while aggregate prices are modeled as being constant, households may still account for short-term uncertainty in their behavior. This dimension of households' dynamic programming problem is straightforward to incorporate into our setting but in view of the absence of data, we have only implicitly addressed it through the randomization strategy that links short- and long-term expectations. Finally, we have remained throughout the analysis agnostic about the expectation-formation process. The reason is that–as with households' perceived uncertainty regarding aggregate prices–this is a first approach to addressing the research question by taking the data *as given*; as such, a reticence in adopting *ad hoc* modeling mechanisms is more compellingly called for, rather than arbitrarily adding features that may lack strong empirical support. All this notwithstanding, the three extensions listed above are valuable and warranted refinements that need to be pursued in future research. Such an analysis is likely to push the field a long way forward towards incorporating realistic measures of expectations into macroeconomic policy frameworks.

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Appendix

A Data Description and Sources

All data is aggregated at the households level and defined in annual terms, unless otherwise stated. The main sample is from 2004 to 2018; The year 2004 is the first year in which questions on households' expectations of house prices were included in the sample and we stop at 2018 in order to avoid the data potentially being contaminated by the SARS-CoV-2 pandemic. Households with negative net worth are dropped from the sample. The sample is further selected by dropping the bottom and top one percent of all expectations questions in order to eliminate extreme values. The household responses on the year in which the current accommodation was purchased and the year in which it was move into underwent an error-correction phase to make sue they are weekly increasing and complete for the period of household participation; when the correct response in not obvious the observation has been dropped. In carrying out all regressions, the data have been transformed into a *beginning-of-period* timing convention, rather than a *period-of-response* convention, since the former is more in line with both formal quantitative models and informal economic reasoning.

- Short-term Market House Price Expectations: Expected average change in house prices in the next two years; in annual percent. Source: DNB Household Survey (WOD205,WOD206, WOD44P,WOD44Q).
- Short-term Own-Home Price Expectations: Expected average change in the price of home owned by household over the next two years; in annual percent. Source: DNB Household Survey (WO44A,WO44B).
- Long-term House Price Expectations: Expected average increase in house prices over a period of ten years; in annual percent. Source: DNB Household Survey (WOD207,WOD44RA).
- Consumer Price Expectations: Expected change in consumer price over the next twelve months; in annual percent. Source: DNB Household Survey (PR0,PR1a,PR2a,PR3a,PR4a).
- Net income: Total net income minus income from interest and real estate income; specified in thousands of 2002 euros. Source: DNB Household Survey; see Appendix D for details.
- Assets: Total assets excluding primary owned house; specified in thousands of 2002 euros. Source: DNB Household Survey.
- Housing: Value of primary owned house; specified in thousands of 2002 euros. Source: DNB Household Survey.

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- Mortgage: Total value outstanding mortgages; specified in thousands of 2002 euros. Source: DNB Household Survey.
- Rent: Total rental expenditure; specified in thousands of 2002 euros. Source: DNB Household Survey (WOD205,WOD206).
- Age: Age of the household head. Source: DNB Household Survey.
- Household size: Number of household members. Source: DNB Household Survey.
- College: Dummy variable indicating if head of household has attended college. Source: DNB Household Survey.
- Retired: Dummy variable indicating if head of household is retired. Source: DNB Household Survey.
- Rural: Dummy variable indicating if household is in a rural region. Source: DNB Household Survey.
- Province: Variable denoting the province where the household is located. Source: DNB Household Survey.
- Home Adjustment Indicator: Dummy variable indicating if the household moved in the period; it is constructed using the variables indicating when the current accommodation was purchased or moved into. Source: DNB Household Survey.
- Consumer Price Index: Price index for the Netherlands. Source: ECB's *Statistical Data Warehouse*.
- House Prices: Price index for housing in the Netherlands. Source: ECB's *Statistical Data Warehouse*.
- Monetary Policy Shocks: Total monetary policy surprises derived from the euro area futures market; in percent. Source: (Gertler and Karadi, 2015).

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B Robustness Checks

In this appendix we provide regression results that sure as robustness exercises for the analysis provided in Section 3. Specifically, the main regressions with regard to house-adjustment behavior are carried out while controlling for cohort effects in the data, and analogous regressions are done employing inflation expectations as as exogenous variable, rather than house-price expectations. This exercise is intended as a sort of *placebo* test to see if house-price expectations are only an indication of general optimism/pessimism, and not specific to the housing market. Based on the inflation-placebo regressions, we rule this out.

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Table A1: Home Adjustment Behavior and House-Price Expectations with Cohort Fixed Effects

Independent Variable:	HH Characteristics	Full Sample	Boom Period	Bust Period	Quintile	House Adj pct
House-Adjustment Indicator	(1)	(2)	(3)	(4)	(5)	(6)
House Price Expectation		0.0012*	0.0036***	-0.0006		3.8969***
		(0.0006)	(0.0010)	(0.0008)		(1.2987)
Quintile 2					0.0262***	
					(0.0084)	
Quintile 3					0.0161*	
					(0.0087)	
Quintile 4					0.0399***	
					(0.0102)	
Quintile 5					0.0679***	
					(0.0138)	
Strictly Inattentive		-0.0003	-0.0111	0.0382**	-0.0011	59.1946***
		(0.0080)	(0.0087)	(0.0149)	(0.0162)	(16.1216)
House-Price Growth	0.0007*	0.0006	-0.0016	0.0117***	0.0006	0.3986
	(0.0004)	(0.0004)	(0.0011)	(0.0024)	(0.0008)	(0.5720)
Net Income	0.0006***	0.0006***	0.0005**	0.0006	0.0003	0.2845*
	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.1482)
Net Financial Assets	0.0000	0.0000	-0.0000	0.0000	0.0001	-0.0213
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0268)
Housing Wealth	-0.0002***	-0.0002***	-0.0002***	-0.0001	-0.0002***	-0.0033
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0486)
Mortgage Value	-0.0001***	-0.0001***	-0.0001***	-0.0000	-0.0002***	0.0691*
	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0001)	(0.0398)
Age of HH Head	-0.0009	-0.0007	-0.0012	0.0293***	-0.0073	1.9071
	(0.0029)	(0.0029)	(0.0032)	(0.0091)	(0.0050)	(1.4603)
Age of HH Head Sq.	-0.0000	-0.0000	0.0000	-0.0001*	0.0000	-0.0211
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0142)
Household Size	-0.0051**	-0.0051**	-0.0067**	-0.0030	-0.0070*	-0.7752
	(0.0025)	(0.0025)	(0.0028)	(0.0030)	(0.0039)	(3.0418)
College	0.0026	0.0027	0.0007	-0.0013	0.0077	0.8807
	(0.0053)	(0.0052)	(0.0060)	(0.0062)	(0.0080)	(6.3431)
Retired	-0.0103	-0.0102	-0.0104	-0.0116	-0.0075	2.9400
	(0.0077)	(0.0077)	(0.0095)	(0.0126)	(0.0121)	(11.7871)
Constant	0.1441	0.1354	0.1589	-1.6537***	1.0852***	-41.0507
	(0.0912)	(0.0914)	(0.0987)	(0.3652)	(0.1122)	(36.3234)
Household FE	Yes	Yes	Yes	Yes	Yes	No
Cohort FE	Yes	Yes	Yes	Yes	Yes	No
Region FE	Yes	Yes	Yes	Yes	Yes	No
Observations	8251	8251	5502	2749	3833	122
R^2	0.0417	0.0422	0.0537	0.0887	0.0833	0.2790

Note: Robust standard errors in parentheses. House-Price Expectations are in percentage points. Full sample encompasses 2003-2019; the bust period is defined as 2009-2013,while the boom period is the complement time-frame. Quintile refers to the intra-year quintile of house-price expectations that attentive households fall into; inattentive household are not included in this regression. The variable for house adjustment is the change in housing wealth –in percentage points– of moving households. Strictly inattentive is an indicator variable for households that always report zero expected house-price growth or do not report expectations. Net income and household portfolio items are in thousands of euros; mortgage values are reported in positive figures. Household size is the number of members in the household. College and Retired are dummy variables.

$^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

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Table A2: Home Adjustment Behavior and Inflation Expectations

House-Adjustment Indicator	HH Characteristics (1)	Full Sample (2)	Boom Period (3)	Bust Period (4)	Quintile (5)	House Adj pct (6)
Inflation Expectation		0.0011	0.0007	0.0020		1.5212
		(0.0016)	(0.0020)	(0.0022)		(2.5491)
Quintile 2					0.0034	
					(0.0057)	
Quintile 3					0.0151**	
					(0.0077)	
Quintile 4					-0.0050	
					(0.0059)	
Quintile 5					0.0067	
					(0.0070)	
Strictly Inattentive		-0.0007	-0.0050	0.0141	-0.0007	46.8954***
		(0.0075)	(0.0089)	(0.0113)	(0.0072)	(12.5511)
Net Income	0.0004**	0.0004**	0.0002	0.0006*	0.0004*	0.3089**
	(0.0002)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.1558)
Net Financial Assets	0.0001**	0.0001**	0.0000	0.0001**	0.0001**	-0.0008
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0294)
Housing Wealth	-0.0004***	-0.0004***	-0.0004***	-0.0002***	-0.0004***	0.0216
	(0.0000)	(0.0000)	(0.0000)	(0.0001)	(0.0000)	(0.0602)
Mortgage Value	-0.0003***	-0.0003***	-0.0003***	-0.0001	-0.0003***	0.0694
	(0.0000)	(0.0000)	(0.0001)	(0.0001)	(0.0000)	(0.0429)
Age of HH Head	-0.0083***	-0.0077***	-0.0089***	-0.0044**	-0.0076***	2.4410
	(0.0014)	(0.0014)	(0.0017)	(0.0021)	(0.0014)	(2.0271)
Age of HH Head Sq.	0.0001***	0.0001***	0.0001***	0.0000*	0.0001***	-0.0285
	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0000)	(0.0205)
Household Size	-0.0067***	-0.0070***	-0.0079***	-0.0037	-0.0064***	-1.5897
	(0.0023)	(0.0024)	(0.0028)	(0.0034)	(0.0024)	(3.2508)
College	0.0217***	0.0195***	0.0200***	0.0061	0.0213***	1.5699
	(0.0054)	(0.0055)	(0.0064)	(0.0068)	(0.0055)	(6.3694)
Retired	-0.0004	-0.0002	-0.0021	-0.0046	-0.0010	5.7424
	(0.0061)	(0.0067)	(0.0081)	(0.0101)	(0.0065)	(11.3825)
Constant	1.2572***	1.2410***	1.2557***	0.1621**	0.3978***	-64.3611
	(0.0477)	(0.0492)	(0.0580)	(0.0653)	(0.0807)	(53.2571)
Household FE	Yes	Yes	Yes	Yes	Yes	No
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	No
Year × Region FE	Yes	Yes	Yes	Yes	Yes	No
Observations	10798	9959	6885	3074	10256	142
R^2	0.1139	0.0911	0.1069	0.0446	0.0598	0.2954

Note: Robust standard errors in parentheses. Inflation Expectations are in percentage points. Full sample encompasses 2003-2019; the bust period is defined as 2009-2013,while the boom period is the complement time-frame. Quintile refers to the intra-year quintile of house-price expectations that attentive households fall into; inattentive household are not included in this regression. The variable for house adjustment is the change in housing wealth –in percentage points– of moving households. Strictly inattentive is an indicator variable for households that always report zero expected house-price growth or do not report expectations. Net income and household portfolio items are in thousands of euros; mortgage values are reported in positive figures. Household size is the number of members in the household. College and Retired are dummy variables.

$^*p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$

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Table A3: Home Adjustment in Response to Monetary Policy Shocks - Cohort Effects

	HH Characteristics	Attentive/Inattentive	Expectation Type
House-Adjustment Indicator	(1)	(2)	(3)
ϵ_{MP}	0.0006**		
	(0.0003)		
Attentive × ϵ_{MP}		0.0007**	
		(0.0003)	
Inattentive × ϵ_{MP}		-0.0001	
		(0.0009)	
Pessimist × ϵ_{MP}			0.0003
			(0.0004)
Neutral × ϵ_{MP}			0.0010**
			(0.0004)
Optimist × ϵ_{MP}			0.0027***
			(0.0009)
Strictly Inattentive			0.0056
			(0.0129)
House-Price Growth	0.0007*	0.0007*	0.0012**
	(0.0004)	(0.0004)	(0.0005)
Net Income	0.0003	0.0003	0.0005*
	(0.0002)	(0.0002)	(0.0003)
Net Financial Assets	0.0001***	0.0001**	0.0001
	(0.0000)	(0.0000)	(0.0000)
Housing Wealth	-0.0005***	-0.0005***	-0.0003***
	(0.0001)	(0.0001)	(0.0001)
Mortgage Value	-0.0003***	-0.0003***	-0.0001**
	(0.0001)	(0.0001)	(0.0001)
Age of HH Head	-0.0190***	-0.0190***	-0.0028
	(0.0033)	(0.0033)	(0.0037)
Age of HH Head Sq.	0.0001***	0.0001***	-0.0000
	(0.0000)	(0.0000)	(0.0000)
Household Size	-0.0089**	-0.0089**	-0.0070*
	(0.0035)	(0.0035)	(0.0040)
College	0.0358***	0.0357***	0.0134
	(0.0087)	(0.0087)	(0.0098)
Retired	-0.0017	-0.0017	-0.0089
	(0.0088)	(0.0088)	(0.0104)
Constant	0.9343***	0.9354***	0.3944***
	(0.1051)	(0.1051)	(0.1151)
Household FE	Yes	Yes	Yes
Cohort FE	Yes	Yes	Yes
Region FE	Yes	Yes	Yes
Observations	8525	8525	6381
R^2	0.0570	0.0570	0.0310

Note: Robust standard errors in parentheses. Sample consists of 2003-2016. The variable for house adjustment is the change in housing wealth –in percentage points– of moving households. Monetary policy shocks are in percent. Strictly inattentive –as well as Attentive/Inattentive variables– is an indicator variable for households that always report zero expected house-price growth or do not report expectations. Pessimistic, Neutral and Optimistic denote attentive households' position in the year-specific distribution of expectations: 1^{st}, $2^{nd} - 4^{th}$ and 5^{th} quintiles, respectively. House-price growth is in percent. Net income, home values and household portfolio items are in thousands of euros; mortgage values are reported in positive figures. Household size is the number of members in the household. College and Retired are dummy variables.

*$p < 0.10$, **$p < 0.05$, ***$p < 0.01$

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C Solution Method

Here we outline a procedure that particularizes the discrete-continuous endogenous gird method (DC-EGM) by Iskhakov et al. (2017).[52] The DC-EGM procedure builds on the EGM of Carroll (2006) and consists in using an exogenous end-of-period (i.e., post-decision) savings grid and the household's Euler equation to back out an endogenous grid for beginning-of-period financial wealth. Lastly, secondary kinds in choice-specific value functions are handled by eliminating segments that fall below the upper envelope of the state-utility correspondence.

In order to present this solution method as it applies to our environment, we slightly modify notation both to bring our exposition closer to that of Iskhakov et al. (2017) and to make it more intuitively in line with the computational algorithm. Let the discrete choice-specific value function of the household be denoted by $v_t^d(X_t)$, where $d = \left(H, \tilde{H}\right) \in \mathcal{D}$ denotes the discrete housing choice and $\mathcal{D}$ the set of possible house choices. Thus, we can write the household's global value function in terms of the choice-specific value functions as follows:

$$V_t(X_t) = \max\left\{V_t^{own}(X_t), V_t^{adj}(X_t), V_t^{rent}(X_t)\right\} = \max\left\{\left\{v^d(X_t)\right\}_{d\in\mathcal{D}}\right\} \tag{1}$$

This problem can be represented as follows:

Definition 4 *The household's consumption-savings problem is given by*

$$V_t(X_t) = \max_{\{C_t, A_t, d_t\}} \left\{U(C_t, S(d_t)) + \beta E^i\left[V_{t+1}(X_{t+1}) \mid \eta_t, P_t\right]\right\}$$

where the choice-specific value functions for period $t < T$ such that $j < J$ are given by:

$$v_t^{d_t}(W_t, X_t) = \max_{\{C_t\}} \left\{U(C_t, S(d_t)) + \beta E^i\left[V_{t+1}(W_{t+1}, X_{t+1}) \mid A_t, d_t, \eta_t, P_t\right]\right\} \tag{2}$$

where equation 1 holds; where at period $t = T$, such that $j = J$,

$$v_T^{d_T}(W_T, X_T) = \max_{\{C_T\}} \left\{U(C_T, S(d_T)) + \beta B(W_{T+1})\right\} \tag{3}$$

and the constraint set is given (as above) by:

$$C_t + A_t + P_t H_t + \mathbb{1}_{\{H_t \neq H_{t-1}\}}\theta(1-\delta)P_t H_{t-1} + \mathbb{1}_{\left\{\tilde{H}_t > 0\right\}}\tilde{P}_t\tilde{H}_t = W_t \tag{4}$$

$$W_{t+1} = Y_{t+1}(\eta_{t+1}, j_{t+1}) + \left(1 + r_b + \mathbb{1}_{\{A_t<0\}}\zeta\right)A_t + (1-\delta)P_{t+1}H_t \tag{5}$$

$$-A_t \leq \begin{cases} \lambda_m P_t H_t & \text{if} \quad H_{t-1} \neq H_t > 0 \\ -\phi(P, r_M, j_{it}, A_{it-1}, H_{it}) & \text{if} \quad H_{t-1} = H_t > 0 \quad \text{and} \quad A_{t-1} < 0 \\ 0 & \text{else} \end{cases} \tag{6}$$

with $A_T \geq 0$ being the relevant borrowing constraint at period $t = T$, such that $j = J$.

[52] For study that is related to this paper, which also employs the DC-EGM but works with continuous housing, see Yao et al. (2015).

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Note that in Definition 4 we have introduced W_t as a state variable. Although technically redundant, this variable will help make notation in algorithm 1 more familiar. The key thing to note is that once H_{t-1}, η_t, j_t, and P_t are fixed, there is a one-to-one mapping between W_t and A_{t-1}. Thus, we can recover the savings state once we know financial wealth.[53] As for finding the level of financial wealth consistent with a post-decision level of savings, this is feasible because the *choice-specific* savings policy function (i.e., for a given choice) is monotone non-decreasing in financial wealth; just as in the standard case of Carroll (2006).[54]

Given this setup, we have the following result that will allow us to use the DC-EGM procedure:[55]

Proposition 1 *Let the household's problem be given by Definition 4. Then, the household's Euler equation for $t < T$, such that $j < J$, can be written as follows:*

$$U_C\left(C_t, S\left(d\right)\right) = max\left\{\bar{U}_C\left(d\right), \beta E^i\left[\Psi_{t+1} \mid A_t, d, \eta_t, P_t\right]\right\} \tag{7}$$

where

$$\begin{aligned} \bar{U}_C\left(d\right) &= U_C\left(W_t - \bar{A}\left(d\right) - F\left(d\right), S\left(d\right)\right) \\ \Psi_{t+1} &= U_C\left(C_{t+1}\left(W_{t+1}, X_{t+1}\right), S\left(d'\right)\right)\left(1 + r_b + \mathbb{1}_{\{A_t<0\}}\zeta\right) \end{aligned}$$

where $U_C\left(C_t, S\left(d\right)\right)$ denotes the partial derivative of the utility function w.r.t. C_t, $C_{t+1}\left(W_{t+1}, X_{t+1}\right)$ denotes the consumption policy function and

$$\bar{A}\left(d\right) = \begin{cases} -\lambda_m P_t H_t & if \quad H_{t-1} \neq H_t > 0 \\ \phi\left(P, r_M, j_{it}, A_{it-1}, H_{it}\right) & if \quad H_{t-1} = H_t > 0 \quad and \quad A_{t-1} < 0 \\ 0 & else \end{cases} \tag{8}$$

$$F\left(d\right) = \begin{cases} P_t H_t + \theta\left(1-\delta\right) P_t H_{t-1} & if \quad H_{t-1} \neq H_t > 0 \\ \delta P_t H_t & if \quad H_{t-1} = H_t > 0 \\ \tilde{P}_t \tilde{H}_t + \theta\left(1-\delta\right) P_t H_{t-1} & else \end{cases} \tag{9}$$

Optimal consumption for period $t = T$, such that $j = J$, is given by the expression:

$$U_C\left(C_T, S\left(d\right)\right) = max\left\{\bar{U}_C\left(d\right), \beta\left(1+r_b\right)\vartheta_1\left[\left(1+r_b\right)A_T + \left(1-\theta\right)\left(1-\delta\right)P_{T+1}H_T + \vartheta_2\right]^{-\gamma}\right\} \tag{10}$$

[53] Technically, this statement is not true for all specifications of $\phi\left(\cdot\right)$ but it will be true for the case we we will work with here. An example where this fail to hold is the fixed refinancing cost constraint of Section 4; such cases can be handled with standard hybrid methods.

[54] Hence, end-of-period savings serves as a sufficient statistic for beginning-of-period financial wealth and savings; given a particular housing choice and state.

[55] Note that apostrophes denote next period values.

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Proof. For any period $t < T$, such that $j < J$, straightforward differentiation of equation 2 subject to constraints (4)–(6) yields the following first-order condition:

$$U_C\left(C_t, S\left(d_t\right)\right) = \beta E_t^i \left[\frac{\partial v_{t+1}^{d_{t+1}}\left(W_{t+1}, X_{t+1}\right)}{\partial W_{t+1}} \left(1 + r_b + \mathbb{1}_{\{A_t<0\}}\zeta\right)\right] + \Lambda_t\left(d_t\right)$$

where d_{t+1} is next period's optimal discrete choice and $\Lambda_t\left(d_t\right) \geq 0$ is the Kuhn-Tucker multiplier associated with the borrowing constraint (6). Hence, we can write:

$$U_C\left(C_t, S\left(d_t\right)\right) \geq \beta E_t^i \left[\frac{\partial v_{t+1}^{d_{t+1}}\left(W_{t+1}, X_{t+1}\right)}{\partial W_{t+1}} \left(1 + r_b + \mathbb{1}_{\{A_t<0\}}\zeta\right)\right]$$

Further, the envelope condition of equation 2, for every $d_t \in \mathcal{D}$, is given by:

$$U_C\left(C_t, S\left(d_t\right)\right) = \frac{\partial v_t^{d_t}\left(W_t, X_t\right)}{\partial W_t}$$

where it is understood that consumption is at its optimal level. Combining these two expressions yields:[56]

$$U_C\left(C_t, S\left(d_t\right)\right) \geq \beta E_t^i \left[U_C\left(C_{t+1}, S\left(d_{t+1}\right)\right)\left(1 + r_b + \mathbb{1}_{\{A_t<0\}}\zeta\right)\right]$$

Finally, noting that when the borrowing constraint (6) holds with equality, the marginal utility from consumption is given by:

$$U_C\left(C_t, S\left(d_t\right)\right) = U_C\left(W_t - \bar{A}\left(d\right) - F\left(d\right), S\left(d\right)\right)$$

where $\bar{A}$ is specified in equation 8, we obtain equation 7.

For period $t = T$, such that $j = J$, we have the following first-order condition:

$$U_C\left(C_T, S\left(d_T\right)\right) = \beta\left(1 + r_b\right)\vartheta_1\left[\left(1 + r_b\right)A_T + \left(1 - \theta\right)\left(1 - \delta\right)P_{T+1}H_T + \vartheta_2\right]^{-\gamma} + \lambda_T$$

where $\lambda_T \geq 0$ is the Kuhn-Tucker multiplier associated with the borrowing constraint $A_T \geq 0$. Following a similar logic as above, equation 10 obtains by noting that at the borrowing constraint the marginal utility of consumption is given by $\bar{U}_C\left(d\right)$. ■

We can now present the DC-EGM solution method. As in the standard EGM solution procedure, we fix an exogenous post-decision savings grid and then use the household's Euler equation the back out the implied level of beginning-of-period financial wealth – the only relevant state for each choice-specific case. The procedure (excluding the upper envelope algorithm) is standard for the *adjustment* and *rent* cases, where we specify the exogenous savings grid such that the consumption decision is always interior. In contrast, the *no adjustment* is non-standard in that the relevant borrowing constraint may depend on the underlying level of assets (i.e., beginning-of-period savings). Therefore, we deviate slightly from the standard procedure by fixing an end-of-period savings grid that includes points where the household is borrowing-constrained. To find the optimal choice, we make use of equation 7 and compute

[56] Note also that $\left(1 + r_b + \mathbb{1}_{\{A_t<0\}}\zeta\right)$ can be taken out of the expectation.

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both terms in the *max* operator to then back out the true state.

Finally, since our application concerns an environment where household's price expectations are exogenous and there is no aggregate risk, we drop –for the sake of simplicity– the price of housing as a state variable. Adding it, in the presence of price fluctuations, is straightforward in the form of a forecasting equation or outer loop variable. In the presence of aggregate risk, any vector of aggregate variables can be incorporated as an outer loop on the algorithm below. Next, we turn to the algorithm.

Algorithm 1 *This algorithm applies the* ***solution method of Iskhakov et al. (2017)*** *to derive the value and policy functions that solve the household problem specified above.*

1. *Fix the following state-specific post-decision savings grid, G, and grids for housing and income states, $\mathcal{H}$ and E, respectively.*

$$\begin{aligned} G &= \left\{\left\{a^1, a^2, ..., a^{N_a}\right\}^X\right\}_{X\in(\mathcal{A}\times\mathcal{H}\times E)} \\ \mathcal{H} &= \left\{h^0, ..., h^{N_h}\right\} \qquad where \quad h^n < h^{n+1} \\ E &= \left\{\eta^1, \eta^2, ..., \eta^{N_\eta}\right\} \end{aligned}$$

   The savings grid should be set so that the minimum grid points that pertain to the ***adjustment*** *and* ***rent*** *cases ensure that the relevant borrowing constraints are slack and that the operative term in the RHS of the Euler equation 7 is the one involving the expectation. This is achieved by setting:*

$$a_h^{min} = \begin{cases} -\lambda_m P_t h & for \quad adj \\ 0 & for \quad rent \end{cases}$$

   For the ***no adjustment*** *case, the minimum point in the grid should be set to either the point where both terms in the max operator on the right hand side of the Euler equation are equal to each other, or where consumption becomes negative.*

2. *Construct value and policy functions for the last period of life at $t = T$ (when the household is $j = J$).*[57]

   for every $A_i = \left\{0, ..., a^{N_a}\right\}$ *(i.e., deals with $A_T \geq 0$ for end-of-period savings)*

   for every $\eta \in E$

   for every $h \in \mathcal{H}$

   for every $d \in \mathcal{D}$

   Set $A_T^d(W_T, X_T) = A_i$

[57] Note that at this period there are no kinks in the choice-specific value functions, therefore there is no need to run the upper envelope algorithm.

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Use equation 10 to find $C_T^d(W_T, X_T)$

Use equation 4 to get $W_T^d(W_T, X_T)$

Use equation 5 to recover beginning of period assets A_{T-1}

Use equation 3 to get $v_T^d(W_T, X_T)$

Add grid points in constrained region

end for

Set global value and policy functions according to equation 1

end for

end for

end for

3. *Obtain value and policy functions by backward induction:*

for $j = J-1, ..., 1$

for every $\eta \in E$

for every $h \in \mathcal{H}$

for every $d \in \mathcal{D}$

Call ***Algorithm 2*** *(i.e., DC-EGM Algorithm)*

Call ***Algorithm 3*** *(i.e., Upper Envelope Algorithm)*

end for

Set global value and policy functions according to equation 1

end for

end for

end for

Algorithm 2 *This algorithm executes the* ***DC-EGM*** *part of the solution method in order to derive current period choice-specific value and policy functions, as well as the endogenous wealth and savings grids. The required inputs are (i) the end-of-period savings grid, (ii) the current income, housing and age states, and (iii) next period's choice-specific value and policy functions.*

for every $A_i \in \left\{a^1, a^2, ..., a^{N_a}\right\}^X$ *(Note that the first grid point must be added later)*

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1. *Compute the second term on the right hand side (RHS) of the Euler equation 7 as follows:*

$$RHS = \beta \sum_{\eta' \in E} \Pi\left(\eta' \mid \eta\right) \Psi_{t+1}$$

where $\Pi\left(\eta' \mid \eta\right)$ denotes the transition matrix for $\{\eta\}$, Ψ_{t+1} is specified in equation 7, and W_{t+1} is computed following equation 5. Note that this step requires computing the expectation of future household wealth, $E_t^i\left(W_{t+1}\right)$, as a function of the household's expectation of future house prices, $E_t^i\left(P_{t+1}\right)$; the specification of the latter is particular to the application under study.

2. *Compute $C_t^{d,i}\left(W_t, X_t\right)$ as follows:*[58]

$$C_t^{d,i}\left(W_t, X_t\right) = U_C^{-1}\left(RHS\right)$$

3. *Compute $W_t^{d,i}\left(X_t\right)$ as follows:*

$$W_t^{d,i}\left(X_t\right) = C_t^{d,i}\left(W_t, X_t\right) + A_i + F\left(d\right)$$

4. *Recover $A_{t-1}^{d,i}\left(X_t\right)$ as follows:*

   Compute, using equation 5,

$$\Xi := \left(1 + r_b + \mathbb{1}_{\{A_{t-1}<0\}}\zeta\right) A_{t-1} = W_t^{d,i}\left(X_t\right) - Y_t\left(\eta, j\right) - \left(1-\delta\right) P_t h$$

   if *$(\Xi \geq 0)$* ***then***

$$A_{t-1}^{d,i}\left(X_t\right) = \frac{W_t^{d,i}\left(X_t\right) - Y_t\left(\eta, j\right) - \left(1-\delta\right) P_t h}{\left(1 + r_b\right)}$$

   else

$$A_{t-1}^{d,i}\left(X_t\right) = \frac{W_t^{d,i}\left(X_t\right) - Y_t\left(\eta, j\right) - \left(1-\delta\right) P_t h}{\left(1 + r_b + \zeta\right)}$$

   end if

5. *Set $A_t^{d,i}\left(W_t, X_t\right) = A_i$*

6. *Compute EV as follows:*

$$EV = \sum_{\eta' \in E} \Pi\left(\eta' \mid \eta\right) V\left(A_i, d_t, \eta', j+1\right) \tag{11}$$

   where W_{t+1} is computed following equation 5, and again, $E_t^i\left(P_{t+1}\right)$ is required to be computed for the value of $E_t^i\left(W_{t+1}\right)$.

7. *Compute $v_t^{d,i}\left(W_t, X_t\right)$ as follows:*

$$v_t^{d,i}\left(W_t, X_t\right) = U\left(C_t^{d,i}\left(W_t, X_t\right), S\left(d\right)\right) + \beta EV$$

[58] The argument (W_t, X_t) is used here to emphasize that the number $C_t^{d,i}\left(W_t, X_t\right)$ corresponds a point in the function that is stored in the solution.

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8. Add grid points in constrained region

end for[59]

Algorithm 3 *This algorithm constructs the correct value and policy functions from those derived in algorithm (2) by finding the* ***upper envelope*** *of the choice-specific value functions.*[60] *In a nutshell, the algorithm breaks up the choice-specific value function into a set of monotonic functions specified over a common grid, and then derives the value function by taking the max for every point on the common grid, and simultaneously saving the corresponding policy functions. Specifically, the procedure works as follows:*

1. *Locate the increasing segments of the choice-specific value function and partition it correspondingly.*

   Set $p = 1$ *(partition count) and* $k = 1$ *(initialize first point in first segment)*

   for $i = 2, ..., N_a$

   if $((W_t^{d,i+1}(X_t) < W_t^{d,i}(X_t))$ ***or*** $(v_t^{d,i}(W_t, X_t) < v_t^{d,i-1}(W_t, X_t)))$ ***then***

   Set $k' = i$

   Define partition $N_p = \{k, ..., k'\}$

   Set $p = p + 1$

   Find $i' > i$ *such that* $W_t^{d,i'+1}(X_t) > W_t^{d,i'}(X_t)$

   Set $k = i'$

   end if

   end for

2. *On the common ordered grid* $W_t^{*d}(X_t)$*, define the choice-specific value function,* $v_t^{*d}(W_t, X_t)$ *as the upper envelope of the partitions.*[61]

   Define $W_t^{*d}(X_t)$ *as the ordered version of* $W_t^d(X_t)$

   for $p = 1, ..., P$ *(where* P *is the number of partitions)*

   Define function $v_{N_p,t}^d(W_t, X_t)$ *by interpolating* $v_t^d(N_p, X_t)$ *and* $W_t(N_p)$ *on* $W_t^{*d}(X_t)$

[59] In practice, for the no-adjustment case, one should proceed from the largest grid point to the smallest, since the constraint is binding for all points below a threshold.

[60] This algorithm follows the `UpperEnvelope` function contained in `Matlab` file `fun.m` of the replication files for Iskhakov et al. (2017) from Thomas H. Jørgensen's homepage (http://www.tjeconomics.com/), which differs somewhat from Algorithm 3 published in the paper.

[61] A refinement that could be added to this section is to add a grid point precisely at the intersection of the different value function segments. However, given that this entails a root-finding problem, we leave it out for the moment.

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Define functions $C^{d}_{N_p,t}(W_t, X_t)$ *and* $A^{d}_{N_p,t}(W_t, X_t)$ *correspondingly*

for $i = 1, ..., N_a$ *(i.e., every point on the common grid)*

Set $v_t^{*d,i} = max\left\{v^{d,i}_{N_p,t}\right\}_{p=1}^{p=P}$ *(i.e., the true value function)*

Set $C_t^{*d,i}$ *and* $A_t^{*d,i}$ *correspondingly (i.e., the true policy functions)*

end for

end for

3. *If the resulting function contains points that are* `NaN`*, set those points by finding the savings choice such that the Euler equation 7 holds with equality.*[62]

[62]This method can be exchanged for interpolation for computational time gains, with little change in terms of the accuracy of the solution.

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D Income Process Estimation

In this section, we describe the procedure implemented to estimate the income process. The procedure we follow is somewhat standard in the literature and a short useful summary can be found in Tonetti (2011). For more substantial discussions on the subject see Guvenen (2011) and Meghir and Pistaferri (2011).

D.1 First-Stage Regression: Deterministic Component of Earnings

In our application, we assume that labor supply is exogenously given and only model households' decision to hold financial assets and owner-occupied homes. Hence, the income process we estimate is for total disposable earnings excluding "interest/dividends/other income" and "real estate income/letting of rooms." This is income risk (i.e., after other insurance mechanisms such as taxes, transfers, etc. have taken place) against which households in the model wish to self-insure. The data on earnings span from 1993 to 2016. We treat the households as our unit of analysis, aggregating the income of all members and employing the oldest male's characteristics when computing the deterministic component. We drop households where the male head is older than 65 or retired, or that participated in only two waves or less; in Section D.2 we describe how the initial age is set. We restrict the sample to households with strictly positive income and that earn less than 1,000,000 euro.[63]

The income process we wish to estimate can be represented as follows:

$$Y_{i,j,t} = w_t exp\left(f\left(X_{i,j,t}\right) + y_{i,j,t}\right)\bar{h}$$

where $Y_{i,j,t}$ denotes the annual earnings as described above of agent i of age j in period t, w_t is the aggregate wage per efficiency unit of labor, $f(\cdot)$ is an invariant function of the predictable – through demographic observables $X_{i,j,t}$ – component of the agents' labor efficiency, $y_{i,j,t}$ is the stochastic component of earnings, and $\bar{h}$ is a fixed exogenous level of hours worked.

[63] The full data set contains 79,373 individual observations. After aggregating to the household level (there are 33,168 households) and restricting the sample as described in the text and starting at age 20, we are left with 12,079 observations for estimation.

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The formula for net income from the survey is as follows.

total net income	=	pay/salary [gross]
	+	max(0,profits) [gross]
	+	government scholarship [net]
	+	study loan [net]
	+	parental support for studies [net]
	+	support from family [net]
	+	inheritance [net]
	+	alimony from spouse [gross]
	+	alimony for children [net]
	+	early retirement benefits [gross]
	+	retirement pension/annuity [gross]
	+	benefits for elderly and partly disabled unemployed/self-employed [gross]
	+	disability benefits [gross]
	+	disability benefits for self-employed, their partner/clergymen etc. [gross]
	+	disability benefits for persons who were already disabled at the age of 17 and therefore could not work [gross]
	+	unemployment benefits [gross]
	+	unempl. benefits civil servants [gross]
	+	general old-age pension (us: social security payments) [gross]
	+	general widows' and orphans' pension [gross]
	+	social assistance (us: welfare)/benefits for self-employed [gross]
	+	premium for subsidized purchase of house [gross]
	+	rateable value of accommodation [gross]
	+	rent allowance [net]
	+	allowance to adjust to new rent [net]
	+	real estate income/letting of rooms [gross]
	+	interest/dividends/other income [gross]
	−	calculated income tax

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As mentioned above, we take the model counterpart of earnings to be as follows:

$$\begin{aligned} Y_{it} = \text{total net income}_{it} \quad &- \quad \text{interest/dividends/other income [gross]}_{it} \\ &- \quad \text{real estate income/letting of rooms [gross]}_{it} \end{aligned}$$

In logs, estimation equation is given as follows:

$$ln(Y_{i,j,t}) = \beta_t + f\left(X_{i,j,t}\right) + y_{i,j,t} \tag{12}$$

where β_t should be interpreted as the price of labor.

We estimate this equation by running an OLS regression of net income on time dummies, education level, an urban dummy and, following Kaplan et al. (2020), a fourth-order polynomial in age.

D.2 Second-Stage Regression: Residual Earnings

The residuals of equation 12 are assumed to follow a statistical model for log residual earnings similar to that of Storesletten et al. (2004). We consider three specifications, starting with the following five-parameter model:

$$y_{i,j} = \alpha_i + \eta_{i,j} + \epsilon_{i,j} \tag{13}$$

$$\eta_{i,j} = \rho\eta_{i,j-1} + \nu_{i,j} \tag{14}$$

where α if the agent-specific heterogeneous term, η is the persistent component of residual earnings, and ϵ is the transitory component. Further, we assume that the stochastic variables are i.i.d and orthogonal to each other; $\alpha \perp \epsilon \perp \nu \perp \eta_0$, where we denote by η_0 the initial observed persistent component of income. Their distribution is given by:

$$\begin{aligned} \alpha &\overset{i.i.d.}{\backsim} \left(0, \sigma_\alpha^2\right) \\ \epsilon &\overset{i.i.d.}{\backsim} \left(0, \sigma_\epsilon^2\right) \\ \nu &\overset{i.i.d.}{\backsim} \left(0, \sigma_\nu^2\right) \\ \eta_0 &\overset{i.i.d.}{\backsim} \left(0, \sigma_{\eta_0}^2\right) \end{aligned}$$

Hence, we wish to estimate the parameter vector $\theta = \left\{\rho, \sigma_\alpha^2, \sigma_\epsilon^2, \sigma_\nu^2, \sigma_{\eta_0}^2\right\}$. The two other specifications we consider are obtained when we impose the following restrictions: (i) $\eta_0 = \sigma_{\eta_0}^2 = 0$, and (ii) the latter plus allowing variance of the heterogeneous term (fixed effect) to be conflated with that of the transitory shock.[64]

Let $m_{n,k}(\theta)$ denote the theoretical covariance in earnings between agents of age n and k.

[64] This follows Storesletten et al. (2004), which provide a reference point for our estimation results.

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Given specification (13)-(14), these are as follows:

$$m_{n,k}(\theta) = \begin{cases} \sigma_\alpha^2 + \sigma_{\eta_0}^2 + \sigma_\epsilon^2 & \text{if} \quad k = n = 0 \\ \sigma_\alpha^2 + \rho^n \sigma_{\eta_0}^2 & \text{if} \quad k = 0, n > 0 \\ \sigma_\alpha^2 + \rho^{2n} \sigma_{\eta_0}^2 + \sigma_\epsilon^2 + \sigma_\nu^2 \sum_{s=0}^{n-1} \rho^{2s} & \text{if} \quad k = n > 0 \\ \sigma_\alpha^2 + \rho^{2n+k-n} \sigma_{\eta_0}^2 + \sigma_\nu^2 \sum_{s=0}^{n-1} \rho^{2s} & \text{if} \quad k > 0, n > 0, k \neq n \end{cases}$$

Further, let $\hat{m}_{n,k}$ be the empirical counterpart of $m_{n,k}(\theta)$. We will compute the *minimum distance estimator*, $\hat{\theta}$, by minimizing the following expression:[65]

$$\hat{\theta} = \underset{\theta}{\operatorname{argmin}} \left[\hat{M} - M(\theta)\right]' W \left[\hat{M} - M(\theta)\right] \tag{15}$$

where $\hat{M}$ is the $(J+1)(J+2)/2 \times 1$ stacked vector of the lower-triangular portion of the $(J+1) \times (J+1)$ variance-covariance matrix of earnings, $(\hat{m})_{n,k}$, $M(\theta)$ is its theoretical counterpart, and W is an $(J+1) \times (J+1)$ weighting matrix.[66] We consider three weighting matrices:

1. Equally Weighted Estimator

$$W = I_{(J+1)\times(J+1)}$$

2. Optimal Weighting Matrix

$$W = V^{-1}$$

where V is the asymptotic variance of $\hat{M}$ (see Chamberlain (1984)).

3. Diagonally Weighted Matrix

$$W = diag\left(V^{-1}\right)$$

This estimator, as well as the equally weighted estimator, is recommended by Altonji and Segal (1996), who document substantial small-sample bias in $\hat{\theta}$ when computed using the optimal weighting matrix.

Finally, the standard errors of the second-stage estimation are given by the 5×5 variance-covariance matrix

$$\hat{\Sigma} = (G'WG)^{-1} G'WVWG (G'WG)^{-1}$$

where G is the $(J+1)(J+2)/2 \times 5$ Jacobian matrix of $M(\theta)$ evaluated at $\hat{\theta}$.[67] Our accepted estimates will use the optimal diagonal weights matrix.

[65] Identification is shown in Appendix D.5.

[66] In practice, we drop from the objective function all moments whose sample counterpart was calculated with less than 20 observations.

[67] Since these estimates are obtained employing residuals from the first-stage regression, their standard errors must be adjusted accordingly (see Murphy and Topel (1985)). In the results that follow, this has not yet been done.

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D.3 Life-Cycle Profile of Log-Earnings Variance

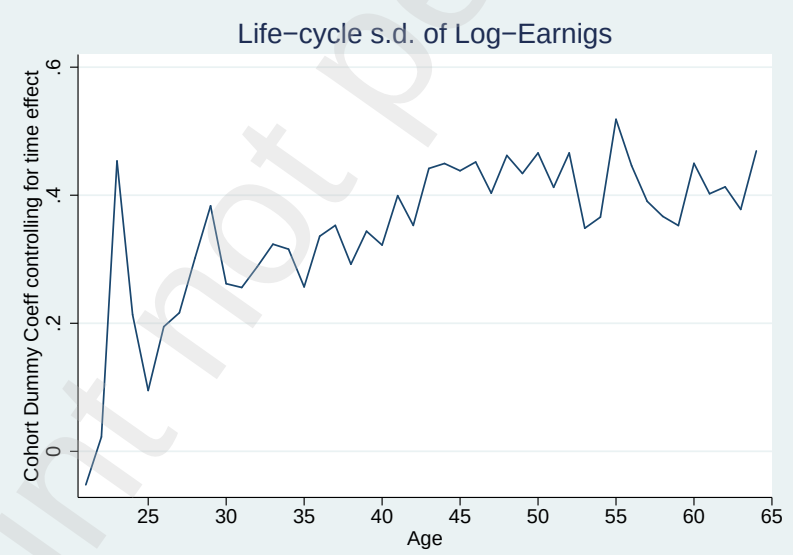
In this section we look at the life-cycle profile of households' log-earnings variance in order to get a sense of whether or not $\rho = 1$ and from which cohort to begin the estimation. We note that if $\rho = 1$, we should expect that the variance of log-earnings increase linearly throughout the life cycle; otherwise, in the case that $\rho < 1$, the life-cylce profile will be concave over the life-cycle.

In Figure A1 we plot the estimation coefficient obtained from regressing the standard deviation of log-earnings on a constant, age and time. Specifically, we plot the OLS parameters associated with the cohort dummies – taking age 21 as the reference – of the following estimation equation:

$$\sigma_{y,jt} = \beta + \beta^{j}_{(1\times J-1)} d^{j}_{(J-1\times 1)} + \beta^{t}_{(1\times T-1)} d^{t}_{(T-1\times 1)} + \epsilon_{jt}$$

where $\sigma_{y,ct}$ denotes the standard deviation of residual log-earnings for cohort $j \in J$ at time $t \in T$, $d^{j}_{(J-1\times 1)}$ is a vector of dummy variables for cohorts $j = 22, 22, ..., 65$, $d^{t}_{(T-1\times 1)}$ is a vector of dummy variables for years $t = 1995, 1996, ..., 2016$, and ϵ_{jt} is an error term.[68]

Figure A1: Standard Deviation of Log-Earnings controlling for Time Effects



As can be observed from the figure, the life-cycle profile of the standard deviation of log-earnings is roughly concave after age 25. For younger cohorts, there is much volatility in the parameters, which is likely due to the small number of observations for these groups. Hence, in the estimation results reported below we restrict the sample to households whose male head is at least 25 years of age and construct the theoretical moments of the objective function under the assumption that $\rho < 1$.

[68] The full time sample of the estimation is 1996-2016.

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D.4 Estimation Results

We report the estimates obtained employing the diagonally weighted estimator. We note that the estimation results obtained under the five-parameter specification indicate that this model is likely misspecified, hence we set $\eta_0 = \sigma^2_{\eta 0} = 0$.

Our estimates follow the regression procedure as above but account for two concerns identified in Carroll and Samwick (1997): (i) MA(q) serial correlation in the transitory shock and (ii) sample selection.

Our estimates follow the regression procedure as above but account for two concerns identified in Carroll and Samwick (1997): (i) MA(q) serial correlation in the transitory shock and (ii) sample selection. This concern follows from Muth (1960) and refers to the fact that "if a process is a random walk at some frequency (say, income, which has a permanent component, is paid to you on a monthly basis) but what is measured is a time aggregate of that data (e.g., the PSID sees only the aggregate of all 12 months' worth of income for a year), then the time aggregated series will exhibit an MA(1) component (even if there is no true transitory component at all)"[69] The same applies for a process with $\rho < 1$. The simplest way to make the estimation procedure robust to this type of serial correlation of order q in the transitory shock is to exclusively use moments computed from differences that are greater than q years (Carroll and Samwick (1997)). Specifically, following Carroll and Samwick (1997) we estimate the income process using differences of three years or greater.[70]

Table A4: Estimated with Optimal Diagonal Weights

	Coef.	Std. Err.	z	$P>\|$ z $\|$	[95% Conf.	Interval]
rho	0.9669285	0.0521278	18.55	0.000	0.8647599	1.069097
sig2_e	0.2907864	0.0364964	7.97	0.000	0.2192547	0.362318
sig2_u	0.0146296	0.0203018	0.72	0.471	-0.0251611	0.054420

Finally, in the empirical calibration we adjust upwardly the non-significant variance parameter reported above in order to match the variance of first-order Markov process approximating the full age-profile-inclusive exogenous income process with that of the data.

[69] Quotation from correspondence with Chris Carroll.

[70] Carroll and Samwick (1997) point to Abowd and Card (1989), who do not find evidence of serial correlation beyond order two.

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D.5 Identification of θ

The parameter vector θ is sequentially identified be the following moments:[71]

1. Slope

$$\frac{m_{03} - m_{02}}{m_{02} - m_{01}} = \frac{\sigma_\alpha^2 + \rho^3\sigma_{\eta_0}^2 - \sigma_\alpha^2 - \rho^2\sigma_{\eta_0}^2}{\sigma_\alpha^2 + \rho^2\sigma_{\eta_0}^2 - \sigma_\alpha^2 - \rho\sigma_{\eta_0}^2} = \frac{\rho^2\left(\sigma_{\eta_0}^2(\rho-1)\right)}{\rho\left(\sigma_{\eta_0}^2(\rho-1)\right)} = \boldsymbol{\rho}$$

2. Difference

$$m_{02} - m_{01} = \sigma_\alpha^2 + \rho^2\sigma_{\eta_0}^2 - \sigma_\alpha^2 - \rho\sigma_{\eta_0}^2 = \boldsymbol{\sigma_{\eta_0}^2}(\rho(\rho-1))$$

3. Level

$$m_{01} = \boldsymbol{\sigma_\alpha^2} + \rho\sigma_{\eta_0}^2$$

4. Variance

$$m_{00} = \sigma_\alpha^2 + \sigma_{\eta_0}^2 + \boldsymbol{\sigma_\epsilon^2}$$

5. Covariance

$$m_{12} = \sigma_\alpha^2 + \rho^3\sigma_{\eta_0}^2 + \boldsymbol{\sigma_\nu^2}$$

[71] Identified parameters shown in bold.

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E MPCs and Moving Rates for different values of λ_E

Table A5: Mean MPC by Expectation Group for $\lambda_E = 1.0$

Net Financial Assets Calibration

Expectation Group	$E_t(\pi^P_{t+1})$	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	-0.073	0.125	0.135	0.136
Quintile 2	-0.015	0.119	0.135	0.133
Inattentive	0.000	0.121	0.133	0.127
Quintile 3	0.020	0.161	0.169	0.139
Quintile 4	0.033	0.215	0.205	0.159
Quintile 5	0.063	0.330	0.245	0.224
Overall Average	0.005	0.179	0.170	0.153

Net Worth Calibration

Expectation Group	$E_t(\pi^P_{t+1})$	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	-0.073	0.064	0.063	0.066
Quintile 2	-0.015	0.065	0.063	0.064
Inattentive	0.000	0.064	0.070	0.069
Quintile 3	0.020	0.082	0.101	0.088
Quintile 4	0.033	0.117	0.133	0.108
Quintile 5	0.063	0.224	0.191	0.144
Overall Average	0.005	0.103	0.104	0.090

Note: The values reported in the second column on house-price growth expectations, $E_t(\pi^P_{t+1})$, are computed from the data. All other values are computed from the models. MPCs are derived from annual variables.

Table A6: House-Adjustment Rates by Expectation Group for $\lambda_E = 1.0$

Net Financial Assets Calibration

Expectation Group	Data	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	0.022	0.018	0.017	0.018
Quintile 2	0.025	0.018	0.018	0.020
Inattentive	0.027	0.019	0.022	0.020
Quintile 3	0.017	0.023	0.023	0.022
Quintile 4	0.031	0.030	0.022	0.026
Quintile 5	0.040	0.039	0.025	0.037
Overall Average	0.027	0.025	0.021	0.024

Net Worth Calibration

Expectation Group	Data	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	0.022	0.018	0.019	0.018
Quintile 2	0.025	0.018	0.019	0.019
Inattentive	0.027	0.018	0.019	0.019
Quintile 3	0.017	0.021	0.023	0.023
Quintile 4	0.031	0.027	0.024	0.026
Quintile 5	0.040	0.039	0.026	0.043
Overall Average	0.027	0.024	0.022	0.025

Note: The values reported in the second column are computed from the data. All other values are computed from the models.

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Table A7: Mean MPC by Expectation Group for $\lambda_E = 0.5$

Net Financial Assets Calibration

Expectation Group	$E_t(\pi^P_{t+1})$	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	-0.073	0.134	0.140	0.139
Quintile 2	-0.015	0.113	0.128	0.144
Inattentive	0.000	0.116	0.135	0.136
Quintile 3	0.020	0.161	0.169	0.172
Quintile 4	0.033	0.216	0.199	0.218
Quintile 5	0.063	0.332	0.252	0.294
Overall Average	0.005	0.179	0.171	0.184

Net Worth Calibration

Expectation Group	$E_t(\pi^P_{t+1})$	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	-0.073	0.066	0.068	0.065
Quintile 2	-0.015	0.064	0.069	0.066
Inattentive	0.000	0.064	0.070	0.072
Quintile 3	0.020	0.081	0.101	0.097
Quintile 4	0.033	0.110	0.126	0.158
Quintile 5	0.063	0.202	0.191	0.261
Overall Average	0.005	0.098	0.104	0.120

Note: The values reported in the second column on house-price growth expectations, $E_t(\pi^P_{t+1})$, are computed from the data. All other values are computed from the models. MPCs are derived from annual variables.

Table A8: House-Adjustment Rates by Expectation Group for $\lambda_E = 0.5$

Net Financial Assets Calibration

Expectation Group	Data	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	0.022	0.019	0.000	0.000
Quintile 2	0.025	0.020	0.019	0.022
Inattentive	0.027	0.021	0.022	0.025
Quintile 3	0.017	0.023	0.023	0.022
Quintile 4	0.031	0.026	0.024	0.026
Quintile 5	0.040	0.029	0.023	0.027
Overall Average	0.027	0.023	0.019	0.020

Net Worth Calibration

Expectation Group	Data	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	0.022	0.019	0.000	0.000
Quintile 2	0.025	0.020	0.018	0.020
Inattentive	0.027	0.020	0.020	0.022
Quintile 3	0.017	0.021	0.023	0.024
Quintile 4	0.031	0.022	0.024	0.024
Quintile 5	0.040	0.028	0.024	0.029
Overall Average	0.027	0.022	0.018	0.020

Note: The values reported in the second column are computed from the data. All other values are computed from the models.

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Table A9: Mean MPC by Expectation Group for $\lambda_E = 0.0$

Net Financial Assets Calibration

Expectation Group	$E_t(\pi^P_{t+1})$	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	-0.073	0.137	0.143	0.144
Quintile 2	-0.015	0.116	0.126	0.145
Inattentive	0.000	0.115	0.135	0.132
Quintile 3	0.020	0.161	0.169	0.174
Quintile 4	0.033	0.214	0.199	0.216
Quintile 5	0.063	0.330	0.255	0.286
Overall Average	0.005	0.179	0.171	0.183

Net Worth Calibration

Expectation Group	$E_t(\pi^P_{t+1})$	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	-0.073	0.068	0.071	0.069
Quintile 2	-0.015	0.065	0.066	0.071
Inattentive	0.000	0.065	0.071	0.075
Quintile 3	0.020	0.081	0.101	0.100
Quintile 4	0.033	0.108	0.123	0.154
Quintile 5	0.063	0.196	0.188	0.257
Overall Average	0.005	0.097	0.103	0.121

Note: The values reported in the second column on house-price growth expectations, $E_t(\pi^P_{t+1})$, are computed from the data. All other values are computed from the models. MPCs are derived from annual variables.

Table A10: House-Adjustment Rates by Expectation Group for $\lambda_E = 0.0$

Net Financial Assets Calibration

Expectation Group	Data	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	0.022	0.019	0.018	0.020
Quintile 2	0.025	0.020	0.020	0.022
Inattentive	0.027	0.022	0.022	0.027
Quintile 3	0.017	0.023	0.023	0.022
Quintile 4	0.031	0.026	0.024	0.021
Quintile 5	0.040	0.029	0.024	0.023
Overall Average	0.027	0.023	0.022	0.023

Net Worth Calibration

Expectation Group	Data	Flexible HELOC Loans	LT Mortgage	Fixed Refinancing Cost
Quintile 1	0.022	0.019	0.017	0.018
Quintile 2	0.025	0.021	0.019	0.019
Inattentive	0.027	0.021	0.021	0.023
Quintile 3	0.017	0.021	0.023	0.024
Quintile 4	0.031	0.022	0.024	0.021
Quintile 5	0.040	0.026	0.024	0.023
Overall Average	0.027	0.022	0.021	0.021

Note: The values reported in the second column are computed from the data. All other values are computed from the models.

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F Moments for Non-Calibrated Model Versions

Table A11: Target & Additional Data Moments for Net Worth Calibration

Targeted Moments under HELOC Calibration	Data	LT Mortgage	Fixed Refinancing Cost
Average Net Worth	7.254	7.13	6.894
Home-ownership rate	0.731	0.681	0.669
Median $NW_{j=80}$ / Median $NW_{j=50}$	1.391	1.168	1.194
Bequests below median $NW_{j=80}$	0.354	0.534	0.522
Polynomial Coefficient (1)	0.031	0.056	0.057
Polynomial Coefficient (2)	-0.0002	-0.0005	-0.0005
Homeowner's Moving Rate	0.019	0.019	0.019

Additional Moments	Data	LT Mortgage	Fixed Refinancing Cost
Ownership Rate per Wealth Quantile			
Homeownership Rate for Quantile 1	0.104	0.021	0.020
Homeownership Rate for Quantile 2	0.584	0.434	0.397
Homeownership Rate for Quantile 3	0.95	0.954	0.941
Homeownership Rate for Quantile 4	0.986	0.996	0.993
Homeownership Rate for Quantile 5	0.994	0.999	0.994
Net Worth Age Ratios			
Med NM(80) / Med NM(55)	1.215	1.039	1.048
Med NM(80) / Med NM(60)	1.168	0.930	0.963
Med NM(80) / Med NM(65)	1.045	0.869	0.871
Average Earnings per Housing State			
Average Earnings for Renters	0.884	0.754	0.755
Average Earnings for Owners	1.125	1.202	1.209
Ratio Owners/Renters	1.272	1.594	1.601
Average Quality of Rental and Owned Houses			
Average Rental House	0.221	0.236	0.237
Average Owned House	0.726	0.354	0.353
Ratio Owners/Renters	3.292	1.502	1.492
Moving Rates per Ownership Status			
Moving Rate for Renters	0.048	0.110	0.111
Moving Rate for Owners	0.019	0.019	0.019
Aggregate Moving Rate	0.027	0.048	0.049
Quantiles for Rental Housing Expenditures			
Rent / Income 10th percentile	0.198	0.23	0.23
Rent / Income 50th percentile	0.347	0.326	0.326
Rent / Income 90th percentile	0.802	0.487	0.489
Gini Coefficents			
Income	0.257	0.275	0.275
Housing Wealth	0.423	0.417	0.426
Net Worth	0.489	0.508	0.518
Average Rental Expenditure over Incomes			
All Age Cohorts	0.328	0.347	0.349
Excluding Retired Households	0.320	0.325	0.327

Note: All measures of household wealth and earnings are expressed in terms of median annual income (i.e., numeraire of the model). House sizes are represented by the housing grids. All other variables and statistics are self-described.

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Table A12: Target & Additional Data Moments for Net Financial Assets

Targeted Moments	Data	LT Mortgage	Fixed Refinancing Cost
Average Net Financial Assets	-0.298	1.173	0.950
Home-ownership rate	0.731	0.626	0.548
Median $NW_{j=80}$ / Median $NW_{j=50}$	1.391	0.881	1.181
Bequests below median $NW_{j=80}$	0.354	0.446	0.378
Polynomial Coefficient (1)	0.031	0.028	0.015
Polynomial Coefficient (2)	-0.0002	-0.0003	-0.0002
Homeowner's Moving Rate	0.019	0.022	0.020

Additional Moments	Data	LT Mortgage	Fixed Refinancing Cost
Ownership Rate per Wealth Quantile			
Homeownership Rate for Quantile 1	0.104	0.003	0.019
Homeownership Rate for Quantile 2	0.584	0.249	0.235
Homeownership Rate for Quantile 3	0.95	0.887	0.517
Homeownership Rate for Quantile 4	0.986	0.993	0.972
Homeownership Rate for Quantile 5	0.994	0.999	0.999
Net Worth Age Ratios			
Med NM(80) / Med NM(55)	1.215	0.831	1.022
Med NM(80) / Med NM(60)	1.168	0.831	1.000
Med NM(80) / Med NM(65)	1.045	0.787	0.929
Average Earnings per Housing State			
Average Earnings for Renters	0.884	0.736	0.767
Average Earnings for Owners	1.125	1.252	1.300
Ratio Owners/Renters	1.272	1.702	1.695
Average Quality of Rental and Owned Houses			
Average Rental House	0.221	0.230	0.241
Average Owned House	0.726	0.341	0.351
Ratio Owners/Renters	3.292	1.480	1.457
Moving Rates per Ownership Status			
Moving Rate for Renters	0.048	0.170	0.166
Moving Rate for Owners	0.019	0.022	0.020
Aggregate Moving Rate	0.027	0.077	0.086
Quantiles for Rental Housing Expenditures			
Rent / Income 10th percentile	0.198	0.230	0.230
Rent / Income 50th percentile	0.347	0.325	0.326
Rent / Income 90th percentile	0.802	0.477	0.478
Gini Coefficents			
Income	0.257	0.275	0.275
Housing Wealth	0.423	0.470	0.527
Net Worth	0.489	0.505	0.554
Average Rental Expenditure over Incomes			
All Age Cohorts	0.328	0.341	0.340
Excluding Retired Households	0.320	0.329	0.334

Note: All measures of household wealth and earnings are expressed in terms of median annual income (i.e., numeraire of the model). House sizes are represented by the housing grids. All other variables and statistics are self-described.

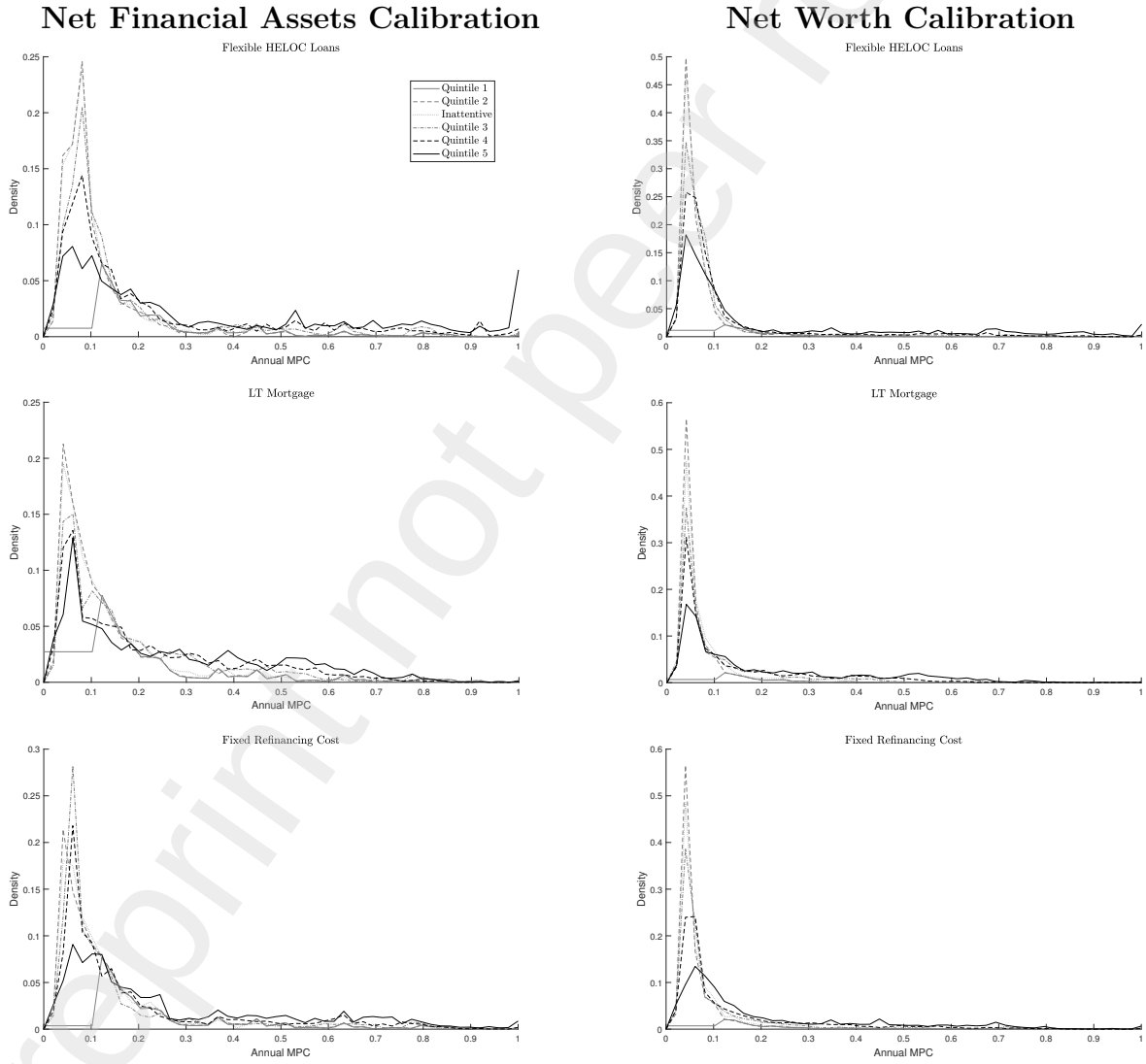
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G MPC Distribution: Additional Graphs

The effect of house-price expectations on the distribution of MPCs is shown in figures A2 and A3. These graphs plot, for both calibrations, the distribution of MPCs by expectation group and the cumulative distribution of MPCs by expectation group, respectively. The graphs are consistent with the positive relationship between expectations and average MPCs and show that the distribution of MPCs shifts to the right for groups of households that expect higher house-price growth. This is especially noticeable for quintiles four and five, whose lines are represented in black.

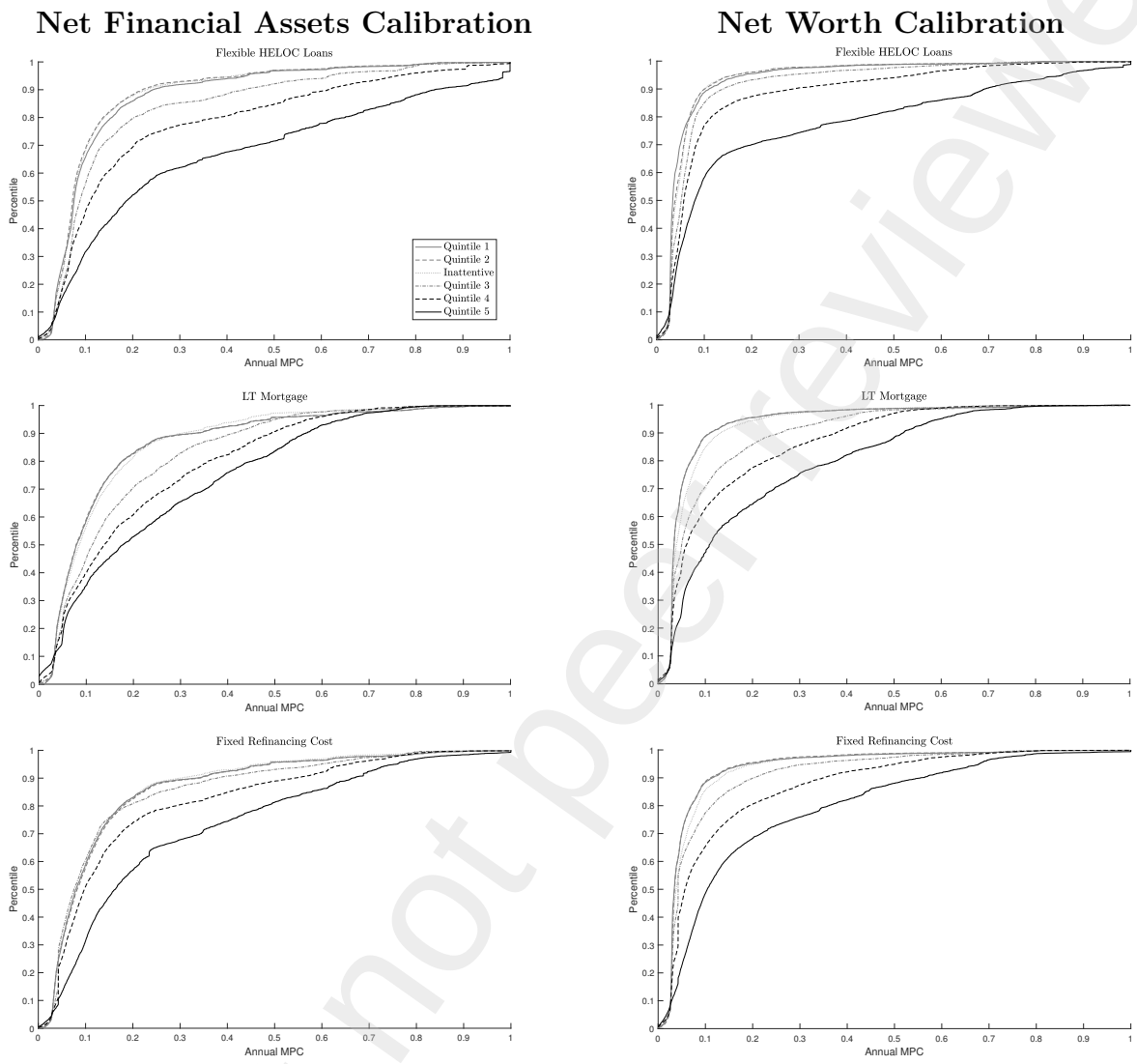
Figure A2: MPC Histogram by Borrowing Constraint



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Figure A3: MPC Cumulative Distributions by Borrowing Constraint and Expectations



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H Housing Numeraire

This note to illustrates the need for a second normalization for the rental price. To clarify the issue, a toy model where only one of the two housing variables is needed. The household lives one period, has exogenous income Y, and spends it on rent or non-durable consumption. Their utility is $U(C, H)$, prices are p_C and p_H.

The problem is described by the Lagrangian:

$$\mathcal{L} = max_{C,H} U(C, H) + \lambda[Y - p_C C - p_H H]$$

The first order conditions are as follows:

$$\frac{\partial \mathcal{L}}{\partial C} : \frac{\partial U}{\partial C} = U_C = \lambda p_C$$
$$\frac{\partial \mathcal{L}}{\partial H} : \frac{\partial U}{\partial H} = U_H = \lambda p_H$$

Next, divide by each other to get:

$$\frac{U_H}{U_C} = \frac{p_H}{p_C}$$

Thus, the marginal rate of substitution equals the relative price. As usual, the level of prices doesn't matter. Therefore, we normalize one of them, here $p_C = 1$. Thus, we have:

$$\frac{U_H}{U_C} = p_H$$

For simplicity, let's assume the following utility function $U(C, H) = log(C) + log(H)$, so we have:

$$\frac{C}{H} = p_H \quad \text{or} \quad C = p_H H$$

Plugging into the budget constraint, we have :

$$C + p_h H = p_h H + p_h H = Y$$

or, alternatively:

$$H^* = \frac{Y}{2p_h} \quad \text{and} \quad C^* = \frac{1}{2} Y$$

This is the usual expenditure share rule for log utility.

Take the concrete example: For $Y = 1$ and $p_H = 2$, we get:

$$H_1^* = \frac{Y}{2p_h} = \frac{1}{2 * 2} = \frac{1}{4} \quad \text{and} \quad C_1^* = \frac{1}{2}$$

The problem What is H? In the model, we need to calibrate the grid for H. But from the solution in the previous equations, H and p_h always appear jointly. Thus, if we half the values of the H grid but double p_H, we have exactly the same result.

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Now, in the example, set $p_H = 4$. This yields:

$$H_2^* = \frac{Y}{2 * 4} = \frac{1}{8} \text{ and } C_2^* = \frac{1}{2}$$

Thus, price doubles, H is halved but essentially same solution. The data can't differentiate between solutions 1 and 2. In the model this is also true as long as the rental price also doubles. Then expenditure shares are the same and the rent-to-price ratio is the same. Thus, one has to normalize one more variable. In this sense, the normal solution is only enough when H has a fixed definition.

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