Marginal Propensity to Consume out of Housing Wealth

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Abstract

This study examines the Marginal Propensity to Consume (MPC) out of housing wealth, highlighting differences in consumption responses between homeowners and renters. Unlike financial wealth, housing wealth affects consumption through multiple channels—substitution, wealth, and collateral effects—which operate differently for homeowners and renters. The model predicts that homeowners should have a higher MPC than renters due to these mechanisms. Using individual-level homeowner data rather than aggregate time-series data, this research provides a more precise estimate of the maximum possible MPC out of housing wealth. A key methodological innovation is the use of variation in housing services rather than housing prices, ensuring a more accurate estimation by minimizing correlation with other macroeconomic aggregates.

Empirical findings indicate that even among homeowners, the MPC out of housing wealth is lower than previously reported in the literature, underscoring the significant role of the substitution channel, which has largely been overlooked in prior studies. To demonstrate the practical relevance of these findings, the study applies its estimates to the California wildfires of January 2025, quantifying the expected short-term decline in aggregate consumption.

Additionally, the model yields a key theoretical insight: the MPC out of housing wealth can serve as a predictor for other types of MPCs, including those out of financial wealth and income.

These results emphasize the need to integrate housing-specific effects into macroeconomic models and policy frameworks to improve the understanding of consumption dynamics and wealth effects.

Keywords: marginal propensity to consume, housing services, household consumption

JEL Codes: E21, R21, D12

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1 Introduction

This study investigates the Marginal Propensity to Consume (MPC) out of housing wealth. In other words, we will explore the marginal change in non-durable consumption in response to changes in housing wealth. More formally, I refer to the MPC as the instant reaction of the expected choice variable to the unexpected change in state variable. I examine this relationship while accounting for a household's tenure status - houseowner or renter. This study highlights that the difference between MPC out of housing wealth and MPC out of financial wealth arises not from estimation methodology but from fundamental theoretical differences. Due to the fact that housing serves act both as a durable consumption good and as an asset, MPC out of housing wealth should be lower the MPC out of financial wealth. Specifically, housing wealth influences consumption through three channels: substitution, wealth and collateral; while financial wealth has only wealth channel and (sometimes) collateral channel in action. By providing a model-implied construction of the MPC out of housing wealth and out of financial wealth, this research contributes to the long-standing discussion on the relative magnitudes of these two MPCs (Case et al., 2001; Benjamin et al., 2004; Juster et al., 2004; Bostic et al., 2009).

The MPC measure holds significant theoretical and applied implications. It helps analyze the heterogeneous effects of aggregate shocks - whether from fiscal and monetary policies or broader macroeconomic factors, such as price fluctuations or natural disasters and other exogenous shocks — and their impact on aggregate outcomes. In addition, MPC plays a crucial role in determining the strength of demand spillovers and assessing the possibility of multiple consumption and income equilibria. Moreover, specifically MPC out of housing wealth informs key parameters in economic models: it is a component of the interest elasticity of consumption and the house price elasticity of consumption; its interaction with the risk aversion of the utility function shapes the risk aversion of the value function with respect to housing. These elements are fundamental in defining the expected present value of an optimized utility function. Hence, overvaluation or undervaluation of these elasticities and

risk aversions can alter the core consumer behavior functions used in economic analysis and subsequent applications. Hence, it is important to have precise data-driven estimations of the components of these parameters.

Given its broad applications, numerous studies have attempted to estimate MPC out of housing wealth. However, for a long time, researchers only had access to aggregated data over time and space. To address endogeneity concerns stemming from omitted variables, measurement errors, or simultaneity, these studies relied on instrumental variables in time series settings (Carroll et al., 2006; Mian et al., 2013; Guren et al., 2018, 2020). Meanwhile, instrumental variables allow for consistent estimation if they meet the conditions of relevance and exogeneity. The latter ensures that the instrument affects consumption through a single channel among the three possible transmission mechanisms. The abovementioned studies focus on estimating MPC through the wealth channel, either directly or indirectly (e.g., considering the budget constraint only). When researchers considered the collateral channel, they explicitly stated it and incorporated specialized data on lending and borrowing activities (Canner et al., 2002; Iacoviello, 2004; Greenspan and Kennedy, 2008; Bostic et al., 2009; Mian and Sufi, 2011; Aladangady, 2017). However, both approaches only capture partial estimates of MPC out of housing wealth, as they do not account for all three channels simultaneously — particularly the substitution channel, which is difficult to identify using aggregate data.

A natural way to address this limitation is by leveraging individual-level data. Although only a few studies have pursued this approach (Lehnert, 2004; Morris, 2011; Caceres, 2019; Choi and Zhu, 2022), their findings have been highly volatile. This variability might stem both from the characteristics and data collection processes of the PSID dataset and from the sensitivity of panel data econometric models.

This study aims to overcome these challenges. I will use an individual-level dataset to estimate the full value of MPC, which includes all three channels, and MPC's distribution across the population. The use of administrative data with repeated cross-sectional observations will enhance the consistency of the estimates. Additionally, I will adopt a semi-

parametric approach rather than a reduced-form one. A key innovation in my methodology is shifting the source of variation: instead of exploiting fluctuations in house prices, I will leverage variations in housing services. Since the total value of housing wealth is the product of housing services and house prices, identifying variation in the former rather than the latter should not introduce confusion as there will be a variation in the housing wealth. At the same time, this approach offers a significant advantage in terms of consistency, as housing services are far less correlated with other macroeconomic aggregates than house prices.

This study is structured as follows. Section 2 presents the theoretical model. Section 3 details the data sources and variables used. Section 4 outlines the baseline estimation approach. Section 5 applies the estimated MPC to a real-world scenario. Finally, Section 6 concludes the study.

2 Lifecycle Model with Housing

This section presents a discrete-time life-cycle model of household optimal consumption choice. Each household i lives for T periods, receiving an idiosyncratic labor income y^i, which remains fixed for each household across all periods. In every period t, households can allocate their wealth between two types of assets: (1) a risk-free savings asset s^i_{jt} and (2) a risky housing asset H^i_{jt}, whose value is subject to regional price fluctuations. The household i resides in local area j, which belongs to a broader regional area k (i.e., $j \subset k$). The entire economy consists of multiple regional areas covering the nation's land. The risk-free asset s^i_{jt} is purchased at a normalized price, similar to the consumption good, and yields a uniform real rate of return $(1 + r_{t+1})$ across the nation in the following period. The housing asset H^i_{jt} in local area j is bought each month at a price q_{kt} or can be rented at a price ρ_{kt}, which both vary exogenously over time across regional areas k.

The household's preferences follow a standard additively separable expected utility framework with a discount factor β. The objective function is given by: $\max_{c^i_{jt}, s^i_{jt}, H^i_{jt}} \mathbb{E} \sum_{t=1}^{T} \beta^{t-1} U(c^i_{jt}, H^i_{jt})$,

where c^i_{jt} represents consumption and H^i_{jt} denotes housing services. Although homeowners and renters share the same objective function, their budget and borrowing constraints differ.

For homeowners, housing is an asset that can serve as collateral. Their budget and borrowing constraints are:

$c^i_{jt} + q_{kt}H^i_{jt} + s^i_{jt} = y^i + q_{kt}H^i_{jt-1} + (1 + r_t)s^i_{jt-1}$,

$s^i_{jt} + q_{kt}H^i_{jt} \geq -b$, where b is the universal borrowing limit.

For renters, housing is not an asset, and they cannot borrow against it. Their budget and borrowing constraints are:

$c^i_{jt} + \rho_{kt}H^i_{jt} + s^i_{jt} = y^i + (1 + r_t)s^i_{jt-1}$,

$s^i_{jt} \geq -b$.

Assumption 1 *Assume the solution to the houseowner problem exists.*

Proposition 1 *From the necessary conditions following from Assumption 1, the Euler equation is satisfied:*

$\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} = \beta \mathbb{E}_t \left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}} ((1 + r_{t+1})q_{kt} - q_{kt+1}) \right]$.

See the proof in Appendix A.1.

Assumption 2 *Assume the solution to the renter problem exists.*

Proposition 2 *From the necessary conditions following from Assumption 2, the Euler equation is satisfied:*

$\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} = \beta \mathbb{E}_t \left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}} (1 + r_{t+1})\rho_{kt} \right] + \rho_{kt}\lambda^i_t$.

See the proof in Appendix A.2.

Next, I define the Marginal Propensity to Consume as a part of the solutions to the abovementioned constrained optimization problems.

Definition 1 (Marginal Propensity to Consume) *A Marginal Propensity to Consume (MPC) is the ratio of the change in the optimal consumption level to the unexpected change in a state variable level.*

The derived optimality conditions allow to analyze the MPC out of housing wealth, out of financial wealth and out of income (see Theorem 3 in Appendix C.1).

Precisely, MPC out of housing wealth is a marginal change in the optimal consumption level with respect to a change in a chosen housing wealth. Housing wealth is $q_{kt}H^i_{jt}$. Then, a universal representation of the MPC out of housing wealth is $\frac{\partial c^{i*}_{jt+1}}{\partial(q_{kt}H^i_{jt})} = \frac{\partial c^{i*}_{jt+1}}{H^i_{jt}\partial q_{kt}+q_{kt}\partial H^i_{jt}}$.

Assumption 3 *Assume all prices r_t, q_{kt}, ρ_{kt} are fixed in the beginning of period t.*

Proposition 3 *MPC out of housing wealth as defined by Definition 1 and under Assumption 3 becomes $\frac{\partial c^{i*}_{jt+1}}{\partial(q_{kt}H^i_{jt})} = \frac{\partial c^{i*}_{jt+1}}{q_{kt}\partial H^i_{jt}}$.*

From propositions 1 and 3, the MPC out of housing wealth for homeowners is (see Appendix C for the detailed derivation): $\frac{\partial c^{i*}_{jt+1}}{\partial q_{kt}H^i_{jt}} = \frac{1}{q_{kt}} \frac{\frac{\partial^2 U(c^i_{jt},H^i_{jt})}{(\partial H^i_{jt})^2}}{\beta\mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)((1+r_{t+1})q_{kt}-q_{kt+1})\right]}$.

From propositions 2 and 3, the MPC out of housing wealth for renters is (see Appendix C for the detailed derivation): $\frac{\partial c^{i*}_{jt+1}}{\partial q_{kt}H^i_{jt}} = \frac{1}{q_{kt}} \frac{\frac{\partial^2 U(c^i_{jt},H^i_{jt})}{(\partial H^i_{jt})^2}-\rho_{kt}\frac{\partial \lambda^i_t}{\partial H^i_{jt}}}{\beta\mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\rho_{kt}\right]}$.

These equations illustrate how homeowners and renters adjust their consumption in response to changes in housing wealth, offering insights into their different economic behavior under the same market conditions.

Assumption 4 *Assume the following functional form of the utility function for both homeowners and renters: $U(c^i_{jt}, H^i_{jt}) = \frac{\gamma c^{i1-\sigma}_{jt}}{1-\sigma} + \frac{(1-\gamma)H^{i1-\varepsilon}_{jt}}{1-\varepsilon}$.*

From Assumption 4 and propositions 1, 2, the following Euler equations become applicable for homeowners and renters, respectively:

$(1-\gamma)(H^i_{jt})^{-\varepsilon} = \beta\mathbb{E}_t\left[\gamma(c^i_{jt})^{-\sigma}((1+r_{t+1})q_{kt} - q_{kt+1})\right]$;

$(1-\gamma)(H^i_{jt})^{-\varepsilon} = \beta\mathbb{E}_t\left[\gamma(c^i_{jt})^{-\sigma}(1+r_{t+1})\rho_{kt}\right] + \rho_{kt}\lambda^i_t$.

Theorem 1 *From propositions 1, 3 and Assumption 4, the MPC out of housing wealth, out of financial wealth and out of income can be derived and the following equations connect different MPCs for households with the homeownership.*

MPC out of housing wealth: $MPC_H = \frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}} = \frac{1}{q_{kt}} \frac{\varepsilon}{\sigma} \frac{c^{i*}_{jt+1}}{H^i_{jt}}$;

MPC out of financial wealth: $MPC_s = \frac{\partial c^{i*}_{jt+1}}{\partial s^i_{jt}} = \frac{\partial H^i_{jt}}{\partial s^i_{jt}} q_{kt} MPC_H$;

MPC out of income: $MPC_y = \frac{\partial c^{i*}_{jt+1}}{\partial y^i} = \frac{\partial H^i_{jt}}{\partial y^i} q_{kt} MPC_H$.

See the proof in Appendix C.2.

Theorem 2 *From propositions 2, 3 and Assumption 4, the MPC out of housing wealth, out of financial wealth and out of income can be derived and the following equations connect different MPCs for households without the homeownership.*

MPC out of housing wealth:

$$MPC_H = \frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}} = \frac{1}{q_{kt}} \frac{\varepsilon}{\sigma} \frac{(1-\gamma)(H^i_{jt})^{-\varepsilon}}{\beta \mathbb{E}_t\left[\left(\gamma (c^{i*}_{jt+1})^{-\sigma}\right)(1+r_{t+1})\rho_{kt}\right]} \frac{c^{i*}_{jt+1}}{H^i_{jt}} - \frac{1}{q_{kt}} \frac{\frac{\partial \lambda^i_t}{\partial H^i_{jt}}}{\beta \mathbb{E}_t\left[\left(\gamma(-\sigma)(c^{i*}_{jt+1})^{-\sigma-1}\right)(1+r_{t+1})\right]};$$

MPC out of financial wealth:

$MPC_s = \frac{\partial c^{i*}_{jt+1}}{\partial s^i_{jt}} = \frac{\partial H^i_{jt}}{\partial s^i_{jt}} q_{kt} MPC_H$;

MPC out of income:

$$MPC_y = \frac{\partial c^{i*}_{jt+1}}{\partial y^i} = \frac{\partial H^i_{jt}}{\partial y^i} q_{kt} MPC_H + \frac{\frac{\partial \lambda^i_t}{\partial H^i_{jt}} \frac{\partial H^i_{jt}}{\partial y^i}}{\beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\right]}.$$

See the proof in Appendix C.3.

Hence, different types of MPCs are connected, but this connection depends on the tenure status. In this study I will estimate the MPC out of housing wealth for homeowners only, as their MPC serves as an upper-bound for the aggregate MPC. This will show what consumption reaction we should expect at most.

3 Data

The core dataset on housing services and consumption is derived from the Home Mortgage Disclosure Act (HMDA) database for the years 2018–2023. This dataset is supplemented with macroeconomic aggregate data, including regional (county-level) monthly house prices and the national monthly risk-free interest rate. Additional details of the data construction process are provided in Appendix E.

Before detailing the variables and applied calculations, I would like to highlight several key features of the dataset that align with the model. This dataset is particularly well-suited for analyzing the MPC out of housing wealth for several reasons. First, it offers extensive cross-sectional variation in both income and housing prices within each period, reasonably capturing income and price uncertainty. Although the data set does not track individual income and price changes over time or throughout the life cycle, it does reflect optimal consumption and housing choices of individuals under different realizations of income and prices. With tens of thousands of observations in each period, linking income, consumption, and housing services at the individual level, it provides a robust foundation for analysis. Second, the dataset captures the precise moment when households make decisions regarding housing, savings, and consumption, given their current income and housing prices. This makes it well-suited for examining one-time intertemporal decisions at the point of housing service's change: from having zero to having a whole house. However, if the focus were on MPC over multiple periods, this dataset would be less applicable. Nevertheless, since MPC represents the immediate optimal response to changes, this dataset effectively captures its most precise definition.

1. Consumption.

Prior to 2018, the HMDA database did not include records on mortgage applicants' income and debt-to-income (DTI) ratio. These variables are essential for capturing information on permanent monthly income flows, outstanding monthly debt payments, and projected mortgage payments. To estimate monthly consumption expenditures, I compute the residual of the budget constraint by subtracting all monthly debt obligations from the reported monthly income.

2. Housing services.

Before 2018, the HMDA database did not contain information on the market value of properties for which mortgage applications were submitted. While loan amounts were reported, they do not fully capture the property's value, as down payments can create substan-

tial variation between the two. However, from 2018 onward, the dataset includes property values, enabling a more accurate assessment of the housing services associated with a given property.

However, the value of a property does not directly reflect the housing services. Rather it reflects the product of the price per standardized housing service unit in a specific area and the quantity of housing services consumed. To estimate the quantity of housing services purchased, I divide the reported property value by the median home price in the corresponding local area, as recorded by Zillow Research for the month in which the mortgage application was submitted. Zillow Research provides a quality-controlled measure of median home prices through the Zillow Home Value Index (ZHVI). Specifically, I use the ZHVI for a "typical home" (including single-family residences and condos/co-ops), which represents "the 35th to 65th percentile range of home values". I use the smoothed, seasonally adjusted measure of ZHVI at the zip-code level.

3. House prices.

House price data, both for the current month and future month, is also sourced from Zillow Research. The same ZHVI measure used for calculating housing services is applied, but at a higher level of spatial aggregation to reflect macroeconomic conditions. House prices vary at the county level, which is the next geographical unit above the zip-code level. For each mortgage application, the initial house price corresponds to the median price in the borrower's county during the month of application. The future house price is defined as the median price in the same county in the month immediately following the application date. Each applicant is matched to these house prices based on the timing and location of their mortgage application.

4. Risk-free interest rate.

To measure the return on a risk-free asset, I use the yield on a 3-month U.S. Treasury bond, sourced from the Federal Reserve Economic Data (FRED) database. This variable is constant across all local and regional areas for a given time period, varying only at the

monthly level.

4 Euler equation estimation

4.1 Baseline

I derive the key Euler equation for homeowners (in Proposition 1), which provides the necessary optimality conditions but does not explicitly define the consumption function. To estimate the structural preference parameters using this condition, it is essential to ensure that the orthogonality condition holds. Specifically, the Euler residual should not exhibit correlation with explanatory variables. To establish this, we must first determine the nature of the Euler residual through consumers' expectations. This analysis relies on the conventional rational expectations hypothesis, which assumes that the conditional expectation operator corresponds to the mathematical expectation of the inner expression. Under this assumption, deviations from the true Euler equation average to zero over time and remain orthogonal to all available information at time t (that is, $\mathbb{E}[r_{t+1}], \mathbb{E}[q_{t+1}], q_t$). In the absence of omitted or unobserved variables, this orthogonality condition provides a sufficient basis to identify the Euler equation for homeowners.

However, estimating the model using the nonlinear equation derived above is likely to result in biased coefficients. As highlighted in previous studies on the estimation of the Euler equation (Attanasio and Low, 2004), there are several reasons why a log-linearized approximation of the Euler equation should be used when bringing the model to the data. First, log-linearization transforms most time series of aggregate macroeconomic variables into a linear form, making their effects on individual-level variables more tractable. Second, linearization mitigates the influence of measurement errors and unobserved heterogeneity. Instead of introducing multiplicative distortions, these factors affect the estimation additively, reducing potential biases. Third, log-linearization yields a regression equation that is linear in parameters and has additive residuals, allowing for the application of standard linear

regression techniques. The presence of nonlinearities in variables does not introduce significant estimation biases for the individual data as it does in the aggregate data (Attanasio and Weber, 1993), so any left nonlinearity in variables is acceptable.

In this study, to derive a linear regression equation in the parameters, we assume that asset prices and the marginal utility of consumption follow a joint log-normal distribution. Following these considerations, I adopt the approach outlined in (Hansen and Singleton, 1983). Details of the linearization procedure can be found in Appendix B. Under the simplest assumptions, this yields the following baseline regression for a homeowner i:

$\ln(c^i_{jt+1}) = \beta_1 + \beta_2 \ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}}) + \beta_3 \ln(q_{kt}) + \beta_4 \ln(H^i_{jt}) + u^i_{t+1}$.

The results are presented in Table 1. This elasticity gives rise to more than 3 million MPCs. These raw values plotted against the value of a property are shown on Figure 1. However, because of the high density of the observations close to zero, I also plot the kernel density estimation (Figure 2), using Epanechnikov kernel and Sheather & Jones bandwidth.

Table 1: Baseline model

	Dependent variable:
	C_t
$\ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$	0.011^{***}
	(0.0003)
$\ln(q_{kt})$	0.525^{***}
	(0.001)
$\ln(H_t)$	0.658^{***}
	(0.001)
Constant	1.879^{***}
	(0.008)
Observations	3,381,857
R^2	0.31075001
Adjusted R^2	0.31074940
Residual Std. Error	0.543 (df = 3381853)
F Statistic	$508{,}238.800^{***}$ (df = 3; 3381853)
Note:	*p<0.1; **p<0.05; ***p<0.01

This regression is obtained under the assumption of constant variance in log-normally dis-

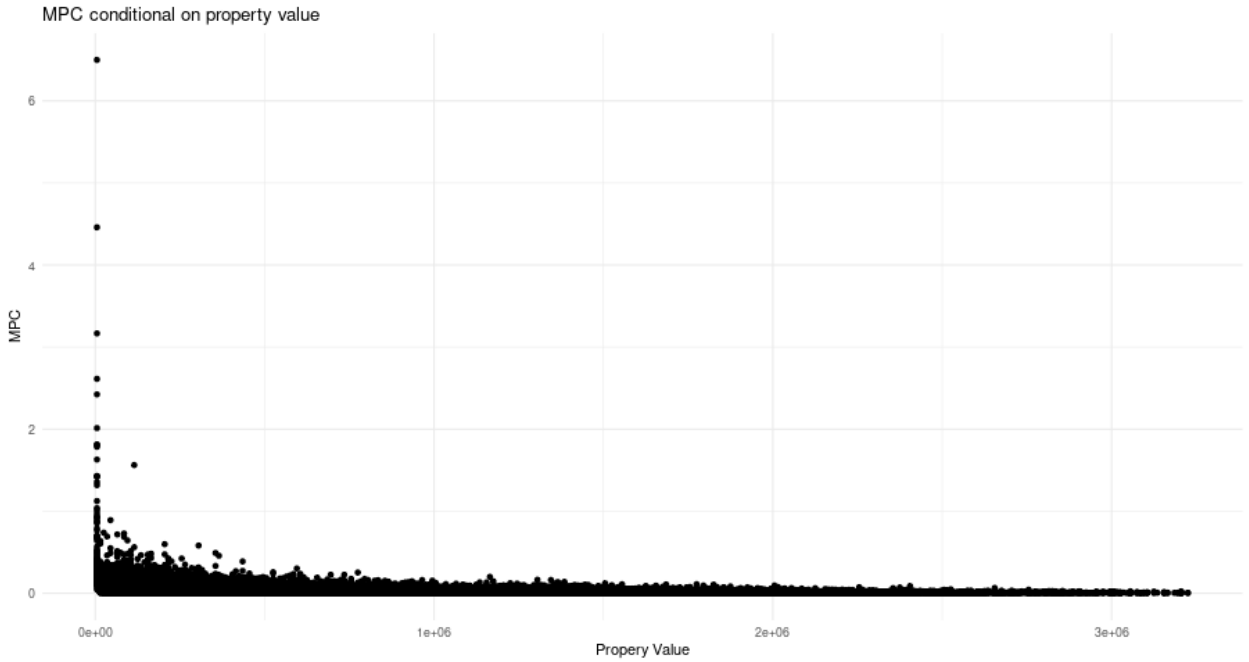


Figure 1: Estimated MPC for the sample

tributed random variables and that the Euler residual can be captured by either a constant, dummy variables (time or group effects), or the error term. However, these assumptions are not guaranteed to hold in practice. Issues such as asymptotic convergence, measurement errors, and unobserved heterogeneity could still affect the validity of estimates. To address these potential challenges, I extend the analysis by relaxing these assumptions and implementing methods to account for such issues.

4.2 Higher-order moments

The linearized Euler equation presented above is generally sufficient for unbiased estimation of structural preference parameters. However, this holds only "if the innovations to the conditional second (and possibly higher) moments ... are uncorrelated with the instruments one uses in estimation" (Attanasio and Low, 2004), as these higher-order moments are typically absorbed into the error term.

In this analysis, I estimate the correlation between the error term u^i_{t+1} and the conditional

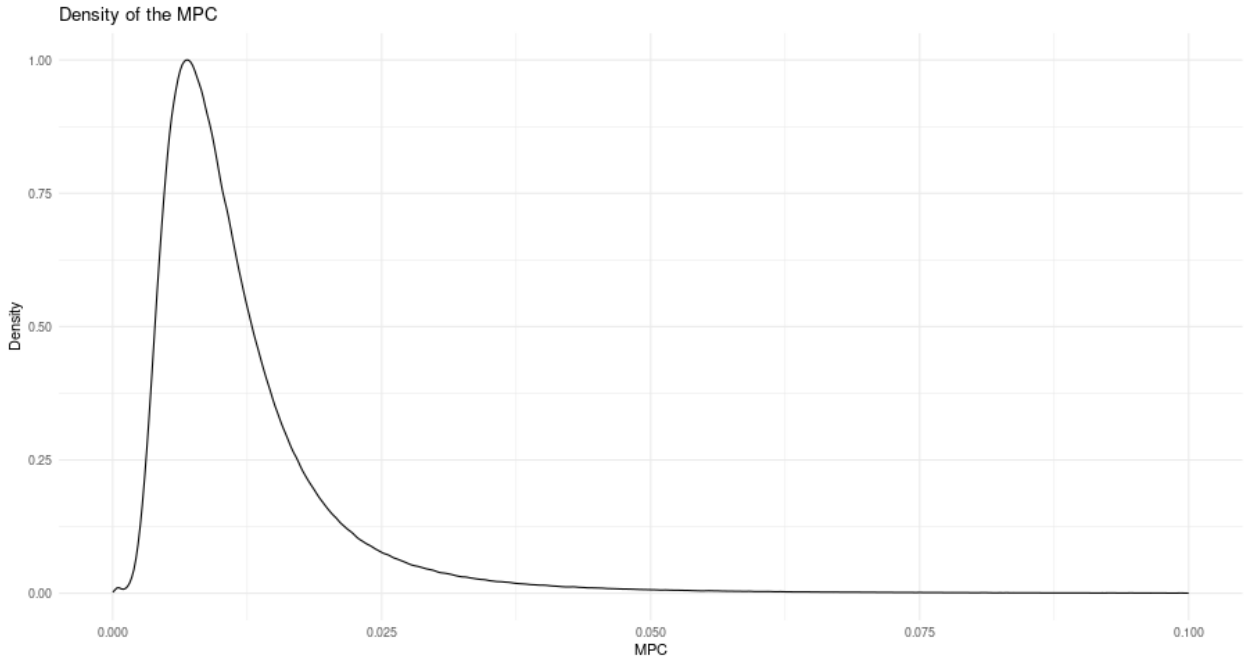


Figure 2: Kernel density estimation of the MPC

variances $Var_t(c), Var_t(1+r-\frac{q_k}{q_k}), Var_t(c)+Var_t(1+r-\frac{q_k}{q_k})-2\rho_t\sqrt{\sigma^2 Var_t(c)Var_t(1+r-\frac{q_k}{q_k})}$. If these variance terms exhibit significant correlation with the error term, I will incorporate time-varying variance as an additional regressor in the estimation. Conversely, if no correlation is detected, the assumption of constant variance remains valid and the variance term will contribute only to the regression constant.

Under the assumption of rational expectations and upon computing the variance terms, the results indicate no significant correlation with the error term, as indicated in Table 2. Therefore, I proceed with the baseline model under the constant variance assumption.

Table 2: Correlation with the error term

	$Var_t(c)$	$Var_t(1+r-\frac{q_k}{q_k})$	$Var_t(c)+Var_t(1+r-\frac{q_k}{q_k})-2\rho_t\sqrt{\sigma^2 Var_t(c)Var_t(1+r-\frac{q_k}{q_k})}$
u^i_{t+1}	2.604e-17	1.766e-17	1.335e-17

4.3 Asymptotical convergence

To obtain systematically unbiased parameter estimates, we typically rely on "large T" asymptotics, which ensures that the expected error converges to zero in the limit. The required length of the time series for this result depends on the variability of the independent variables. Fortunately, leveraging a diverse cross-sectional dataset allows for a faster rate of convergence. The figures below illustrate the statistical properties of the residuals conditional on time. Although the confidence intervals of the error residual stabilize rapidly (Figure 3), the mean error term requires nearly the entire sample period to converge to zero (Figure 4). Additionally, I present the distribution of the residuals for the baseline regression (Figure 5). The error term follows a normal distribution with a mean of zero, supporting the validity of the estimation approach. Given these properties, a sample comprising 72 periods of cross-sectional data should be sufficient for precise estimation.

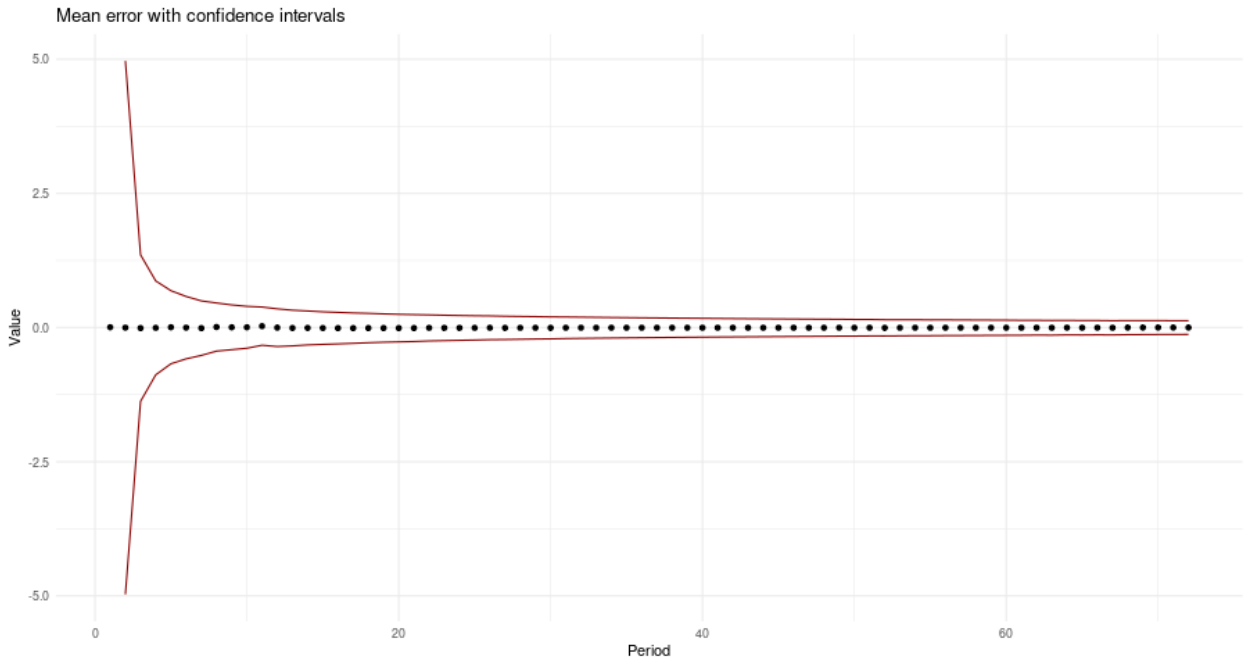


Figure 3: Convergence with confidence intervals

However, if the number of periods is considered insufficient, an alternative approach would require assuming a complete market structure to derive similar asymptotic properties for the

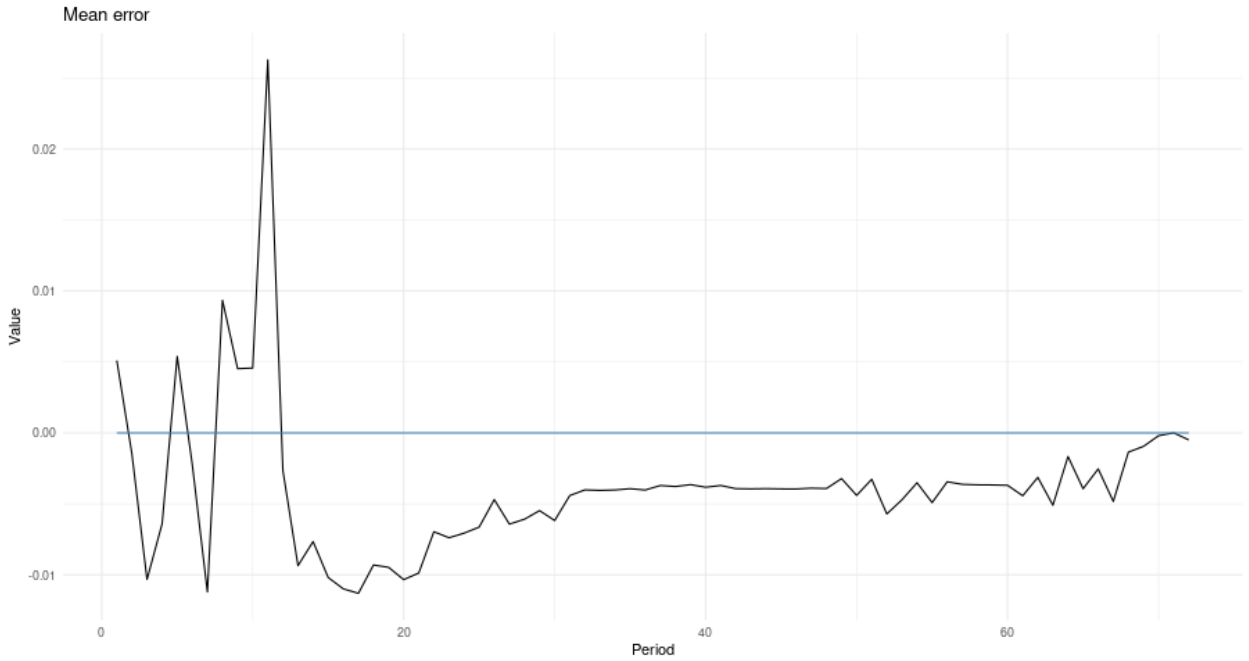


Figure 4: Convergence of the mean error

cross-sectional data. This would involve estimating the regression separately for each time period while decomposing the expectation error into aggregate and idiosyncratic components. The aggregate component would be absorbed into the regression constant or time dummies, while the idiosyncratic component would remain in the error term. However, I refrain from utilizing these specifications, as the assumption of complete markets in the housing sector is highly questionable. Nonetheless, for the sake of illustration of this alternative approach, I include some of these alternative specifications in Appendix D.

4.4 Omitted variables

Given the methodology and data characteristics, several potential sources of omitted variable bias need to be considered, including measurement errors, unobserved heterogeneity, and innovations to higher-order moments of the time series. However, because of the log-linear approximation employed, these factors are expected to have only an additive effect on the Euler equation of interest. Consequently, in most cases, their impact can be accounted for using dummies at the time, spatial, or demographic level.

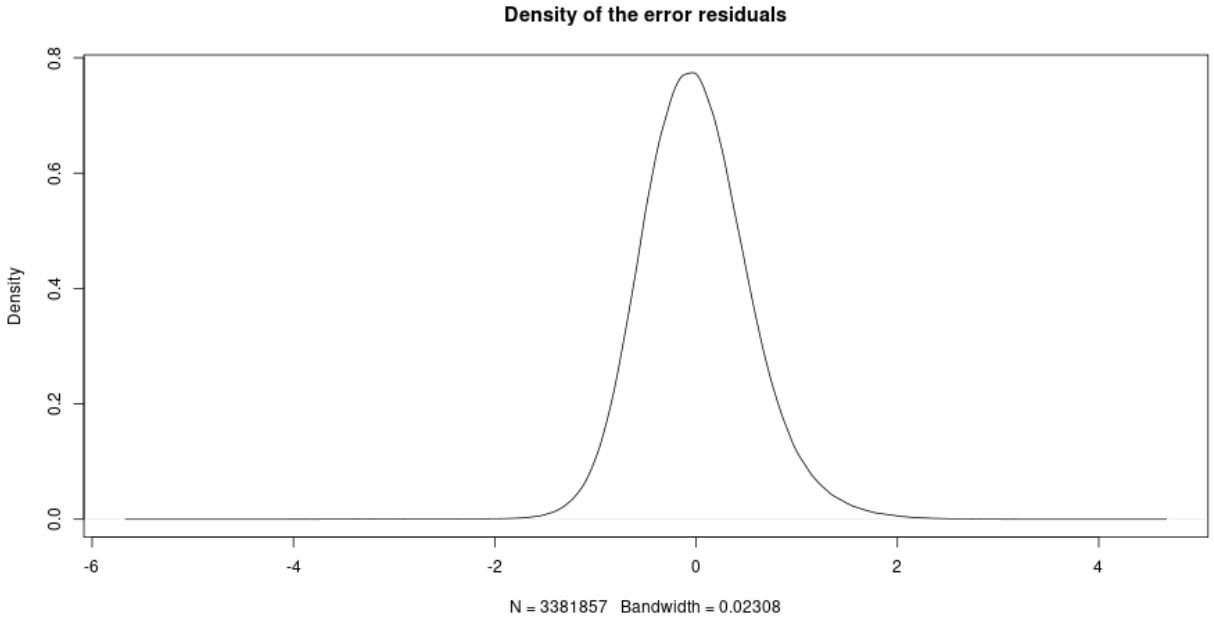


Figure 5: Density of the baseline regression error

Appendix D presents multiple model specifications that explicitly test for these potential problems. Among the factors examined, only the unobserved heterogeneity emerges as statistically significant. In particular, both the geographical and demographic components exhibit strong significance. While incorporating these variables as fixed effects does not substantially alter the primary estimates of the preference parameters [1], their significance underscores the necessity of estimating the regression within specific geographical and demographic subgroups.

Notably, state of residence and key demographic characteristics of the primary applicant—such as ethnicity, race, and sex—have the potential to slightly influence the estimated preference parameters when the analysis is conducted within subgroups. However, this shift does not in general affect the nature of the MPC - the one stays at low but positive values. For example, the average MPC changes from 0.012 in the nationwide estimate to 0.008 for the state of California. More detailed group-specific estimates can be found in Appendix D.

[1]Baseline estimation provides elasticity parameter of 0.6584622;Adding state fixed effect create elasticity parameter of 0.6607919; Adding control for main applicant ethnicity create 0.6513898; Adding main applicant race creates 0.6584124; Adding main applicant sex creates 0.6429982

5 Example: Impact of the California wildfires in January 2025 on Aggregate Demand

In this section, I apply the estimated MPC out of housing wealth to a real-world scenario: the impact of natural disasters. This case is particularly relevant for several reasons.

First, natural disasters primarily affect housing services rather than housing prices, making them an ideal test case for the model. Since the estimated MPC relies on variations in housing services rather than price fluctuations, this application ensures that the empirical estimates remain highly relevant in measuring consumption responses.

Second, the shock induced by a natural disaster is permanent, unlike house price fluctuations, which may be temporary or subject to shifting household expectations. Even if a decline in house prices persists for several years, households may anticipate price recovery, altering their consumption behavior accordingly. In contrast, damage to housing services cannot be reversed by market forces alone—households must adapt to the new circumstances. This key distinction ensures that expectations align with reality, allowing for a more direct application of the model.

Third, natural disasters introduce an unexpected shock to the state variable, whereas changes in house prices can often be anticipated. If households foresee a decline in home values, they may adjust their consumption preemptively, introducing bias into observable state and choice variables. By contrast, the sudden and largely unpredictable nature of direct housing damage from natural disasters provides a unique opportunity to observe an optimal consumption response to an exogenous shock.

These factors make natural disasters an ideal setting to apply the estimated MPC out of housing wealth, providing empirical validation of the model in a context where expectations and economic reality align seamlessly.

I estimate the MPC out of housing wealth specifically for the state of California. The results of the baseline model, along with the aggregated MPC, are presented in Table 3.

Table 3: Model for CA state

	Dependent variable:
	C_t
$\ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$	0.026^{***}
	(0.001)
$\ln(q_{kt})$	0.634^{***}
	(0.002)
$\ln(H_t)$	0.623^{***}
	(0.003)
Constant	0.458^{***}
	(0.034)
Observations	300,010
R^2	0.2633903
Adjusted R^2	0.2633829
Residual Std. Error	0.545 (df = 300006)
F Statistic	$35{,}757.820^{***}$ (df = 3; 300006)
Note:	*p<0.1; **p<0.05; ***p<0.01

Next, I calculate the total damage to housing services caused by the January 2025 wildfires. The estimated damage to residential housing amounts to \$1 319 643 674[2]. Based on this, the expected decline in consumption expenditures on nondurable goods is projected to be \$10 875 806,7. It is important to note that, according to the model, this consumption decline is expected to persist for the following month of the damage, that is February 2025, reflecting the short-term response of households to the shock in housing services.

6 Conclusion

This study contributes to the estimation of the MPC out of housing wealth by employing a more precise dataset, a theoretically refined model of consumption and housing choice, and an approach that leverages variation in housing services rather than housing prices. This latter innovation is particularly significant, as it captures individual consumption choices

[2]DINS Data, https://data.ca.gov/dataset/cal-fire-damage-inspection-dins-data

while minimizing concerns about correlation with broader macroeconomic price fluctuations. Additionally, this framework allows for the use of a simple yet flexible linear least squares estimator while effectively controlling for potential omitted variables through fixed effects.

The baseline regression results indicate that the estimated MPC out of housing wealth is both consistent and unbiased. The inclusion of regional and demographic controls enables a more granular understanding of MPC variation across different subgroups. Nonetheless, the national average remains a reasonable and informative aggregate measure, providing a useful benchmark that accounts for the composition of diverse demographic and regional groups.

The findings suggest that the MPC out of housing wealth is relatively lower than many previous estimates in the literature. My findings suggest a $\sim$\$0.01 response in consumption to the change of \$1 change in housing wealth. The theoretical model predicts a positive MPC for homeowners, whereas renters exhibit a lower, potentially even negative, MPC out of housing wealth. This distinction highlight the importance of considering tenure status and appropriate benchmark values when estimating consumption responses to wealth fluctuations. Overlooking these factors may have led to biases in prior estimations.

As an additional theoretical result, the model yields a key theoretical insight: the MPC out of housing wealth can serve as a predictor for other types of MPCs, including those out of financial wealth and income.

This study provides robust estimates of only the MPC out of housing wealth for homeowners. Expanding the analysis to estimate multiple MPCs (out of financial wealth and income) across households with different tenure statuses would be a valuable direction for future research.

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A Appendix

A.1 Proof of Proposition 1

Houseowner i's monthly problem:

$\max_{c^i_{jt}, s^i_{jt}, H^i_{jt}} \mathbb{E}\sum_{t=1}^{T} \beta^{t-1} U(c^i_{jt}, H^i_{jt})$,

s.t. $c^i_{jt} + q_{kt}H^i_{jt} + s^i_{jt} = y^i + q_{kt}H^i_{jt-1} + (1+r_t)s^i_{jt-1}$,

$s^i_{jt} + q_{kt}H^i_{jt} \geq -b$.

j - local area; k - regional area; $j \subset k$; t - month period.

r_t, q_{kt} - fixed at t.

y^i - time-invariant individual idiosyncratic const.

H^i_{j0}, s^i_{j0} - given individual starting points.

If the solution exists, the constrained optimization problem can be rewritten in the Lagrangian formulation:

$L(c^i_{jt}, H^i_{jt}, s^i_{jt}; \mu^i_t, \lambda^i_t) = \mathbb{E}\sum_{t=1}^{T} \beta^{t-1} U(c^i_{jt}, H^i_{jt}) + \mathbb{E}\sum_{t=1}^{T} \beta^{t-1}\mu^i_t(y^i + q_{kt}H^i_{jt-1} + (1+r_t)s^i_{jt-1} - q_{kt}H^i_{jt} - s^i_{jt} - c^i_{jt}) + \mathbb{E}\sum_{t=1}^{T} \beta^{t-1}\lambda^i_t(s^i_{jt} + q_{kt}H^i_{jt} + b)$

Kuhn-Tucker conditions for houseowner:

(1) $\frac{\partial L}{\partial c^i_{jt}} = \frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} - \mu^i_t = 0$

(2) $\frac{\partial L}{\partial s^i_{jt}} = -\mu^i_t + \beta\mathbb{E}_t\left[\mu^i_{t+1}(1+r_{t+1})\right] + \lambda^i_t = 0$

(3) $\frac{\partial L}{\partial H^i_{jt}} = \frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} - \mu^i_t q_{kt} + \beta\mathbb{E}_t\left[\mu^i_{t+1}q_{kt+1}\right] + \lambda^i_t q_{kt} = 0$

(4) $\mu^i_t(y^i + q_{kt}H^i_{jt-1} + (1+r_t)s^i_{jt-1} - q_{kt}H^i_{jt} - s^i_{jt} - c^i_{jt}) = 0$

(5) $\lambda^i_t(s_{tj} + q_{kt}H^i_{jt} + b) = 0$

We consider the simple case of always binding budget constraint, which implies that $\mu^i_t > 0$, and we consider interior solutions when $s^i_{jt} > 0, c^i_{jt} > 0, H^i_{jt} > 0$. From (1) get $\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} = \mu^i_t$ and substitute into (2), (3) to get

(6) $\frac{\partial L}{\partial s^i_{jt}} = -\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} + \beta\mathbb{E}_t\left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}(1+r_{t+1})\right] + \lambda^i_t = 0$,

(7) $\frac{\partial L}{\partial H^i_{jt}} = \frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} - q_{kt}\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} + \beta\mathbb{E}_t\left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}q_{kt+1}\right] + \lambda^i_t q_{kt} = 0$.

Next, from (6) express $\lambda^i_t = \frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} - \beta\mathbb{E}_t\left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}(1+r_{t+1})\right]$ and substitute into (7):

$\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} - q_{kt}\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} + \beta\mathbb{E}_t\left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}q_{kt+1}\right] + \left(\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} - \beta\mathbb{E}_t\left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}(1+r_{t+1})\right]\right)q_{kt} = 0$. We get $\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} + \beta\mathbb{E}_t\left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}q_{kt+1}\right] - \beta\mathbb{E}_t\left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}(1+r_{t+1})\right]q_{kt} = 0$, which by rearranging becomes $\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} = \beta\mathbb{E}_t\left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}((1+r_{t+1})q_{kt} - q_{kt+1})\right]$.

We end up with the Euler equation of the main interest, which connects housing services choice in the previous period and consumption choice in the upcoming period:

$\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} = \beta\mathbb{E}_t\left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}((1+r_{t+1})q_{kt} - q_{kt+1})\right]$.

A.2 Proof of Proposition 2

Renter i's monthly problem:

$\max_{c^i_{jt}, s^i_{jt}, H^i_{jt}} \mathbb{E} \sum_{t=1}^{T} \beta^{t-1} U(c^i_{jt}, H^i_{jt})$,

s.t. $c^i_{jt} + \rho_{kt} H^i_{jt} + s^i_{jt} = y^i + (1 + r_t) s^i_{jt-1}$,

$s^i_{jt} \geq -b$.

j - local area; k - regional area; $j \subset k$; t - month period.

r_t, ρ_{kt} - fixed at t.

y^i - time-invariant individual idiosyncratic const.

H^i_{j0}, s^i_{j0} - given individual starting points.

If the solution exists, the constrained optimization problem can be rewritten in the Lagrangian formulation:

$L(c^i_{jt}, H^i_{jt}, s^i_{jt}; \mu^i_t, \lambda^i_t) = \mathbb{E} \sum_{t=1}^{T} \beta^{t-1} U(c^i_{jt}, H^i_{jt}) + \mathbb{E} \sum_{t=1}^{T} \beta^{t-1} \mu^i_t (y^i + (1+r_t) s^i_{jt-1} - \rho_{kt} H^i_{jt} - s^i_{jt} - c^i_{jt}) + \mathbb{E} \sum_{t=1}^{T} \beta^{t-1} \lambda^i_t (s^i_{jt} + b)$

Kuhn-Tucker conditions for renter:

(1) $\frac{\partial L}{\partial c^i_{jt}} = \frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} - \mu^i_t = 0$

(2) $\frac{\partial L}{\partial s^i_{jt}} = -\mu^i_t + \beta \mathbb{E}_t \left[\mu^i_{t+1} (1 + r_{t+1}) \right] + \lambda^i_t = 0$

(3) $\frac{\partial L}{\partial H^i_{jt}} = \frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} - \mu^i_t \rho_{kt} = 0$

(4) $\mu^i_t (y^i + (1 + r_t) s^i_{jt-1} - \rho_{kt} H^i_{jt} - s^i_{jt} - c^i_{jt}) = 0$

(5) $\lambda^i_t (s^i_{jt} + b) = 0$

We consider the simple case of the always binding budget constraint, which implies that $\mu^i_t > 0$, and we consider interior solutions when $s^i_{jt} > 0, c^i_{jt} > 0, H^i_{jt} > 0$. From (1) get $\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} = \mu^i_t$ and substitute into (2), (3) to get

(6) $\frac{\partial L}{\partial s^i_{jt}} = -\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} + \beta \mathbb{E}_t \left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}} (1 + r_{t+1}) \right] + \lambda^i_t = 0,$

(7) $\frac{\partial L}{\partial H^i_{jt}} = \frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} - \rho_{kt} \frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} = 0.$

Next, from (6) express $\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}} = \beta \mathbb{E}_t \left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}} (1 + r_{t+1}) \right] + \lambda^i_t$ and substitute into (7): $\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} = \rho_{kt} (\beta \mathbb{E}_t \left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}} (1 + r_{t+1}) \right] + \lambda^i_t)$.

We get the Euler equation of interest, which connects the housing services choice in the previous period and optimal consumption choice in the upcoming period:

$\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} = \beta \mathbb{E}_t \left[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}} (1 + r_{t+1}) \rho_{kt} \right] + \rho_{kt} \lambda^i_t.$

B Appendix

B.1 Log-linearization of homeowner Euler equation

The Euler equation of interest is $\beta \mathbb{E}_t [\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}} (q_{kt}(1 + r_{t+1}) - q_{kt+1})] = \frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}}$.

Assumption 5 *Assume rational expectations of individuals.*

Assumption 6 *Assume joint log-normal distribution of asset prices* $(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$ *and the marginal utility of consumption.*

Proposition 4 *From assumptions 4, 5 and 6, the relevant regression equation for the Euler equation* $\beta\mathbb{E}_t[\frac{\partial U(c^i_{jt+1},H^i_{jt+1})}{\partial c^i_{jt+1}}(q_{kt}(1+r_{t+1}) - q_{kt+1})] = \frac{\partial U(c^i_{jt},H^i_{jt})}{\partial H^i_{jt}}$ *becomes*

$\ln(c^i_{jt+1}) = \beta_1 + \beta_2 \ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}}) + \beta_3 \ln(q_{kt}) + \beta_4 \ln(H^i_{jt}) + u^i_{t+1}$.

See the proof below.

B.1.1 Proof of Proposition 4

Suppose that the first t observations are used to predict the values in the $t+1$ period of time. Then, the constants can be excluded from the expectational operator:

$\mathbb{E}_t[(c^i_{jt+1})^{-\sigma}(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})] = \frac{1-\gamma}{\beta\gamma}\frac{1}{q_{kt}}(H^i_{jt})^{-\varepsilon}$.

According to the distributional assumption, it should be true that the expected value of jointly log-normal variables is:

$\mathbb{E}_t[(c^i_{jt+1})^{-\sigma}(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})] = \exp(\mu^c_t + \mu_t^{1+r-\frac{q_k}{q_k}} + \frac{1}{2}(\sigma^2 Var_t(c) + Var_t(1 + r - \frac{q_k}{q_k}) - 2\rho_t\sqrt{\sigma^2 Var_t(c) Var_t(1 + r - \frac{q_k}{q_k})}))$, where $\mu^c_t = \mathbb{E}^t_{-\infty}[(c^i_j)^{-\sigma}]$ is the linear function of the previous observation to predict $(c^i_{jt+1})^{-\sigma}$, and $Var_t(c)$ is the variance of c^i_{jt+1} derived from previous observations of c^i_j,up to t. The same notation applies to $1 + r - \frac{q_k}{q_k}$, which according to the independence of prices for different assets transforms into one random variable. The variable ρ_t can be derived from the combination of joint and marginal distributional assumptions. To do this, consider the standard covariance formula $COV_t(c^{-\sigma}, 1+r-\frac{q_k}{q_k}) = \mathbb{E}_t[c^{-\sigma}(1+r-\frac{q_k}{q_k})] - \mathbb{E}_t[c^{-\sigma}]\mathbb{E}_t[1+r-\frac{q_k}{q_k}]$. Notice that $\mathbb{E}_t[c^{-\sigma}(1+r-\frac{q_k}{q_k})] = \exp(\mu^c_t+\mu_t^{1+r-\frac{q_k}{q_k}}+\frac{1}{2}(\sigma^2 Var_t(c)+Var_t(1+ r-\frac{q_k}{q_k})-2\rho_t\sqrt{\sigma^2 Var_t(c) Var_t(1 + r - \frac{q_k}{q_k})}))$, and that $\mathbb{E}_t[c^{-\sigma}] = \exp(\mu^c_t+\frac{1}{2}\sigma^2 Var_t(c))$, and the same applies to another variable $\mathbb{E}_t[1+r-\frac{q_k}{q_k}] = \exp(\mu_t^{1+r-\frac{q_k}{q_k}}+\frac{1}{2}Var_t(1+r-\frac{q_k}{q_k}))$. Combining the three formulas above, get $COV_t(c^{-\sigma}, 1 + r - \frac{q_k}{q_k}) = \exp(\mu^c_t + \mu_t^{1+r-\frac{q_k}{q_k}} + \frac{1}{2}(\sigma^2 Var_t(c) + Var_t(1 + r - \frac{q_k}{q_k}) - 2\rho_t\sqrt{\sigma^2 Var_t(c) Var_t(1 + r - \frac{q_k}{q_k})})) - \exp(\mu^c_t + \frac{1}{2}\sigma^2 Var_t(c) + \mu_t^{1+r-\frac{q_k}{q_k}} + \frac{1}{2}Var_t(1 + r - \frac{q_k}{q_k}))$. Factor out the term $\exp(\mu^c_t + \frac{1}{2}\sigma^2 Var_t(c) + \mu_t^{1+r-\frac{q_k}{q_k}} + \frac{1}{2}Var_t(1 + r - \frac{q_k}{q_k}))$ and rearrange to get the formula $\rho_t = \ln(\frac{COV_t(c^{-\sigma}, 1+r-\frac{q_k}{q_k})}{\exp(\mu^c_t+\frac{1}{2}\sigma^2 Var_t(c)+\mu_t^{1+r-\frac{q_k}{q_k}}+\frac{1}{2}Var_t(1+r-\frac{q_k}{q_k}))} + 1) * \frac{1}{\sqrt{\sigma^2 Var_t(c) Var_t(1+r-\frac{q_k}{q_k})}}$.

From equating the right-hand side of the two Euler equations expressed in expectations, one can derive the following:

$\mu^c_t + \mu_t^{1+r-\frac{q_k}{q_k}} = \ln(1-\gamma) - \ln(\beta\gamma) - \ln(q_{kt}) - \varepsilon\ln(H^i_{jt}) - \frac{1}{2}\sigma^2 Var_t(c) - \frac{1}{2}Var_t(1+r-\frac{q_k}{q_k}) + \rho_t\sqrt{\sigma^2 Var_t(c) Var_t(1 + r - \frac{q_k}{q_k})}$

Next, define $u^i_{t+1} = \ln((c^i_{jt+1})^{-\sigma}(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})) - \mu^c_t - \mu_t^{1+r-\frac{q_k}{q_k}}$.

According to the assumption of rational expectations, this residual should be orthogonal to all information possessed at time t:

$\mathbb{E}_t[u^i_{t+1}] = 0$.

Then, considering rational expectations, the following equation should be true.

$\ln((c^i_{jt+1})^{-\sigma}) + \ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}}) - \ln(1-\gamma) + \ln(\beta\gamma) + \ln(q_{kt}) + \varepsilon \ln(H^i_{jt}) + \frac{1}{2}\sigma^2 Var_t(c) + \frac{1}{2}Var_t(1 + r - \frac{q_k}{q_k}) - \rho_t\sqrt{\sigma^2 Var_t(c)Var_t(1 + r - \frac{q_k}{q_k})} = 0$.

The applicable regression model can be represented as

$\sigma \ln(c^i_{jt+1}) = \ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}}) - \ln(1-\gamma) + \ln(\beta\gamma) + \ln(q_{kt}) + \varepsilon \ln(H^i_{jt}) + \frac{1}{2}\sigma^2 Var_t(c) + \frac{1}{2}Var_t(1 + r - \frac{q_k}{q_k}) - \rho_t\sqrt{\sigma^2 Var_t(c)Var_t(1 + r - \frac{q_k}{q_k})}$

Or

$\sigma \ln(c^i_{jt+1}) = const + \ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}}) + \ln(q_{kt}) + \varepsilon \ln(H^i_{jt}) + \frac{1}{2}Var_t(c) + \frac{1}{2}Var_t(1 + r - \frac{q_k}{q_k}) - \rho_t\sqrt{Var_t(c)Var_t(1 + r - \frac{q_k}{q_k})} + u^i_{t+1}$.

In more formal econometric terms, the regression is $\ln(c^i_{jt+1}) = \beta_1 + \beta_2 Var_t(c) + \beta_3 Var_t(1 + r - \frac{q_k}{q_k}) - \beta_4\rho_t\sqrt{Var_t(c)Var_t(1 + r - \frac{q_k}{q_k})} + \beta_5 \ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}}) + \beta_6 \ln(q_{kt}) + \beta_7 \ln(H^i_{jt}) + u^i_{t+1}$.

If we provide simpler assumptions about variance, such that there is only one joint variance term, the regression consequentially becomes $\ln(c^i_{jt+1}) = \beta_1 + \beta_2 Var_t + \beta_3 \ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}}) + \beta_4 \ln(q_{kt}) + \beta_5 \ln(H^i_{jt}) + u^i_{t+1}$.

If we assume even simpler constant variance of the log-normal distribution, then the regression will be $\ln(c^i_{jt+1}) = \beta_1 + \beta_2 \ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}}) + \beta_3 \ln(q_{kt}) + \beta_4 \ln(H^i_{jt}) + u^i_{t+1}$. This regression will be the starting point of my econometric analysis, as the simplest case possible.

B.2 Log-linearization of renter Euler equation

The Euler equation of interest is $\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} = \beta\mathbb{E}_t[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}(1 + r_{t+1})\rho_{kt}] + \rho_{kt}\lambda^i_t$.

Assumption 7 *Assume joint log-normal distribution of asset prices* $(1 + r_{t+1})$ *and the marginal utility of consumption.*

Proposition 5 *From assumptions 4, 5 and 7, the relevant regression equation for the Euler equation* $\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} = \beta\mathbb{E}_t[\frac{\partial U(c^i_{jt+1}, H^i_{jt+1})}{\partial c^i_{jt+1}}(1 + r_{t+1})\rho_{kt}] + \rho_{kt}\lambda^i_t$ *becomes*

$\ln(c^i_{jt+1}) = \beta_1 + \beta_2 \ln(1 + r_{t+1}) + \beta_3 \ln(\frac{1}{\rho_{kt}}\frac{1-\gamma}{\beta\gamma}(H^i_{jt})^{-\varepsilon} - \lambda^i_t) + u^i_{t+1}$.

Proposition 6 *From assumptions 4 and 5, the relevant regression equation for the Euler equation* $\frac{1}{\rho_{kt}}\frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial H^i_{jt}} = \frac{\partial U(c^i_{jt}, H^i_{jt})}{\partial c^i_{jt}}$ *becomes*

$\ln(c^i_{jt+1}) = \beta_1 + \beta_2 \ln(\rho_{kt}) + \beta_3 \ln(H^i_{jt}) + u^i_{t+1}$.

See the proofs below.

B.2.1 Proof of Proposition 5

Most of the following steps are analogous to the ones in section B.1 of the Appendix B.

Under rational expectations and log-normal joint distribution

$\mathbb{E}_t[(c^i_{jt+1})^{-\sigma}(1+r_{t+1})] = \frac{1}{\rho_{kt}}\frac{1-\gamma}{\beta\gamma}(H^i_{jt})^{-\varepsilon} - \lambda^i_t$,

$\mathbb{E}_t[(c^i_{jt+1})^{-\sigma}(1+r_{t+1})] = \exp(\mu^c_t+\mu^{1+r}_t+\frac{1}{2}(\sigma^2 Var_t(c)+Var_t(1+r)-2\rho_t\sqrt{\sigma^2 Var_t(c)Var_t(1+r)}))$.

From two equations above $\mu^c_t + \mu^{1+r}_t = \ln(\frac{1}{\rho_{kt}}\frac{1-\gamma}{\beta\gamma}(H^i_{jt})^{-\varepsilon} - \lambda^i_t) - \frac{1}{2}Var_t(c) - \frac{1}{2}\sigma^2 Var_t(1+r) + \rho_t\sqrt{\sigma^2 Var_t(c)Var_t(1+r)}$.

Define $u^i_{t+1} = \ln((c^i_{jt+1})^{-\sigma}(1+r_{t+1})) - \mu^c_t - \mu^{1+r}_t$, which should be orthogonal to all information possessed at time t, $\mathbb{E}_t[u^i_{t+1}] = 0$.

Then, the following should be true:

$\ln((c^i_{jt+1})^{-\sigma}) + \ln(1+r_{t+1}) - \ln(\frac{1}{\rho_{kt}}\frac{1-\gamma}{\beta\gamma}(H^i_{jt})^{-\varepsilon} - \lambda^i_t) + \frac{1}{2}\sigma^2 Var_t(c) + \frac{1}{2}Var_t(1+r) - \rho_t\sqrt{\sigma^2 Var_t(c)Var_t(1+r)} = 0$.

The applicable regression model can be represented as

$\sigma\ln(c^i_{jt+1}) = \ln(1+r_{t+1}) - \ln(\frac{1}{\rho_{kt}}\frac{1-\gamma}{\beta\gamma}(H^i_{jt})^{-\varepsilon} - \lambda^i_t) + \frac{1}{2}\sigma^2 Var_t(c) + \frac{1}{2}Var_t(1+r) - \rho_t\sqrt{\sigma^2 Var_t(c)Var_t(1+r)}$.

Or,

$\sigma\ln(c^i_{jt+1}) = \ln(1+r_{t+1}) - \ln(\frac{1}{\rho_{kt}}\frac{1-\gamma}{\beta\gamma}(H^i_{jt})^{-\varepsilon} - \lambda^i_t) + \frac{1}{2}\sigma^2 Var_t(c) + \frac{1}{2}Var_t(1+r) - \rho_t\sqrt{\sigma^2 Var_t(c)Var_t(1+r)} + u^i_{t+1}$.

If we assume the simplest constant variance of the log-normal distribution, then the regression will be $\ln(c^i_{jt+1}) = \beta_1 + \beta_2\ln(1+r_{t+1}) + \beta_3\ln(\frac{1}{\rho_{kt}}\frac{1-\gamma}{\beta\gamma}(H^i_{jt})^{-\varepsilon} - \lambda^i_t) + u^i_{t+1}$.

B.2.2 Proof of Proposition 6

The Euler equation of interest becomes $\frac{1}{\rho_{kt}}(1-\gamma)(H^i_{jt})^{-\varepsilon} = \gamma(c^i_{jt})^{-\sigma}$, and does not change under the assumption of rational expectations. Hence, we can log-linearize this Euler equation under the assumption of noncorner solutions:

$\sigma\ln(c^i_{jt}) = \ln(\gamma) - \ln(1-\gamma) + \ln(\rho_{kt}) + \varepsilon\ln(H^i_{jt})$.

The applicable regression model can be represented as

$\sigma\ln(c^i_{jt}) = const + \ln(\rho_{kt}) + \varepsilon\ln(H^i_{jt}) + u^i_t$

C Appendix

C.1 Theoretical derivation of the MPC via the Implicit Function Theorem

Theorem 3 *From the Euler equation depicted either in Proposition 1 or 2, the following MPCs can be derived:*

MPC out of housing wealth: $\frac{\partial c^{i*}_{jt+1}(H^i_{jt}, Z_{jkt+1})}{\partial q_{kt}H^i_{jt}} = -\frac{1}{q_{kt}}\frac{\frac{\partial F(.^*)}{\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial H^i_{jt}} + \frac{\partial F(.^*)}{\partial H^i_{jt}}}{\frac{\partial F(.^*)}{\partial c^{i*}_{jt+1}}}$;

MPC out of financial wealth: $\frac{\partial c^{i*}_{jt+1}(s^i_{jt}, Z_{jkt+1})}{\partial s^i_{jt}} = -\frac{\frac{\partial F(.^*)}{\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial s^{i*}_{jt}} + \frac{\partial F(.^*)}{\partial s^i_{jt}}}{\frac{\partial F(.^*)}{\partial c^{i*}_{jt+1}}}$;

MPC out of income: $\frac{\partial c^{i*}_{jt+1}(y^i, Z_{jkt+1})}{\partial y^i} = -\frac{\frac{\partial F(.^*)}{\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial y^{i*}} + \frac{\partial F(.^*)}{\partial y^{i*}}}{\frac{\partial F(.^*)}{\partial c^{i*}_{jt+1}}}$, *where* $F(.^*)$ *is the Euler equation evaluated at the point where the equality sign is satisfied exactly.*

See the proofs below.

C.1.1 Proof: MPC out of housing wealth

Let $F(c^{i*}_{jt+1}(H^i_{jt}, s^i_{jt}, y^i, q_{kt+1}, r_{t+1}), H^{i*}_{jt+1}(H^i_{jt}, s^i_{jt}, y^i, q_{kt+1}, r_{t+1}); c^i_{jt}, H^i_{jt}, q_{kt}, r_t)$ be the Euler equation, depicted either in Proposition 1 or 2.

Assume:
A1) F(.) is continuously differentiable and $F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t) = 0$
(For shorter notation, let $F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t) = F(.^*)$);
A2) $\frac{\partial F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t)}{\partial c^{i*}_{jt+1}}$, $\frac{\partial F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t)}{\partial H^i_{jt}}$, $\frac{\partial F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t)}{\partial H^{i*}_{jt+1}}$ exist;
A3) All state variables except H^i_{jt} remain constant.
From A1,A2 and A3, by the Implicit Function Theorem, there will exist an implicitly defined function $c^{i*}_{jt+1}(H^i_{jt}, Z_{jkt+1})$ that is continuously differentiable, and where $Z_{jkt+1} = \{s^i_{jt}, y^i, q_{kt+1}, r_{t+1}\}$.

Then, the first-order effect of H^i_{jt} on c^{i*}_{jt+1} can be derived via
$\frac{\partial F(.^*)}{\partial c^{i*}_{jt+1}}\frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} + \frac{\partial F(.^*)}{\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial H^i_{jt}} + \frac{\partial F(.^*)}{\partial H^i_{jt}} = 0.$

Then, a local function of interest is $\frac{\partial c^{i*}_{jt+1}(H^i_{jt}, Z_{jkt+1})}{\partial H^i_{jt}} = -\frac{\frac{\partial F(.^*)}{\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial H^i_{jt}} + \frac{\partial F(.^*)}{\partial H^i_{jt}}}{\frac{\partial F(.^*)}{\partial c^{i*}_{jt+1}}}$, which is the part of the MPC. Precisely, MPC out of housing wealth will be

$$\frac{\partial c^{i*}_{jt+1}(H^i_{jt}, Z_{jkt+1})}{\partial q_{kt} H^i_{jt}} = -\frac{1}{q_{kt}} \frac{\frac{\partial F(.^*)}{\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial H^i_{jt}} + \frac{\partial F(.^*)}{\partial H^i_{jt}}}{\frac{\partial F(.^*)}{\partial c^{i*}_{jt+1}}}$$

C.1.2 Proof: MPC out of financial wealth

Let $F(c^{i*}_{jt+1}(H^i_{jt}, s^i_{jt}, y^i, q_{kt+1}, r_{t+1}), H^{i*}_{jt+1}(H^i_{jt}, s^i_{jt}, y^i, q_{kt+1}, r_{t+1}); c^i_{jt}, H^i_{jt}, q_{kt}, r_t)$ be the Euler equation, depicted either in Proposition 1 or 2.

Assume:
A1) F(.) is continuously differentiable and $F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t) = 0$
(For a shorter notation, let $F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t) = F(.^*)$);
A2) $\frac{\partial F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t)}{\partial c^{i*}_{jt+1}}$, $\frac{\partial F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t)}{\partial H^i_{jt}}$, $\frac{\partial F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t)}{\partial H^{i*}_{jt+1}}$ exist;
A3) All state variables except s^i_{jt} remain constant.
From A1,A2 and A3, by the Implicit Function Theorem, there will exist an implicitly defined function $c^{i*}_{jt+1}(s^i_{jt}, Z_{jkt+1})$ that is continuously differentiable, and where $Z_{jkt+1} = \{H^i_{jt}, y^i, q_{kt+1}, r_{t+1}\}$.

Then, the first-order effect of s^i_{jt} on c^{i*}_{jt+1} can be derived via
$\frac{\partial F(.^*)}{\partial c^{i*}_{jt+1}}\frac{\partial c^{i*}_{jt+1}}{\partial s^i_{jt}} + \frac{\partial F(.^*)}{\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial s^{i*}_{jt}} + \frac{\partial F(.^*)}{\partial s^i_{jt}} = 0.$

Then, a local function of interest is $\frac{\partial c^{i*}_{jt+1}(s^i_{jt}, Z_{jkt+1})}{\partial s^i_{jt}} = -\frac{\frac{\partial F(.^*)}{\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial s^{i*}_{jt}} + \frac{\partial F(.^*)}{\partial s^i_{jt}}}{\frac{\partial F(.^*)}{\partial c^{i*}_{jt+1}}}$, which is immediately the MPC out of financial wealth.

C.1.3 Proof: MPC out of income

Let $F(c^{i*}_{jt+1}(H^i_{jt}, s^i_{jt}, y^i, q_{kt+1}, r_{t+1}), H^{i*}_{jt+1}(H^i_{jt}, s^i_{jt}, y^i, q_{kt+1}, r_{t+1}); c^i_{jt}, H^i_{jt}, q_{kt}, r_t)$ be the Euler equation, depicted either in Proposition 1 or 2.

Assume:
A1) F(.) is continuously differentiable and $F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t) = 0$
(For a shorter notation, let $F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t) = F(.^*)$);
A2) $\frac{\partial F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t)}{\partial c^{i*}_{jt+1}}$, $\frac{\partial F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t)}{\partial H^i_{jt}}$, $\frac{\partial F(c^{i*}_{jt+1}, H^{i*}_{jt+1}; c^i_{jt}, H^i_{jt}, q_{kt}, r_t)}{\partial H^{i*}_{jt+1}}$ exist;
A3) All state variables except y^i remain constant.
From A1,A2 and A3, by the Implicit Function Theorem, there will exist an implicitly defined function $c^{i*}_{jt+1}(y^i, Z_{jkt+1})$ that is continuously differentiable, and where $Z_{jkt+1} = \{H^i_{jt}, s^i_{jt}, q_{kt+1}, r_{t+1}\}$.

Then, the first-order effect of y^i on c^{i*}_{jt+1} can be derived via
$\frac{\partial F(.^*)}{\partial c^{i*}_{jt+1}}\frac{\partial c^{i*}_{jt+1}}{\partial y^i} + \frac{\partial F(.^*)}{\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial y^{i*}} + \frac{\partial F(.^*)}{\partial y^{i*}} = 0.$

Then, a local function of interest is $\frac{\partial c^{i*}_{jt+1}(y^i, Z_{jkt+1})}{\partial y^i} = -\frac{\frac{\partial F(.^*)}{\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial y^{i*}} + \frac{\partial F(.^*)}{\partial y^{i*}}}{\frac{\partial F(.^*)}{\partial c^{i*}_{jt+1}}}$, which is the MPC out of income change.

C.2 Proof of Theorem 1

C.2.1 Proof: MPC out of housing wealth

Consider the derived Euler equation as in Proposition 1, the MPC out of housing wealth as in Proposition 3, and the utility function as in Assumption 4.

To find the first-order effect of H^i_{jt} on c^{i*}_{jt+1} the Euler equation is differentiated accordingly:
$\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2} = \beta\mathbb{E}_t[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} + \frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{\partial c^{i*}_{jt+1}\partial H^{i*}_{jt+1}}\frac{\partial H^{i*}_{jt+1}}{\partial H^i_{jt}}\right)((1+r_{t+1})q_{kt} - q_{kt+1})]$.
Due to the assumption about utility function, cross-product derivatives of marginal utility ($\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{\partial c^{i*}_{jt+1}\partial H^{i*}_{jt+1}}$) are neither positive nor negative, but zero. This simplifies the above equation to:
$\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2} = \beta\mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}}\right)((1+r_{t+1})q_{kt} - q_{kt+1})\right]$.
From above, the MPC out of housing wealth for homeowners is

$$\frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}} = \frac{1}{q_{kt}} \frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} = \frac{1}{q_{kt}} \frac{\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2}}{\beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \right) ((1+r_{t+1}) q_{kt} - q_{kt+1}) \right]}.$$

Considering the special functional form chosen for this paper, the equation above becomes

$$\frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}} = \frac{1}{q_{kt}} \frac{(1-\gamma)(-\varepsilon)(H^i_{jt})^{-\varepsilon-1}}{\beta \mathbb{E}_t \left[\left(\gamma(-\sigma)(c^{i*}_{jt+1})^{-\sigma-1} \right) ((1+r_{t+1}) q_{kt} - q_{kt+1}) \right]} = \frac{1}{q_{kt}} \frac{\varepsilon}{\sigma} \frac{(1-\gamma)(H^i_{jt})^{-\varepsilon}}{\beta \mathbb{E}_t \left[\left(\gamma (c^{i*}_{jt+1})^{-\sigma} \right) ((1+r_{t+1}) q_{kt} - q_{kt+1}) \right]} \frac{c^{i*}_{jt+1}}{H^i_{jt}}.$$

Notice that according to the Euler equation $\beta \mathbb{E}_t[\gamma (c^{i*}_{jt+1})^{-\sigma} ((1 + r_{t+1}) q_{kt} - q_{kt+1})] = (1 - \gamma)(H^i_{jt})^{-\varepsilon}$, and this is how the third fraction is canceled out. Hence, the final MPC for the specific functional form is:

$$\frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}} = \frac{1}{q_{kt}} \frac{\varepsilon}{\sigma} \frac{c^{i*}_{jt+1}}{H^i_{jt}}.$$

C.2.2 Proof: MPC out of financial wealth

Consider the derived Euler equation as in Proposition 1 and the utility function as in Assumption 4.

To find the first-order effect of s^i_{jt} on c^{i*}_{jt+1} the Euler equation is differentiated accordingly, simplified by assuming utility function such that cross-product derivatives of marginal utility ($\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{\partial c^{i*}_{jt+1} \partial H^{i*}_{jt+1}}$) are zero:

$$\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2} \frac{\partial H^i_{jt}}{\partial s^i_{jt}} = \beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \frac{\partial c^{i*}_{jt+1}}{\partial s^i_{jt}} \right) ((1 + r_{t+1}) q_{kt} - q_{kt+1}) \right].$$

From above, the MPC out of financial wealth for homeowners is

$$\frac{\partial c^{i*}_{jt+1}}{\partial s^i_{jt}} = \frac{\partial H^i_{jt}}{\partial s^i_{jt}} \frac{\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2}}{\beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \right) ((1+r_{t+1}) q_{kt} - q_{kt+1}) \right]}.$$

Notice that according to the previous derivations $\frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} = \frac{\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2}}{\beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \right) ((1+r_{t+1}) q_{kt} - q_{kt+1}) \right]}$.

Then, MPC out of financial wealth for homeowners is connected with MPC out of housing wealth via the following equation:

$$\frac{\partial c^{i*}_{jt+1}}{\partial s^i_{jt}} = \frac{\partial H^i_{jt}}{\partial s^i_{jt}} \frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} = \frac{\partial H^i_{jt}}{\partial s^i_{jt}} q_{kt} \frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}}.$$

C.2.3 Proof: MPC out of income

Consider the derived Euler equation as in Proposition 1 and the utility function as in Assumption 4.

To find the first-order effect of y^i on c^{i*}_{jt+1} the Euler equation is differentiated accordingly, simplified by assuming utility function such that the derivatives of cross-product of marginal utility ($\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{\partial c^{i*}_{jt+1} \partial H^{i*}_{jt+1}}$) are zero:

$$\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2} \frac{\partial H^i_{jt}}{\partial y^i} = \beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \frac{\partial c^{i*}_{jt+1}}{\partial y^i} \right) ((1 + r_{t+1}) q_{kt} - q_{kt+1}) \right].$$

From above, the MPC out of income for homeowners is

$$\frac{\partial c^{i*}_{jt+1}}{\partial y^i} = \frac{\partial H^i_{jt}}{\partial y^i} \frac{\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2}}{\beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \right) ((1+r_{t+1}) q_{kt} - q_{kt+1}) \right]}.$$

Notice that according to the previous derivations $\frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} = \frac{\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2}}{\beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \right) ((1+r_{t+1}) q_{kt} - q_{kt+1}) \right]}$.

Then, MPC out of financial wealth for homeowners is connected with MPC out of housing wealth via the following equation:

$$\frac{\partial c^{i*}_{jt+1}}{\partial y^i} = \frac{\partial H^i_{jt}}{\partial y^i} \frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} = \frac{\partial H^i_{jt}}{\partial y^i} q_{kt} \frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}}.$$

C.3 Proof of Theorem 2

C.3.1 Proof: MPC out of housing wealth

Consider the derived Euler equation as in Proposition 2, the MPC out of housing wealth as in Proposition 3, and the utility function as in Assumption 4.

To find the first-order effect of H^i_{jt} on c^{i*}_{jt+1} the Euler equation is differentiated accordingly:

$$\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2} = \beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} + \frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{\partial c^{i*}_{jt+1} \partial H^{i*}_{jt+1}} \frac{\partial H^{i*}_{jt+1}}{\partial H^i_{jt}} \right) (1 + r_{t+1}) \rho_{kt} \right] + \rho_{kt} \frac{\partial \lambda^i_t}{\partial H^i_{jt}}.$$

According to the assumption about the utility function, the cross-product derivatives of marginal utility ($\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{\partial c^{i*}_{jt+1} \partial H^{i*}_{jt+1}}$) are neither positive nor negative but zero. This simplifies the above equation to:

$$\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2} = \beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} \right) (1 + r_{t+1}) \rho_{kt} \right] + \rho_{kt} \frac{\partial \lambda^i_t}{\partial H^i_{jt}}.$$

From above, the MPC out of housing wealth for renters is

$$\frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}} = \frac{1}{q_{kt}} \frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} = \frac{1}{q_{kt}} \frac{\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2} - \rho_{kt} \frac{\partial \lambda^i_t}{\partial H^i_{jt}}}{\beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \right) (1 + r_{t+1}) \rho_{kt} \right]}.$$

Specifically, the equation above becomes

$$\frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}} = \frac{1}{q_{kt}} \frac{(1-\gamma)(-\varepsilon)(H^i_{jt})^{-\varepsilon-1} - \rho_{kt} \frac{\partial \lambda^i_t}{\partial H^i_{jt}}}{\beta \mathbb{E}_t \left[\left(\gamma(-\sigma)(c^{i*}_{jt+1})^{-\sigma-1} \right) (1 + r_{t+1}) \rho_{kt} \right]} = \frac{1}{q_{kt}} \frac{\varepsilon}{\sigma} \frac{(1-\gamma)(H^i_{jt})^{-\varepsilon}}{\beta \mathbb{E}_t \left[\left(\gamma (c^{i*}_{jt+1})^{-\sigma} \right) (1 + r_{t+1}) \rho_{kt} \right]} \frac{c^{i*}_{jt+1}}{H^i_{jt}} - \frac{1}{q_{kt}} \frac{\frac{\partial \lambda^i_t}{\partial H^i_{jt}}}{\beta \mathbb{E}_t \left[\left(\gamma(-\sigma)(c^{i*}_{jt+1})^{-\sigma-1} \right) (1+r \right.}$$

Notice, the first term cannot be canceled out due to the different Euler equation for renter.

C.3.2 Proof: MPC out of financial wealth

Consider the derived Euler equation as in Proposition 2 and the utility function as in Assumption 4.

To find the first-order effect of s^i_{jt} on c^{i*}_{jt+1} the Euler equation is differentiated accordingly, simplified by assuming the utility function such that the cross-product derivatives of marginal utility ($\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{\partial c^{i*}_{jt+1} \partial H^{i*}_{jt+1}}$) are zero:

$$\frac{\partial^2 U(c^i_{jt}, H^i_{jt})}{(\partial H^i_{jt})^2} \frac{\partial H^i_{jt}}{\partial s^i_{jt}} = \beta \mathbb{E}_t \left[\left(\frac{\partial^2 U(c^{i*}_{jt+1}, H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2} \frac{\partial c^{i*}_{jt+1}}{\partial s^i_{jt}} \right) (1 + r_{t+1}) \rho_{kt} \right] + \rho_{kt} \frac{\partial \lambda^i_t}{\partial s^i_{jt}}.$$

From above, the MPC out of financial wealth for renters is

$$\frac{\partial c^{i*}_{jt+1}}{\partial s^i_{jt}} = \frac{\partial H^i_{jt}}{\partial s^i_{jt}} \frac{\frac{\partial^2 U(c^i_{jt},H^i_{jt})}{(\partial H^i_{jt})^2}}{\beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\rho_{kt}\right]} - \frac{\rho_{kt}\frac{\partial \lambda^i_t}{\partial s^i_{jt}}}{\beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\rho_{kt}\right]}.$$

Notice that according to the previous derivations for renters $\frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} = \frac{\frac{\partial^2 U(c^i_{jt},H^i_{jt})}{(\partial H^i_{jt})^2} - \rho_{kt}\frac{\partial \lambda^i_t}{\partial H^i_{jt}}}{\beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\rho_{kt}\right]}$.

Then, MPC out of financial wealth for renters can be expressed as

$$\frac{\partial c^{i*}_{jt+1}}{\partial s^i_{jt}} = \frac{\partial H^i_{jt}}{\partial s^i_{jt}}\frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} + \frac{\rho_{kt}\frac{\partial \lambda^i_t}{\partial H^i_{jt}}\frac{\partial H^i_{jt}}{\partial s^i_{jt}}}{\beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\rho_{kt}\right]} - \frac{\rho_{kt}\frac{\partial \lambda^i_t}{\partial s^i_{jt}}}{\beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\rho_{kt}\right]} =$$

$$\frac{\partial H^i_{jt}}{\partial s^i_{jt}} q_{kt} \frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}}.$$

C.3.3 Proof: MPC out of income

Consider the derived Euler equation as in Proposition 2 and the utility function as in Assumption 4.

To find the first-order effect of y^i on c^{i*}_{jt+1} the Euler equation is differentiated accordingly, simplified by assuming the utility function such that the derivatives of the cross-product of marginal utility ($\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{\partial c^{i*}_{jt+1}\partial H^{i*}_{jt+1}}$) are zero:

$$\frac{\partial^2 U(c^i_{jt},H^i_{jt})}{(\partial H^i_{jt})^2}\frac{\partial H^i_{jt}}{\partial y^i} = \beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\frac{\partial c^{i*}_{jt+1}}{\partial y^i}\right)(1+r_{t+1})\rho_{kt}\right] + 0.$$

From above, the MPC out of income for renters is

$$\frac{\partial c^{i*}_{jt+1}}{\partial y^i} = \frac{\partial H^i_{jt}}{\partial y^i} \frac{\frac{\partial^2 U(c^i_{jt},H^i_{jt})}{(\partial H^i_{jt})^2}}{\beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\rho_{kt}\right]}.$$

Notice that according to the previous derivations $\frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} = \frac{\frac{\partial^2 U(c^i_{jt},H^i_{jt})}{(\partial H^i_{jt})^2} - \rho_{kt}\frac{\partial \lambda^i_t}{\partial H^i_{jt}}}{\beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\rho_{kt}\right]}$.

Then, MPC out of income for renters can be expressed as

$$\frac{\partial c^{i*}_{jt+1}}{\partial y^i} = \frac{\partial H^i_{jt}}{\partial y^i}\frac{\partial c^{i*}_{jt+1}}{\partial H^i_{jt}} + \frac{\rho_{kt}\frac{\partial \lambda^i_t}{\partial H^i_{jt}}\frac{\partial H^i_{jt}}{\partial y^i}}{\beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\rho_{kt}\right]} = \frac{\partial H^i_{jt}}{\partial y^i} q_{kt}\frac{\partial c^{i*}_{jt+1}}{\partial q_{kt} H^i_{jt}} + \frac{\rho_{kt}\frac{\partial \lambda^i_t}{\partial H^i_{jt}}\frac{\partial H^i_{jt}}{\partial y^i}}{\beta \mathbb{E}_t\left[\left(\frac{\partial^2 U(c^{i*}_{jt+1},H^{i*}_{jt+1})}{(\partial c^{i*}_{jt+1})^2}\right)(1+r_{t+1})\rho_{kt}\right]}.$$

D Appendix

D.1 Cross-sectional asymptotics

I first include time dummies in the baseline regression. The results are presented in Table 4. Controlling for time periods, and, thus, taking advantage of multiple cross-sections does not bias the results. However, if we try to exploit only one period cross-section, then the estimation biases in accordance with the macroeconomic conditions in a given period. For

example, see Tables 5, 6. This confirms the preference of the asymptotics across time periods and not across individuals for the choice involving intertemporal decision.

D.2 Measurement error

The measurement error might come from the fact that the exact consumption variable is unobservable and instead we use the residual of the budget constraint proxy. However, under the assumption of statistical independence between the potential measurement error and the regressors, the OLS estimation is still consistent and unbiased. To bring this assumption closer to the data, I will check the correlation between the errors and all regressors in the baseline model. Before doing that I present VIF results in Table 7 for the independent variables in order to be sure that it is enough to check for the correlation with the error term separately for each regressor.

Next, in Table 8 I present the result of the estimation of the correlation between the error term and independent variables. No significant correlation has been found. This suggests that the potential measurement error is independent from the regressors enough so as not to bias the results.

D.3 Unobserved heterogeneity

Individual-specific heterogeneity might show up in the regression equation in two ways. First, it might be negligible and then can be captured by an error term. Second, if substantial, it can be captured by the constant term. In the first case there are no extra actions needed. In the second case, we can control for the age, gender, ethnicity and race group and location by adding relevant group-specific dummies, hoping to capture heterogenous effects.

Here, I present the baseline specifications with the added dummies. Table 9 present controls for the age of the main applicant; Table 10 presents controls for the gender of the main applicant; Table 11 presents controls for the ethnicity of the main applicant; Table 12 presents controls for the race of the main applicant; Table 13 presents controls for the state in which mortgage was received. Admitting that everything except age appeared to be significant, I want to underline the importance of using geographical and demographic characteristics to predict consumption responses, but will not provide group-specific estimates in this study.

D.4 Innovations to higher moments

As shown in (Attanasio and Low, 2004), the conditional variance in consumption is mostly flat. Hence, the usage of the fixed variance in consumption should not bias the results. According to the distributional assumption, no other higher moment can bias the results. However, there might be unobserved innovations in the second moments of marginal utility of consumption. To test for the bias from this, I add the difference between the conditional variance in consumption and the unconditional variance in consumption to the baseline model. The results are presented in Table 14. As including innovation of the variance term does not bias the estimation, no need to account for these innovatons arises.

Table 4: Model with dummies for states

	Dependent variable:
	C_t
2019	0.009***
	(0.001)
2020	0.016***
	(0.001)
2021	0.011***
	(0.003)
2022	-0.004***
	(0.001)
2023	0.048***
	(0.001)
month 2	-0.001
	(0.001)
month 3	0.006***
	(0.001)
month 4	0.006***
	(0.001)
month 5	0.009***
	(0.001)
month 6	0.005***
	(0.001)
month 7	-0.004***
	(0.001)
month 8	0.016***
	(0.002)
month 9	0.018***
	(0.002)
month 10	0.003**
	(0.001)
month 11	-0.011***
	(0.002)
month 12	-0.006***
	(0.002)
$\ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$	0.006***
	(0.001)
$\ln(q_{kt})$	0.520***
	(0.001)
$\ln(H_t)$	0.658***
	(0.001)
Constant	1.896***
	(0.008)
Observations	3,381,857
R^2	0.311
Adjusted R^2	0.311
Residual Std. Error	0.542 (df = 3381837)

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Table 5: Model for Sep, 2020

	Dependent variable:
	C_t
$\ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$	-0.023*
	(0.014)
$\ln(q_{kt})$	0.328***
	(0.058)
$\ln(H_t)$	0.579***
	(0.037)
Constant	4.286***
	(0.806)
Observations	1,016
R^2	0.230
Adjusted R^2	0.228
Residual Std. Error	0.511 (df = 1012)
F Statistic	100.988*** (df = 3; 1012)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 6: Model for Sep, 2023

	Dependent variable:
	C_t
$\ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$	0.060
	(0.037)
$\ln(q_{kt})$	0.616***
	(0.007)
$\ln(H_t)$	0.714***
	(0.007)
Constant	0.891***
	(0.120)
Observations	28,167
R^2	0.348
Adjusted R^2	0.348
Residual Std. Error	0.535 (df = 28163)
F Statistic	5,013.240*** (df = 3; 28163)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 7: VIF matrix

	$\ln(1+r_{t+1}-\frac{q_{kt+1}}{q_{kt}})$	$\ln(q_{kt})$	$\ln(H_t)$
VIF	1.028	1.05	1.023

Table 8: Correlation with the error term

	$\ln(1+r_{t+1}-\frac{q_{kt+1}}{q_{kt}})$	$\ln(q_{kt})$	$\ln(H_t)$
u^i_{t+1}	7.397e-17	-7.9991e-18	-2.443e-17

Table 9: Model with dummies for main applicant's age

	Dependent variable:
	C_t
applicant age ¡ 35	-0.001
	(0.001)
applicant age ¡ 45	0.001
	(0.001)
applicant age ¡ 55	-0.001
	(0.001)
applicant age ¡ 65	-0.001
	(0.001)
applicant age ¡ 75	-0.001
	(0.001)
applicant age ¡ 100	-0.001
	(0.001)
$\ln(1+r_{t+1}-\frac{q_{kt+1}}{q_{kt}})$	0.011***
	(0.0003)
$\ln(q_{kt})$	0.525***
	(0.001)
$\ln(H_t)$	0.658***
	(0.001)
Constant	1.875***
	(0.009)
Observations	2,959,602
R^2	0.311
Adjusted R^2	0.311
Residual Std. Error	0.543 (df = 2959592)
F Statistic	148,256.700*** (df = 9; 2959592)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 10: Model with dummies for main applicant's sex

	Dependent variable:
	C_t
Female	-0.120***
	(0.001)
$\ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$	0.013***
	(0.0003)
$\ln(q_{kt})$	0.522***
	(0.001)
$\ln(H_t)$	0.643***
	(0.001)
Constant	1.961***
	(0.008)
Observations	3,185,724
R^2	0.319
Adjusted R^2	0.319
Residual Std. Error	0.539 (df = 3185719)
F Statistic	372,331.500*** (df = 4; 3185719)
Note:	*p<0.1; **p<0.05; ***p<0.01

E Appendix

E.1 Data Subset Selection

Rather than utilizing the entire HMDA dataset, I apply a series of selection criteria to reduce bias from unobserved factors affecting income, property value, and savings. First, I restrict the sample to applicants who were both approved by the bank and accepted the loan offer. I focus exclusively on Conventional loans, excluding those insured or guaranteed by the FHA, VA, RHS, or FSA. Next, I limit the sample to mortgage holders who obtained a loan solely for purchasing a house (as indicated in the "loan purpose" field). Additionally, I exclude mortgages with variable interest rates, selecting only those with fixed interest rates ("intro rate period" = 0), and require that the loan has primary lien status. The restriction of the loan purpose ensures that the mortgage represents the acquisition of a new home rather than refinancing or home improvement. The primary lien status further guarantees that the property is the household's sole home, eliminating potential bias from unobserved housing wealth. Finally, I truncate the dataset by removing the top 0.25% of income earners. This step excludes a small number of extreme outliers in both income and property values, preventing distortions in the analysis due to exceptionally high-income households.

Table 11: Model with dummies for main applicant's ethnicity

	Dependent variable:
	C_t
Not Hispanic or Latino	0.165^{***}
	(0.001)
$\ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$	0.012^{***}
	(0.0003)
$\ln(q_{kt})$	0.529^{***}
	(0.001)
$\ln(H_t)$	0.651^{***}
	(0.001)
Constant	1.674^{***}
	(0.009)
Observations	2,964,263
R^2	0.317
Adjusted R^2	0.317
Residual Std. Error	0.538 (df = 2964258)
F Statistic	$344{,}743.500^{***}$ (df = 4; 2964258)
Note:	*p<0.1; **p<0.05; ***p<0.01

E.2 Matching HMDA and Zillow Research, FRED

The month of mortgage application is not explicitly reported in the HMDA dataset. However, the dataset provides both the mortgage interest rate offered to the applicant and the rate spread. The difference between these two values corresponds to the Average Prime Offer Rate (APOR) applicable during the week of application. In theory, this allows for determining the application date with weekly precision. However, for the purposes of this research, only the month of application is required.

To identify the mortgage application month, I match the implied APOR rate from HMDA with the APOR rate published by the FFIEC in a fixed table (https://ffiec.cfpb.gov/tools/rate-spread). This matching process, however, results in data loss: approximately half of the selected subset aligns with the fixed-rate table, while the other half corresponds to the adjustable-rate table. Since my analysis is restricted to fixed-interest mortgages, I choose to use the fixed-rate APOR table for consistency. Importantly, using an alternative table for determining the application month does not bias the results or affect the statistical properties of the variables in the regression. The discrepancy in table usage likely stems from idiosyncratic decisions made by individual banks rather than systematic differences.

Similarly, the zip code of the mortgage property is not explicitly recorded in HMDA. Instead, the dataset provides a more granular spatial identifier: the census tract. To assign a zip code to each observation, I utilize the HUD USPS ZIP Crosswalk Files (https://www.huduser.gov/apps/pub which provide a mapping between census tracts and zip code.

Table 12: Model with dummies for main applicant's race

	Dependent variable:
	C_t
Asian	0.036***
	(0.004)
Black or African American	-0.068***
	(0.004)
Native Hawaiian	-0.038***
	(0.008)
White	0.054***
	(0.004)
$\ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$	0.012***
	(0.0003)
$\ln(q_{kt})$	0.523***
	(0.001)
$\ln(H_t)$	0.658***
	(0.001)
Constant	1.852***
	(0.010)
Observations	2,960,407
R^2	0.313
Adjusted R^2	0.313
Residual Std. Error	0.540 (df = 2960399)
F Statistic	192,927.200*** (df = 7; 2960399)
Note:	*p<0.1; **p<0.05; ***p<0.01

Table 13: Model with dummies for states

	Dependent variable:
	C_t
...	...
state CA	-0.107***
	(0.003)
state CO	-0.147***
	(0.003)
state CT	0.003
	(0.004)
state DE	-0.047***
	(0.005)
state DC	0.009
	(0.006)
state FL	-0.030***
	(0.003)
state GA	-0.036***
	(0.003)
state HI	-0.159***
	(0.006)
state ID	-0.212***
	(0.004)
...	...
state MT	-0.149***
	(0.006)
state NE	-0.023***
	(0.005)
state NV	-0.173***
	(0.004)
state NH	-0.012**
	(0.005)
...	...
	(0.003)
state TX	0.084***
	(0.003)
state UT	-0.230***
	(0.004)
...	...
$\ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$	0.007***
	(0.0003)
$\ln(q_{kt})$	0.580***
	(0.001)
$\ln(H_t)$	0.661***
	(0.001)
Constant	1.204***
	(0.011)
Observations	3,380,646

Table 14: Model with potential higher moments

	Dependent variable:
	C_t
$Var_t(c) + Var_t(1+r) - Var(c) - Var(1+r)$	0.000^{***}
	(0.000)
$\ln(1 + r_{t+1} - \frac{q_{kt+1}}{q_{kt}})$	0.011^{***}
	(0.0003)
$\ln(q_{kt})$	0.526^{***}
	(0.001)
$\ln(H_t)$	0.658^{***}
	(0.001)
Constant	1.864^{***}
	(0.008)
Observations	3,381,455
R^2	0.311
Adjusted R^2	0.311
Residual Std. Error	0.543 (df = 3381450)
F Statistic	$381{,}136.600^{***}$ (df = 4; 3381450)
Note:	*p<0.1; **p<0.05; ***p<0.01