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Maiko Koga*
koga@isc.senshu-u.ac.jp

Kohei Matsumura**
kouhei.matsumura@boj.or.jp

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Bank of Japan
2-1-1 Nihonbashi-Hongokucho, Chuo-ku, Tokyo 103-0021, Japan

* School of Economics, Senshu University
** Research and Statistics Department

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Marginal Propensity to Consume and the Housing Choice*

Maiko Koga† Kohei Matsumura‡

Abstract

We study the MPC heterogeneity of households in Japan both theoretically and empirically. We build a heterogeneous-agent overlapping-generations general equilibrium model with an illiquid and indivisible housing asset. We show that mortgage debtor exhibits high MPC and households about to upgrade their house exhibit low MPC. Using Japanese household survey data, we empirically support our theoretical predictions.

JEL classifications: D15, E21, E50, R21
Keywords: Consumption, Heterogeneity, Housing choices, Liquidity constraints, Marginal propensity to consume

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†Senshu University, 2-1-1, Higashimita, Tama-ku, Kawasaki, Kanagawa 214-8580 Japan, email: koga@isc.senshu-u.ac.jp

‡Research and Statistics Department, Bank of Japan, 2-1-1 Nihonbashi-Hongokucho, Chuo-ku, Tokyo, 103-8660 Japan, email: kouhei.matsumura@boj.or.jp

1 Introduction

As the lower bound on nominal interest rates becomes binding, central banks and academics have made various efforts to deepen understanding of the effective transmission of monetary policy. Kaplan, Moll and Violante (2018) underscore the importance of an indirect channel in which the effect of monetary policy on consumption operates by expanding labor demand in general equilibrium, as opposed to the traditional direct channel that works through intertemporal substitution. Their model is driven by the heterogeneity of households in terms of the size and composition of their asset holdings and therefore in their propensity to consume out of transitory income. Households that hold a sizable amount of wealth in illiquid assets but have very little or no liquid wealth cannot smooth consumption, behave as if they are subject to liquidity constraint, and exhibit higher propensity of consumption.

Against this backdrop, we study the heterogeneity of the marginal propensity to consume (MPC) out of transitory income shocks. The presence of illiquid assets is recognized as the key instrument to yield the relevant MPC heterogeneity. It is also notable that housing wealth accounts for a significant share of household illiquid assets. In addition to its outsized presence on household balance sheets, there are two further reasons why housing should be treated as a distinct asset in analyzing consumption behavior. First, households must secure and allocate sizable amounts of money to purchase housing. The lumpy nature of such purchases affects the consumption behavior of households making housing choices as some of them will need to adjust their nondurable consumption to finance those choices. Second, households can finance house purchases via mortgage loans. Households with mortgages need to make repayments each period and the size of such repayments cannot be easily adjusted even in the face of an unexpected decline in income. We therefore shed light on MPC heterogeneity with respect to housing tenure choice (whether to own or rent) and the size of residential loan.

We build a model incorporating the above characteristics to understand the relationship between MPC and housing choice. Our model takes the form of a heterogeneous-agent overlapping-generations general equilibrium model with an indivisible housing asset and rigid mortgage market structure. In our model, housing is both a saving instrument and a durable consumption good. Housing choice is modeled as a discrete problem; thus, households are not allowed to sell some fraction of their home. Most macroeconomic models that include housing assume that households can borrow against some fraction of the home value at any time. However, home equity extraction is subject to costs and is not customary in some economies. In Japan, for example, the home equity loan market is negligibly small.[1] Our model captures such features by providing no mechanism whereby

[1]The Ministry of Land, Infrastructure, Transport, and Tourism reports that only 1.5% of financial institutions provided home equity loans in 2018. The market for reverse mortgages is also small. The

households can withdraw cash from an owned home. In addition, reflecting the rigidity of mortgage repayment plans, households need to repay a fraction of their mortgage every period in our model.

The discrete housing choice leads to discontinuity of the consumption function, which means the MPC is not computable at some points. We overcome this challenge by incorporating a random utility structure into the discrete and lumpy housing choice problem. A random utility structure has been frequently employed to address such discrete choice problems since McFadden (1973). This structure is especially useful for our purposes since smoothing the consumption function yields quantitatively plausible values of the MPC even when housing is lumpy and indivisible. Without this device, the consumption function simulated from the model exhibits intractably strong nonlinearity and discontinuity.

We calibrate the model to Japan's economy, targeting four observable housing market variables. The calibrated model successfully produces reasonable magnitudes of the MPC that vary by household characteristics. Our main quantitative results are as follows. First, we show that the MPC of mortgage debtors is high because the share of households that are liquidity constrained is relatively high. Second, households respond less to income shocks when they decide to upgrade their housing. The magnitude of this difference in MPC depends on the size of the consumption loss they incur when they purchase a new home.

We also empirically examine MPC heterogeneity using Japanese household data. Measuring MPC heterogeneity is difficult because it requires identification of the consumption response to a transitory income shock; also, the statistical error becomes large when the sample is split in order to detect heterogeneity. Our survey-based MPC data allows us to finesse these two difficulties. The survey asks for the consumption response to transitory income. Using the observable MPC as a dependent variable in the regression, we can detect heterogeneity without splitting the sample. The empirical results support the hypothesis of heterogeneous responses of consumption according to cash-on-hand, the amount of residential loans, and households' plans to purchase a home, which is consistent with the predictions derived in our model. More specifically, MPC is higher for households with less cash-on-hand and those with larger residential loans. Households who plan to purchase a home exhibit low MPC. In addition, by utilizing an information-rich survey that allows us to identify MPC from statistical assumptions, we are able to corroborate our empirical results with an alternative approach.

Our contribution to the literature in this paper is twofold. First, we propose a quantitative framework for examining MPC heterogeneity with an indivisible housing choice structure; we then show that mortgage debtors exhibit high MPC and that households intending to upgrade (from renting to owning or to a larger home) may exhibit low

share of financial institutions providing such mortgages was 6.5% in 2018.

MPC. Second, we empirically demonstrate the high MPC of mortgage debtors and the MPC heterogeneity over housing choice in the future after controlling for relevant factors like the amount of cash-on-hand. We provide empirical evidence supporting the model's predictions regarding MPC heterogeneity using Japanese household data. Although the marginal propensity to consume out of transitory income shocks is an important measure to assess policy effects, empirical investigations using Japanese data are scarce; our paper thus provides valuable evidence on the existence and shape of MPC heterogeneity.

Related literature. This article relates to three strands of literature. First, our paper contributes to the large empirical literature that estimates heterogeneous consumption responses to income shocks from household survey data. Past studies document how the size of responses vary depending on household demographic features, income and asset holdings. Most report excess sensitivity to transitory income shocks and offer support for theories based on liquidity constraints or precautionary motives (e.g., Johnson, Parker and Souleles (2006); Parker et al. (2013); Jappelli and Pistaferri (2014)). More recent studies focus especially on mortgage debt as a source of MPC heterogeneity across households. They demonstrate that households with mortgage debt exhibit large and significant consumption responses to transitory income shocks (e.g., Misra and Surico (2014); Cloyne and Surico (2017); Cloyne, Ferreira and Surico (2020)).[2]

Second, our work is also related to theoretical studies investigating consumption behavior using heterogeneous agent models with a housing asset. Seminal work by Kaplan and Violante (2014) shows how the presence of high-return illiquid assets can explain the significant number of wealthy but liquidity-constrained households in the economy. Our model has a similar structure to a number of studies in which economically relevant housing market features are incorporated into a heterogeneous agent model: Luengo-Prado (2006), Díaz and Luengo-Prado (2010), Sommer, Sullivan and Verbrugge (2013), Floetotto, Kirker and Stroebel (2016), Hedlund (2016), and Gorea and Midrigan (2017). As a general equilibrium model with an indivisible housing choice, our model also bears similarities to Rios-Rull and Sanchez-Marcos (2008). The mechanism yielding consumption heterogeneity over housing choice in our model is close to de Francisco (2019); however, our study is differentiated from hers by making use of a general equilibrium framework and incorporating income uncertainty, a rigid mortgage market, and a random utility structure.

Finally, recent literature points to the significance of redistributional channels for macroeconomic policy effectiveness. Auclert (2019) and Luetticke (2018) show that MPC heterogeneity is a relevant transmission mechanism for monetary policy. Doepke and

[2]Using Japanese household survey data, Nakajima (2020) documents higher income elasticity of consumption for highly-indebted households. In addition, Hara, Unayama and Weidner (2016) explore the share and characteristics of hand-to-month households in Japan using national survey data. Their studies suggest the importance of MPC heterogeneity across Japanese households.

Schneider (2006) estimate the size of the redistributional effect of unexpected inflation. Both our empirical and quantitative results demonstrate significant MPC heterogeneity and thus indicate that housing tenure status is an important factor impacting redistributional channels.

The rest of the article is organized as follows. Section 2 presents the theoretical analysis. Two empirical examinations are presented in Section 3. Section 4 concludes.

2 Theoretical Analysis

To analyze the MPC heterogeneity among households with different housing tenure status, we build a heterogeneous-agent overlapping-generations general equilibrium model with an illiquid housing asset. We first present the model setup and then explain the implications of the model regarding MPC.

2.1 Model setup

The economy comprises households, firms, apartment owners, and the government.

2.1.1 Households

We assume that households face uninsurable idiosyncratic labor income risk following the seminal works by Bewley (1983), Aiyagari (1994), and Huggett (1993). Households can self-insure themselves by investing a risk-free financial asset a which pays interest rate r. Households live for up to J discrete periods with probability π_j of surviving from age j to $j+1$. Since we focus on the steady state in the economy when all prices are constant, we omit time indices. There are no aggregate uncertainties.

Preferences. Household utility depends on nondurable consumption c and housing service h. Households can either rent or own their homes. We assume that households choose to purchase a home from a discrete choice set $h_j \in \left\{0, h^1, ..., h^{N_h}\right\}$ and renters buy housing service $h^r \in [0, \underline{h}^r]$, which is in line with Hedlund (2016) and Gorea and Midrigan (2017). Note that $h_j = 0$ means that a household chooses to be a renter. Owners derive higher utility than renters given the same size of housing following Kiyotaki, Michaelides and Nikolov (2011). We assume that housing service flow equates to housing size, so our notation does not distinguish between them. Housing choice is assumed to be subject to taste shocks.

Housing market. Let p be the price for a given housing size. Households can purchase or sell housing at the market price with some transaction costs. Renters pay rent p_r to receive one unit of rental housing service without transaction costs. In purchasing housing, households can borrow money up to some fraction of the housing value: $(1-d_j)\, ph_{j+1}$,

where d_j denotes a required downpayment. We assume that households can take out loans only when they purchase a new property. That is, households are not allowed to extract home equity. Moreover, households must repay $1-\gamma$ of the mortgage loan balance. This assumption is consistent with the fact that households pay a prespecified amount in their monthly repayment plans.

Household income. Households supply one unit of labor inelastically until age $J_R - 1$. Working households are different in their productivity level η_j where $\eta_j \in \left(\eta_{1,j}, ..., \eta_{N_\eta,j}\right)$. Following De Nardi, Fella and Pardo (2016), we set nonparametric process η_j by directly calculating it from household income data. The transition probability of shifting from η_j to η_{j+1} is age-dependent; this process thus captures age-dependent income risk. The market wage for a given level of productivity is w from which the government levies fraction τ_p for financing pensions. Retirees receive a public pension from the government. For simplicity, we assume that the amount of the pension payment is the same across households. In summary, the households income flow at age j is given by

$$y_j(\eta_j) = \begin{cases} w\left(1-\tau_p\right)\eta_j & \text{for} \quad j < J_R, \\ \kappa \bar{y} & \text{for} \quad j \geq J_R, \end{cases}$$

where $\bar{y}$ is the average earnings of workers and κ is the pension replacement rate.

Recursive formulation. Households maximize expected lifetime utility subject to the budget constraint and liquidity constraints. We let $\tilde{V}_j\left(a_j, h_j, h_{j+1}, \eta_j\right)$ be the value function given housing choice next period. Households choose housing next period subject to a taste shock such that

$$V_j\left(a_j, h_j, \eta_j\right) = \max_{h_{j+1} \in \left\{0, h^1, ..., h^{N_h}\right\}} \left\{\tilde{V}_j\left(a_j, h_j, h_{j+1}, \eta_j\right) + \epsilon\left(h_{j+1}\right)\right\},$$

where the taste shock $\varepsilon\left(h_{j+1}\right)$ is assumed to be i.i.d. and has an extreme value distribution with scale parameter σ_ϵ. We let $\tilde{V}_j^s\left(a_j, h_j, h_{j+1}, \eta_j\right)$ and $\tilde{V}_j^m\left(a_j, h_j, h_{j+1}, \eta_j\right)$ be the value function conditional on staying in the same housing and on moving, respectively;

$$\tilde{V}_j\left(a_j, h_j, h_{j+1}, \eta_j\right) = \begin{cases} \tilde{V}_j^s\left(a_j, h_j, h_{j+1}, \eta_j\right) & \text{for} \quad h_j = h_{j+1}, \\ \tilde{V}_j^m\left(a_j, h_j, h_{j+1}, \eta_j\right) & \text{for} \quad h_j \neq h_{j+1}. \end{cases}$$

These value functions are defined as follows:

$$\tilde{V}_j^s\left(a_j, h_j, h_{j+1}, \eta_j\right) = \max_{c_j, a_{j+1}, h^r} u\left(c_j, h_j, h^r\right) + \beta \pi_j \mathrm{E}\left[V_{j+1}\left(a_{j+1}, h_j, \eta_{j+1}\right)\right],$$

subject to the budget constraint

$$a_{j+1} = y_j(\eta_j) + (1+r)a_j - (1+\tau_c)c_j - \mathbf{1}\{h_j = 0\} p_r h^r,$$

and the liquidity constraints

$$\begin{aligned} a_{j+1} &\geq 0, \quad \text{if } a_j \geq 0, \\ a_{j+1} &\geq \gamma a_j, \text{ if } a_j < 0, \end{aligned}$$

where β is the discount rate, a_j denotes the amount of financial wealth at the beginning of the age j, $\mathbf{1}\{\}$ is an indicator function and τ_c is the consumption tax rate. Available resources are the sum of labor income or pension $y_j(\eta_j)$ and liquid asset $(1+r)a_j$. Households allocate their resources for consumption $(1+\tau_c)c_j$, savings next period a_{j+1} and rent $p_r h^r$ if they are renters. Households with mortgages need to repay fraction $1-\gamma$ of their loan balance as described in the second liquidity constraint inequality above.

The value function conditional on moving $V_j^m(a_j, h_j, h_{j+1}, \eta_j)$ is defined as follows

$$\tilde{V}_j^m(a_j, h_j, h_{j+1}, \eta_j) = \max_{c_j, a_{j+1}, h^r} u(c_j, h_j, h^r) + \beta \pi_j \mathrm{E}\left[V_{j+1}(a_{j+1}, h_{j+1}, \eta_{j+1})\right],$$

subject to the budget constraint

$$\begin{aligned} a_{j+1} = {} & y_j(\eta_j) + (1+r)a_j - (1+\tau_c)c_j + p\left[(1-\phi_s)h_j - (1+\phi_b)h_{j+1}\right] \\ & -\mathbf{1}\{h_j = 0\} p_r h^r, \end{aligned}$$

and the liquidity constraint

$$a_{j+1} \geq -(1-d_j) p h_{j+1},$$

where $p(1-\phi_s)h_j$ denotes the revenue from selling the current residence and $p(1+\phi_b)h_{j+1}$ is the expenditure for purchasing a new residence. Note that ϕ_b and ϕ_s are transaction costs for buyers and sellers, respectively.

Households' housing choice can be represented as a probability. The choice probability, i.e. the probability of choosing housing h', is given by

$$\mathrm{P}(h_{j+1} = h' \mid a_j, h_j, \eta_j) = \frac{\exp\left\{\tilde{V}_j(a_j, h_j, h', \eta_j)/\sigma_\epsilon\right\}}{\sum_{h_{j+1}} \exp\left\{\tilde{V}_j(a_j, h_j, h_{j+1}, \eta_j)/\sigma_\epsilon\right\}}.$$

2.1.2 Apartment owners and housing supply

Apartment owners borrow money at interest rate r, obtain rental housing without incurring transaction costs, and rent it out at rental price p_r in the competitive market. Apartment owners receive profit $p_r \Phi_{h_r} - rp\Phi_{h_r}$ where Φ_{h_r} is the quantity of the rental

housing. To satisfy the zero profit condition, the rental price of housing p_r must be rp. Housing supply is fixed and denoted by $\bar{H}$.

2.1.3 Firms and government

Firms. Goods other than housing are produced by firms. The production technology is represented by the production function $F(K, L)$ whose input arguments are capital K and labor L. Note that L is measured in efficiency units. The production function is assumed to be homogeneous of degree one. Capital depreciates geometrically at the rate of δ every period.

Government. The government collects revenue from consumption tax and unintended bequests B which consist of the liquid and housing assets left by deceased households. Unintended bequests are used to decrease the consumption tax burden of households, in line with the formulation in the related literature (e.g., Krueger and Ludwig (2007); Conesa, Kitao and Krueger (2009)). We assume that the government can sell houses without transaction costs. Government budgets are expressed by the following two equations:

$$G = \tau_c C + B,$$

$$\kappa \bar{y} \Phi_R = \tau_p w L,$$

where G is government expenditure which does not affect households' utility, C is aggregate nondurable consumption in the economy, and Φ_R is the number of retired households. Government expenditure is financed by the consumption tax and bequests as shown in the first equation. Public pensions are financed by a tax on earnings.

2.1.4 Equilibrium

The stationary equilibrium is characterized by quantities (c, a, h, h^r, K, L) and prices (p, w, r) which clear housing, goods, asset, and labor markets, and economic agents that solve optimization problems given prices. The rental price of housing p_r satisfies the zero profit condition of apartment owners. Tax rates τ_c and τ_p are determined to balance the government's budget.

2.2 Calibration

We now turn to the functional forms and parameter values that characterize the model. We calibrate the model to Japan's economy in 2005-2017 whenever possible. We choose parameters so that the model can produce some key features of the housing market. We use a conventional two-step procedure. First, we take parameters values directly from the

parameter	description	value
ν	Share of nondurable consumption	0.756
α	Labor share	0.638
δ	Capital depreciation rate[a]	0.089
d	Downpayment requirement[b]	0.200
γ	Coupon depreciation[a]	0.953
ϕ_b	Transaction cost for buyers	0.03
ϕ_s	Transaction cost for sellers	0.03
g_y	Government expenditure	0.19
κ	Gross pension replacement rate	0.63

Table 1: Predefined parameter values

[a] Annual rate.
[b] The value of the downpayment requirement is for working households.

data or the literature and assign them to a subset of parameters. Next, the remaining parameters are set to yield relevant moments in the data.

2.2.1 Predefined parameter values

Table 1 summarizes the predefined parameter values.

Demographics. One model period covers 2 years for computational reasons. Households start their economic life at age 24 as a renter ($j = 1$), retire at age 64 ($J^R = 21$), and live up to age 99 ($J = 37$). The survival probability at each age is calculated from the Complete Life Tables published in 2018 by Ministry of Health, Labour, and Welfare. The population in Japan did not change much during 2005-2017, and thus we assume that it is constant.

Preferences. The utility function is as follows:

$$u\left(c, h, h^r\right) = \begin{cases} \log\left(c^\nu h^{r\,1-\nu}\right) & \text{for} \quad h = 0, \\ \log\left(\chi c^\nu h^{1-\nu}\right) & \text{for} \quad h \neq 0, \end{cases}$$

where $\chi > 1$ denotes the utility gain from owning a house. The housing choice is subject to a taste shock ε which is assumed to be i.i.d. and have an extreme value distribution with scale parameter σ_ϵ. The taste shock variance σ_ϵ needs to be calibrated. In solving households' utility-maximization problem, we employ the discrete-continuous endogenous grid-point method (DC-EGM) algorithm proposed by Iskhakov et al. (2017). They show that adding a choice-specific taste shock can significantly decrease the computational difficulty stemming from discrete choices.

Income process. Following De Nardi, Fella and Pardo (2016), we calculate the value and the transition probabilities for η_j by using Japanese household panel data (the Japan

Household Panel Survey (JHPS/KHPS) data described in detail in Section 3). We set the size of the grid N_η to 9. Household income data is sorted in ascending order at each age and allocated into 9 bins. At each age, bins 1-2 and 8-9 contain 5%, bins 3 and 7 contain 10%, and bins 4-6 contain 20% of the sample, respectively. We set η_j equal to the median household income within each bin. The elements of the transition matrix are calculated as follows: the transition probability from $\eta_{m,j}$ to $\eta_{n,j+1}$ is the proportion of households in bin m at age j that are in bin n at the age $j+1$, which is easily computable from panel data. We normalize the labor productivity of the average worker to unity.

Production technology. The firm's production technology follows the standard Cobb-Douglas production function $f(K, L) = AK^{1-\alpha}L^{\alpha}$. The constant TFP A does not affect any results in this paper and therefore value A is set so as to normalize the equilibrium wage to unity. Parameters for the production technology are taken from Hayashi and Prescott (2002): labor share α is set to 0.638 and the annual capital depreciation rate is 0.089.

Housing market. The downpayment requirement is 0.2, which is the average downpayment calculated from JHPS/KHPS. From the fact that banks tend to turn down mortgage applications from retired individuals, d_j is set to 1 for those who are retired. Transaction costs for buyers and sellers reflect the brokerage charge, conventionally 3% of property value. Following Gorea and Midrigan (2017), we choose the parameter constraining repayment plan to match the mortgage half-life. In Japan, the average duration of a mortgage is 25.5 years according to survey data from the Japan Housing Finance Agency. Assuming the real mortgage interest rate is 2%, the number of model periods required to repay half of the present value of mortgage obligations is 5.97 model periods (=11.95 years). The resulting value of γ is 0.908. The upper bound on rental housing size $\underline{h}^r$ is set to 1.0. We set $N_h = 2$; that is, households can choose to buy a small or large house, as in Rios-Rull and Sanchez-Marcos (2008) and de Francisco (2019). The housing size for sale is 1.0 or 2.0.

Government Spending. Government spending G is assumed to be a constant fraction of output: $G = g_y Y$. We set g_y equal to the average government expenditure share in 2005-2017 calculated from SNA data. The pension replacement rate is 0.63 reflecting the averages in 2009 and 2014, taken from estimates by the Ministry of Health, Labour, and Welfare.

2.2.2 Calibrated parameter values

The remaining parameter values to be determined are the time discount factor β, the variance of the taste shock σ_ϵ, the utility gain from owning a house χ and the quantity of the housing supply $\overline{H}$. We set these four parameters to fit the liquid asset-output ratio, homeownership rate, aggregate mortgage debt to GDP, and price to income ratio.

parameter	description	value
β	Time discount factor	0.957
σ_ϵ	Taste shock variance	0.25
χ	Utility gain from owning a house	1.39
$\overline{H}$	Housing Supply	26.0

(a) Calibrated parameter values

Target moment	Data	Model
Asset-output ratio	3.21	3.20
Homeownership rate	0.61	0.61
Mortgage debt to GDP	0.26	0.26
Price to income ratio	6.08	6.08

(b) Moments

Table 2: Parameterization

The liquid asset-output ratio is calculated from the liquid asset holdings of households taken from the Flow of Funds, divided by GDP.[3] The homeownership rate is the average of 2005, 2010, and 2015 from the Census data issued by the Ministry of Internal Affairs and Communications. The survey conducted by the Ministry of Land, Infrastructure, Transport, and Tourism reports that the aggregate mortgage debt balance during 2005-2017 was 132.8 trillion yen. The ratio of aggregate mortgage debt to GDP is 0.26. The average price of housing is 33.8 million yen according to survey data from the Japan Housing Finance Agency. We calculate the price to income ratio as the ratio of 33.8 million to the earnings per household taken from Comprehensive Survey of Living Conditions: the resulting value is 6.08.

These parameter values are determined to minimize the sum of squares of the four moment conditions. The model yields reasonably close moments to the data as shown in Table 2. The annualized value of the discount factor is 0.957. The taste shock variance is set to 0.25. The utility gain from owning a house is 1.39. The housing supply is set to 26.0.

2.3 Theoretical predictions of the model regarding MPC heterogeneity

In this subsection, we answer the following questions: what are the quantitative differences in MPC among households with respect to their housing status and housing tenure choices? What mechanisms yield MPC heterogeneity among those groups? What is the quantitative importance of this heterogeneity?

[3]Flow of Funds data is released by the Bank of Japan, while the GDP figures come from the Cabinet Office.

We proceed with our analysis as follows. First, we check the relationship between cash-on-hand and MPC. Second, we document the relatively high MPC of households with a mortgage. Finally, we argue that housing choice is the key factor affecting the level of MPC. All our results are based on the MPCs generated from the model described above. Our results take the household distribution into account in a well-calibrated economy. This enables us to highlight the MPCs for relevant households in the distribution.

We calculate MPC from policy function $\tilde{C}_j\left(a_j, h_j, h_{j+1}, y\left(\eta_j\right)\right)$ which determines the optimal consumption given housing choice h_{j+1}. Consumption unconditional on housing choice is the weighted average of the choice probability and the policy function conditional on housing choice:

$$C_j\left(a_j, h_j, y\left(\eta_j\right)\right) = \sum_{h'} \mathrm{P}\left(h_{j+1} = h' \mid a_j, h_j, y\left(\eta_j\right)\right) \tilde{C}_j\left(a_j, h_j, h', y\left(\eta_j\right)\right).$$

where $\mathrm{P}\left(h_{j+1} = h' \mid a_j, h_j, y\left(\eta_j\right)\right)$ denotes the choice probability of choosing h' next period given the current state variables. Using this policy function, MPC is calculated as follows:

$$\begin{aligned}\mathrm{MPC}_j\left(a_j, h_j, y\left(\eta_j\right)\right) &\equiv \left(1+\tau_c\right) \frac{\partial C_j\left(a_j, h_j, y\left(\eta_j\right)\right)}{\partial y} \\ &\approx \left(1+\tau_c\right) \frac{C_j\left(a_j, h_j, y\left(\eta_j\right)+\epsilon\right) - C_j\left(a_j, h_j, y\left(\eta_j\right)\right)}{\epsilon}.\end{aligned}$$

for sufficiently small ϵ.[4] We include the consumption tax $1+\tau_c$ to measure the propensity for total nondurable expenditure.

2.3.1 Cash-on-hand and MPC

Both theoretical and empirical literature agree on the point that households with low liquidity asset holdings exhibit a relatively high MPC. Before stating the results from simulated data, we briefly review the mechanisms involved, in line with Jappelli and Pistaferri (2014). Standard consumption theory points to two relevant mechanisms. Firstly, Carroll and Kimball (1996) show that optimal consumption is a concave function of the amount of liquid assets held when income uncertainty is added to the standard optimization problem. MPC is thus high for households with fewer liquid assets given precautionary motives. Intuitively, an unexpected positive windfall mitigates the need for precautionary saving and thus encourages additional consumption. Second, the consumption behavior of liquidity constrained households is quite different from that of those who are not constrained. Households subject to binding liquidity constraints consume all of a small unexpected positive windfall. In contrast, if households can smooth their intertemporal consump-

[4]The small income change ϵ does not affect the future income path. That is, $\mathrm{MPC}_j\left(a_j, h_j, y\left(\eta_j\right)\right)$ captures the MPC out of a transitory income shock.

tion without impediment, the consumption response to a temporary income shock will be small. Zeldes (1989), Souleles (1999), Kaplan, Violante and Weidner (2014), and other authors demonstrate empirically that the consumption response of liquidity constrained households is larger.

Since our model features idiosyncratic labor income risk and credit constraint, simulated MPCs are expected to exhibit a negative correlation with available resources. We define cash-on-hand as the sum of liquid asset holdings and income $y(\eta_j)$ minus the interest payment and the mortgage payment.[5] Panel (a) of Table 3 reports average MPC over cash-on-hand quartiles for working households.[6] Households in the first cash-on-hand quartile exhibit significantly higher MPC, which accords with previous studies. The second and third quartiles exhibit relatively low MPC.[7]

2.3.2 Housing tenure choice, mortgage debt, and MPC

In the rest of the subsection, we study the relationship between housing choice and MPC. We first review the mechanisms explored in previous studies and then present our main quantitative results.

The key mechanism driving the result here is as described in Kaplan and Violante (2014) and Kaplan, Violante and Weidner (2014): if the illiquid asset is attractive enough, households will on occasion choose to sacrifice some intertemporal consumption smoothing and incur a degree of liquidity constraint in order to invest in it. In their model, the high return on the illiquid asset drives agents to invest considerably in it, even though they remain eager to increase current consumption.

Institutional arrangements in the housing market are also important, as argued in Gorea and Midrigan (2017). Households with a mortgage must repay some fraction of their outstanding loan balance each period, so their consumption plans are not as flexible as those of households without such mortgage debts. The degree of flexibility depends on the difficulty of home equity extraction. In Japan, the home equity loan market is negligibly small. Facing this rigidity, households with a mortgage are likely to become liquidity constrained when faced with a negative income shock.

We compare MPC averages across households with different status with regard to housing tenure. Table 3 summarizes MPC averages for these different groups by cash-on-

[5]This does not capture available household resources exactly because it does not include revenue or expenditure from trading houses.

[6]Note that these figures are sensitive to the inclusion/exclusion of retired households. Panel (b) in Table 3 displays average MPC by housing tenure status and age-group. The average MPC for those over age 63 is significantly higher than for other cohorts. Older households wish to spend all their available resources before they die as there is no bequest motive. As our model simplifies the behavior of older households, calculated MPC is implausibly higher. We thus focus on average MPCs for working households.

[7]This is partly explained by the low MPC of renters in the second and third cash-on-hand quartiles.

	total	cash-on-hand quartile			
		I	II	III	IV
total working households	0.088	0.151	0.060	0.056	0.083
owners	0.110	0.176	0.090	0.070	0.091
owners with mortgages	0.146	0.186	0.098	0.081	–
renters	0.061	0.118	0.018	0.045	0.073

(a) cash-on-hand quartiles

	age			
	working households			retired
	24-39	40-49	50-63	64-99
total households	0.080	0.095	0.091	0.205
owners	0.127	0.118	0.097	0.186
owners with mortgages	0.145	0.159	0.121	–
renters	0.059	0.053	0.076	0.267

(b) age groups

Table 3: Simulated MPCs

hand and age-group. As shown in panel (a), the average MPC for working households is 0.088. The MPC of owners with mortgages is the highest by housing tenure status, at 0.146. This is confirmed when MPCs are averaged over cash-on-hand quartiles. Panel (b) displays MPC averages by age-group. Again, the MPC of mortgage debtors is higher than those of other housing tenure status groups in every age-group of working households. We provide more detailed tables in Appendix Table A.1.

To understand the relationship between MPC and housing choice, we average MPCs over housing choice. We calculate MPC conditional on housing choice as follows:

$$\begin{aligned}\mathrm{MPC}_j\left(a_j, h_j, h_{j+1}, y\left(\eta_j\right)\right) &\equiv \left(1+\tau_c\right)\frac{\partial \tilde{C}_j\left(a_j, h_j, h_{j+1}, y\left(\eta_j\right)\right)}{\partial y} \\ &\approx \left(1+\tau_c\right)\frac{\tilde{C}_j\left(a_j, h_j, h_{j+1}, y\left(\eta_j\right)+\epsilon\right)-\tilde{C}_j\left(a_j, h_j, h_{j+1}, y\left(\eta_j\right)\right)}{\epsilon}.\end{aligned}$$

for sufficiently small ϵ.

Table 4 displays MPC averages and shares of liquidity constrained households by current housing status and housing choice next period. As shown in panel (a), households who remain in the same residence exhibit larger responses to income shocks. The high MPC values for owners who will not move in the next period can be explained by liquidity constraints, as evidenced by the large share of such households that are constrained shown in panel (b). Although unable to smooth their intertemporal consumption as much as they would like, the utility from holding onto their house and the transaction costs incurred if they were to sell it mean that such households choose to retain their current housing situation. In addition, around 3% of renters purchasing a new (small) home are

current period	next period rental	small house	large house
rental	0.092	0.112	0.103
small house	0.084	0.168	0.106
large house	0.095	0.097	0.176

(a) MPC and housing choice

current period	next period rental	small house	large house
rental	0.036	0.030	0.009
small house	0.000	0.082	0.003
large house	0.000	0.001	0.077

(b) Share of constrained households and housing choice

Table 4: MPC and housing choice for working households

liquidity constrained, as a result of using their cash-on-hand to finance their purchase. In contrast, few households downgrading their homes are liquidity constrained since they realize liquidity through the sale.

The MPC averages shown in Table 3 are relevant in the macroeconomic policy context of redistribution channels. The results imply that if the government wants to increase aggregate consumption, a tax refund for mortgage debtors would be more effective than returning tax to renters or those who own their homes outright. This mortgage relief channel potentially augments the impact of monetary easing since lowering interest rates is also of benefit to mortgage debtors.

2.3.3 Upgrading housing and MPC

Next we explore the impact of a change in housing choice on MPC. de Francisco (2019) argues that households may decrease their nondurable consumption when they decide to purchase a lumpy housing asset. Intuitively, households with low asset holdings cannot maintain consumption levels after allocating significant resources for a housing purchase. For this reason, the housing choice matters. We show the quantitative significance of this channel.

Our random utility model allows us to single out the impact of a change in housing choice on MPC. The relationship between MPC unconditional on housing choice and that conditional on housing choice is

$$\frac{\partial C_j\left(a_j, h_j, y\left(\eta_j\right)\right)}{\partial y} = \sum_{h'} \left\{ \mathrm{P}\left(h_{j+1} = h' \mid a_j, h_j, y\left(\eta_j\right)\right) \frac{\partial \tilde{C}_j\left(a_j, h_j, h', y\left(\eta_j\right)\right)}{\partial y} + \frac{\partial \mathrm{P}\left(h_{j+1} = h' \mid a_j, h_j, y\left(\eta_j\right)\right)}{\partial y} \tilde{C}_j\left(a_j, h_j, h', y\left(\eta_j\right)\right) \right\}. \quad (1)$$

The first term denotes the weighted average of the MPC conditional on the housing choice and the second term reflects the change in the housing choice. The choice probability $\mathrm{P}\left(h_{j+1} = h' \mid a_j, h_j, y\left(\eta_j\right)\right)$ is an increasing function in $y\left(\eta_j\right)$ when h' is large; meanwhile, nondurable consumption $\tilde{C}_j\left(a_j, h_j, h', y\left(\eta_j\right)\right)$ is a decreasing function in h'. This implies that, when upgrading to a larger house causes a significant decrease in consumption, the second term becomes negative and large.

Using the second term in the equation (1), we can measure the impact of a lumpy housing choice on MPC. Table 5 reports the impact for total working households to be -0.036, which shows that a change in housing choice significantly lowers average MPC in the economy. This channel is particularly important for owners with mortgages in the first cash-on-hand quartile and renters in the second cash-on-hand quartile. Intuitively, if owners do not have sufficient cash-on-hand, they are tempted to sell their homes for the sake of nondurable consumption. An unexpected windfall mitigates this motive and thus lowers their MPC significantly. In the case of renters in the second cash-on-hand quartile, a positive income shock raises their motivation to buy a new home and thus lowers their MPC. This drives the result shown in panel (a) in Table 3, where the MPC of renters in the second cash-on-hand quartile is seen to be significantly low.

To complement the above intuition, we calculate the consumption loss for households upgrading their housing status. We define the consumption loss for renters purchasing a small house next period as $\tilde{C}_j\left(a_j, h^r, h^s, y\left(\eta_j\right)\right) - \tilde{C}_j\left(a_j, h^r, h^r, y\left(\eta_j\right)\right)$ and for small house owners purchasing a larger property next period as $\tilde{C}_j\left(a_j, h^s, h^l, y\left(\eta_j\right)\right) - \tilde{C}_j\left(a_j, h^s, h^s, y\left(\eta_j\right)\right)$ where h^s and h^l are the sizes of a small and a large house, respectively. Panel (b) of Table 5 reports the simulated consumption losses. The consumption loss is higher for low cash-on-hand households. Such households must accept reduced consumption since they do not have sufficient resources for intertemporal consumption smoothing. For such households, a positive income shock can have a significant impact on housing choice.

In summary, the model allows us to make the following theoretical predictions regarding MPCs:

1. Households with low cash-on-hand exhibit high MPC.

2. Households with large mortgages exhibit high MPC.

3. MPC depends on the housing choice. In particular, households planning a housing purchase who do not have a large amount of cash-on-hand exhibit low MPC.

We will empirically examine these predictions in the next section.

		cash-on-hand quartile			
		I	II	III	IV
total working households	-0.036	-0.057	-0.021	-0.031	-0.015
owners	-0.035	-0.115	-0.004	-0.011	-0.010
owners with mortgages	-0.137	-0.134	-0.001	-0.008	–
renters	-0.038	-0.012	-0.054	-0.050	-0.018

(a) contribution of change in housing choice on MPC

	cash-on-hand			
	I	II	III	IV
renter to small house owner	-0.049	-0.033	-0.020	-0.008
small house owner to large house owner	-0.164	-0.059	-0.071	-0.063

(b) consumption loss from updating housing

Table 5: The impact of change in housing choice on MPC

3 Empirical Analysis

This section presents the two types of empirical examination that we use to confirm the theoretical predictions of our model and discusses their results.

In the existing literature, there are three main approaches in estimating the impact of income shocks on consumption: employing a quasi-experimental setting; utilizing statistical restrictions to identify income shocks; making direct use of the subjective propensity to consume reported in survey data (Jappelli and Pistaferri (2014)). We adopt the last two approaches in this paper. First, we utilize survey responses from households on how their consumption reacts to transitory income, following the methodology in Jappelli and Pistaferri (2014). Second, we use statistical assumptions about the processes involved to identify transitory income shocks and measure their impact on consumption, following the approach in Blundell, Pistaferri and Preston (2008). The results gained in the two empirical exercises complement each other.

3.1 Description of the dataset

We utilize two data sets for our two empirical examinations, as each has properties that make it suitable for the examination concerned. The "Survey of Household Finances" provides a unique set of survey responses that enables us to measure consumption reactions to transitory income shocks following Jappelli and Pistaferri (2014). Meanwhile, the "Japan Household Panel Survey (JHPS/KHPS) " allows us to calculate marginal propensity to consume with respect to unexpected transitory income shocks in the manner of Blundell, Pistaferri and Preston (2008).

Survey of Household Finances. The first data set is the "Survey of Household Finances" conducted by the Financial Public Relations Central Committee at the Bank of Japan. The data set is based on a longitudinal annual survey that is conducted from June to July each year. We use the waves from 2007 to 2017 in order to preserve sample consistency; the survey provides consistent sample data since 2007 when a major questionnaire revision was carried out. The response rate exceeds 40%, and the data cover about 8,000 households on average each year. Survey households are chosen based on stratified two-stage random sampling.

The advantage of this survey is its inclusion of a unique question regarding how much households save out of their transitory income. Specifically, the question on the household saving rate looks as follows:

- *What percentage did you save out of your bonuses and temporary income you received in the past one year?*

Assuming that households reveal their propensity to save out of transitory income in the above question, we calculate their MPC as "100 minus their response".

The items we use in the survey and their summary statistics are described in Appendix Table A.3. The sample mean of the MPC to transitory income shock is 73 %.[8] This is considerably higher than the predictions of standard consumption models regarding the impact of a transitory shock. One possible explanation for this discrepancy, as discussed in Jappelli and Pistaferri (2014) who report a figure of 48% based on Italian household survey data, appeals to differences in definitions of consumption. In this type of household survey, households provide answers regarding total consumption including durables, while theory generally defines consumption as nondurable consumption. Another explanation is that respondents' answers reflect their propensity to consume out of all income shocks, both permanent and transitory; this is because it is generally difficult for households to distinguish the latter accurately. To the extent that responses view permanent income to be transitory, reported MPC will likely be higher.

Japan Household Panel Survey (JHPS/KHPS). The source of our second data set is microdata from the "Japan Household Panel Survey (JHPS/KHPS)" conducted by the Panel Data Research Center at Keio University. The survey covers detailed components of household annual earnings and monthly expenditure.[9] It also collects responses on asset holdings (broken down into real assets, financial assets, and various debt components)

[8] If we include respondents who answer "did not save any of temporary income" by presuming their MPC to be 100%, the average MPC including all sample households rises to 85%. We confirm that our empirical results remain unchanged when we alter the coverage of sample households in this respect.

[9] As the data only provide monthly expenditure for January, we assume that it corresponds to annual income over the past year. This is based on the assumption that the monthly and yearly changes in consumption are equal.

as well as individual characteristics such as gender, age, employment status, educational background, and family structure.

The survey is conducted annually in February, and the response rate is approximately 50% on average. The data set comprises what were originally two separate surveys: the Keio Household Panel Survey (KHPS) started in 2004, and the Japan Household Panel Survey started in 2009. These two surveys have been consolidated and managed collectively as JHPS since 2014. KHPS surveyed approximately 7,000 individuals aged 20 and over when it started in 2004. Data have been continuously collected since then, with 1,400 respondents added in 2007, followed by another 1,000 in 2012, to make up for missing respondents. JHPS started with 4,000 individual respondents aged 20 to 69. In both surveys, the sample is selected using two stage stratified random sampling for individuals, and there is no overlap in respondents between the two surveys.

The advantage of the JHPS/KHPS is its collection of quantitative data on income and consumption, and its identification of each household in every sample period. It thus allows us to calculate changes in income and consumption each year for every household, in the same way as the Panel Study of Income Dynamics (PSID) does for U.S. households. The items we use in the survey and their summary statistics are described in Appendix Table A.2.

3.2 Self-reported MPC and its determinants

The following approach relies on a unique survey question in the Survey of Household Finances regarding saving out of transitory income. The results supplement those of the alternative procedure shown in the next subsection, addressing its main drawback —namely, the size of the statistical errors. Whereas using statistical identification to measure MPC generates large error bands, the approach described in this section provides a direct measure of MPC based on survey responses and so is not subject to such errors arising from statistical practice.

Jappelli and Pistaferri (2014) uses a self-reported measure of MPC, taken from an Italian survey in which respondents are asked to report how much they would save/spend out of an unexpected windfall equal to the amount of their monthly earnings.[10] Such a hypothetical scenario may not reflect actual household behavior. In contrast, respondents in our survey are asked to report the actual proportion of bonuses and other temporary income that they saved in the past year.

Utilizing this measure, we run the following regression to identify factors affecting the

[10]Concretely, the question used in Jappelli and Pistaferri (2014) is as follows: Imagine you unexpectedly receive a reimbursement equal to the amount your household earns in a month. How much of it would you save and how much would you spend? Please give the percentage you would save and the percentage you would spend.

MPC:

$$\text{MPC}_{i,t} = X_{i,t}\beta_i + Y_t\gamma + \epsilon_{i,t},$$

where $\text{MPC}_{i,t}$ denotes the MPC for household i for time t, and $X_{i,t}$ is a matrix of possible determinants of MPC. Following our theoretical predictions derived in the previous section, we first examine the effect of cash-on-hand on MPC. Cash-on-hand is calculated as the sum of household disposable income, financial assets, and consumer debt.[11] We also add other possible determinants of heterogeneity in MPC that are explained later. Y_t is a year dummy to control for aggregate shocks affecting MPC like business cycles or a consumption tax hike. ϵ is the error term. We also control for possible effects from the age of the household head and the number of family members. As the MPC measure is truncated at zero and 100, Tobit regression is applied to the above specification.

Baseline results. Table 6 presents our results. In all cases, MPC is seen to be lower for households with larger amounts of cash-on-hand. In column (1), we use quartile dummies for amount of cash-on-hand. Specifically, as the omitted category is the first quartile of cash-on-hand, the decline in MPC from the first to the fourth quartile is 5 percentage points. In column (2), we break down the effects into those from disposable income and financial assets. Going from the first to the fourth quartile for financial assets is associated with a 21 percentage point decline in MPC. As for the effect of total disposable income, MPC declines by 2 percentage points between the first to the third quartiles, but as incomes rises into the fourth quartile the impact on MPC becomes insignificant. Column (3) refines the results regarding cash-on-hand. The coefficient on the cash-on-hand variable reflects how a gradual increase in cash-on-hand accompanies a decline in MPC. Age dummies are also significantly positive. The omitted category here is "head of household aged 20 to 34", and we find higher MPC for families with older household heads. Our findings support the predictions of standard consumption theory.[12] As lifetime is finite, households are likely to consume more out of assets when their remaining lifetime is shorter. The positive sign on the coefficient for number of family members implies that a larger family pushes up MPC. The negative association between MPC and cash-on-hand is consistent with results in similar exercises by Jappelli and Pistaferri (2014).

Column (4) in Table 6 offers a robustness analysis with respect to other possible determinants. Household income may follow various patterns depending on working status, industry of employment or educational background. This may cause heterogeneity in re-

[11] We define financial assets as the sum of deposit, bond, stock, investment trust, money trust, and other financial instruments.

[12] Jappelli and Pistaferri (2014) report that the empirical relation between age and MPC is roughly constant throughout working life.

	(1)	(2)	(3)	(4)	(5)
Cash-on-hand II	-2.406***				
	(0.814)				
Cash-on-hand III	-2.477***				
	(0.825)				
Cash-on-hand IV	-5.060***				
	(0.837)				
Financial assets II		-6.245***			
		(0.686)			
Financial assets III		-10.40***			
		(0.727)			
Financial assets IV		-20.52***			
		(0.790)			
Total income II		-2.026**			
		(0.964)			
Total income III		-2.175**			
		(0.851)			
Total income IV		-0.621			
		(0.860)			
Cash-on-hand			-0.00285***	-0.00279***	-0.00287***
			(0.000383)	(0.000386)	(0.000424)
Age 35-49	9.335***	11.08***	9.033***	8.965***	8.919***
	(0.808)	(0.791)	(0.795)	(0.794)	(0.798)
Age 50-64	13.17***	16.15***	12.56***	12.48***	12.57***
	(0.864)	(0.827)	(0.862)	(0.863)	(0.872)
Age 65 and over	11.20***	17.44***	11.23***	11.21***	
	(1.230)	(1.030)	(1.569)	(1.569)	
Number in family	2.219***	1.867***	2.073***	2.062***	2.190***
	(0.233)	(0.207)	(0.233)	(0.235)	(0.252)
Constant	58.89***	64.52***	57.46***	59.45***	61.29***
	(1.412)	(1.392)	(2.966)	(3.031)	(3.759)
Observations	7,779	10,079	7,779	7,779	7,237
Income status dummies	NO	NO	NO	YES	YES
Regional dummies	NO	NO	NO	NO	YES
Year dummies	YES	YES	YES	YES	YES

Table 6: Determinants of MPC: Baseline Estimates

Notes: Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively. Cash-on-hand I, Financial assets I, Total income I, and Age under 35 are omitted categories.

ported MPC, and we control for this effect by including dummy variables representing working status (full-time employee, part-time employee, self-employed, or unemployed), industry of employment, and education level of the household head. These variables are labelled as income status dummies.[13] Our results are robust to adding these controls.

In the final column, we focus on the sample in the labor force by removing those aged 65 and over; we also include regional dummies to account for any possible effect of city size on consumption, for example through differences in life-style. The results are robust to these changes. Regional dummies are assigned according to the size of districts: government designated areas with a population of 500,000 or over; areas with 40,000 or more households; areas 20-40,000 households; areas with 10-20,000 households; areas with up to 10,000 households; other areas.

MPC and housing choice. The second prediction derived from the model is that households with mortgages are likely to exhibit a higher propensity to consume out of transitory income shocks. The third prediction concerns the relation between consumption and home purchasing behavior: the model predicts that a household with probability of purchasing a home in the next period is less responsive to income shocks due to the anticipated liquidity constraint.

Table 7 shows the empirical results. Although home ownership has a significantly positive impact on MPC in column (1), the effect disappears when we control for the impact of residential loans in the other columns. This clearly demonstrates that the key factor driving MPC is not home ownership *per se*, but whether or not a homeowner has a mortgage on the property. In column (2), after controlling for the effect of residential loan status, the amount outstanding of the residential loan is still statistically significant, suggesting that a larger loan hampers consumption. These results are consistent with past studies analyzing the impact of tax rebates in the U.S. and tax changes in the U.K. on consumption (Cloyne and Surico (2017) and Misra and Surico (2014)) .

Existing empirical studies report that having a residential loan raises MPC, but none examines whether this effect increases monotonically with respect to the loan size. We address this question by estimating the effects of quartile dummy variables that capture residential loan size. Columns (4)-(8) show that the effect of residential loan size on consumption is consistently significant for households classified into the third or fourth quartiles —namely, those with an outstanding loan exceeding about 18 million yen. Loan size has more a substantial impact on MPC for households with larger mortgages.[14]

[13] Among variables associated with income status, Jappelli and Pistaferri (2014) show a positive effect from the unemployment dummy on MPC, and we also find a similar pattern in our data.

[14] The average amount of residential loan for each category is (I) 3.69 million yen, (II) 10.41 million yen, (III) 17.82 million yen, and (IV) 29.31 million yen, respectively. Households with residential loan of about 30 million yen show around three percentage points higher MPC compared to the omitted category of first quartile (those with the loan of 4 million yen).

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Homeowner	5.512***	0.611	0.412	0.318	-0.950	0.995	0.724	0.749
	(0.580)	(0.810)	(0.813)	(0.815)	(0.862)	(1.017)	(1.018)	(1.090)
With residential loan		6.661***	5.212***	4.701***	4.891***	4.904***	4.973***	5.081***
		(0.771)	(0.967)	(1.036)	(1.048)	(1.047)	(1.050)	(1.115)
Residential loan (amount)			0.000967**					
			(0.000390)					
Residential loan II				1.967*	1.821	1.789	1.859	1.779
				(1.127)	(1.134)	(1.133)	(1.131)	(1.162)
Residential loan III				2.826**	2.672**	2.626**	2.651**	2.748**
				(1.128)	(1.132)	(1.131)	(1.128)	(1.158)
Residential loan IV				3.342***	3.263***	3.203***	3.338***	3.464***
				(1.122)	(1.126)	(1.125)	(1.122)	(1.153)
Plan to purchase home in 5 years					-5.594***	-3.716***	-3.644***	-3.481***
					(1.021)	(1.146)	(1.143)	(1.161)
No plan to purchase home						3.658***	3.474***	3.618***
						(1.017)	(1.015)	(1.050)
Cash-on-hand	-0.00352***	-0.00344**	-0.00350***	-0.00348***	-0.00343***	-0.00339***	-0.00291***	-0.00310***
	(0.000372)	(0.000370)	(0.000371)	(0.000371)	(0.000372)	(0.000372)	(0.000381)	(0.000421)
Age 35-49	7.581***	7.221***	7.343***	7.322***	6.671***	6.443***	6.306***	6.268***
	(0.811)	(0.808)	(0.809)	(0.810)	(0.818)	(0.820)	(0.818)	(0.822)
Age 50-64	11.14***	11.83***	12.35***	12.45***	11.61***	11.37***	10.57***	10.75***
	(0.874)	(0.874)	(0.898)	(0.898)	(0.916)	(0.918)	(0.928)	(0.939)
Age 65 and over	10.13***	12.43***	12.86***	12.99***	11.99***	11.70***	10.11***	
	(1.240)	(1.262)	(1.274)	(1.275)	(1.302)	(1.303)	(1.606)	
Number in family	1.937***	1.888***	1.883***	1.879***	1.798***	1.867***	1.751***	1.851***
	(0.233)	(0.232)	(0.232)	(0.232)	(0.234)	(0.235)	(0.236)	(0.255)
Constant	58.27***	57.96***	57.80***	57.79***	59.89***	57.85***	57.48***	59.53***
	(1.356)	(1.350)	(1.351)	(1.351)	(1.399)	(1.508)	(3.027)	(3.791)
Observations	7,754	7,754	7,754	7,754	7,669	7,669	7,669	7,141
Income status dummies	NO	NO	NO	NO	NO	NO	YES	YES
Regional dummies	NO	NO	NO	NO	NO	NO	NO	YES
Year dummies	YES	YES	YES	YES	YES	YES	YES	YES

Table 7: Determinants of MPC: MPC and housing choice

Notes: Standard errors in parentheses. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively. Residential loan I and Age under 35 are omitted categories.

Our dataset also contains valuable information regarding household plans to purchase a new home, which allows us to examine the third prediction of our model. We use a dummy variable which takes the value one when a household plans to purchase a home within 5 years and check its relation with self-reported MPC. Column (5) shows that such households are likely to consume less out of transitory income, which accords with our prediction. We also find that households who have no home and do not plan to purchase one in the near future are likely to consume more out of transitory income, presenting a similar intuition (Column (6)).[15] These results are robust to adding income status and regional dummies, as well as to removing retirees. Independent work by Gross (2019) reports results similar to ours for U.S. PSID data.[16] In all cases, the effect of cash-on-hand, age, and number of family members are significant and unchanged from the baseline results.

3.3 Identifying MPC from income and consumption covariance

Following Blundell, Pistaferri and Preston (2008), we estimate the MPC out of a transitory income shock by making statistical assumptions on the income process and consumption rule. The covariance structure estimated using panel data enables us to identify relevant parameters. The advantage of the method is that we can identify the MPC out of a transitory income shock without relying on quasi-experimental situations. We present the framework below, following Blundell, Pistaferri and Preston (2008). More detail can be found in their paper, as well as Gorodnichenko, Peter and Stolyarov (2010), Kaplan and Violante (2010), and Jappelli and Pistaferri (2014). Suppose that the income process of household i at time t is represented as follows:

$$\ln y_{it} = z'_{it}\lambda^y + P_{it} + u_{it},$$

where z_{it} are observable deterministic characteristics, λ^y is the coefficient vector, and P_{it} is the persistent component modeled as $P_{it} = P_{i,t-1} + \zeta_{it}$. A permanent income shock ζ_{it} and transitory income shock u_{it} are assumed to be i.i.d. random variables.

Our interest is to measure the consumption response to unexpected income shocks ζ_{it} and u_{it}. We thus assume that the consumption rule is given by

$$\triangle \ln c_{it} = \triangle z'_{it}\lambda^c + \phi_1\zeta_{it} + \phi_2\triangle u_{it} + \triangle\xi_{it},$$

where ϕ_1 and ϕ_2 denote the marginal propensities to consume with respect to permanent

[15] These are households who will inherit a home from their parents or prefer not to buy a home in their lifetime.

[16] He reports that consumption falls in anticipation of, and after, changes in the stock of housing and households who are planning on purchasing housing have negative marginal propensities to consume.

and transitory income shocks, respectively. The consumption specific shock ξ_{it} is also assumed to be an i.i.d. random variable.

We assume that MPC parameters are constant over time and the variances of ζ_{it}, u_{it}, and ξ_{it} are time-variant.[17] In addition, ζ_{it}, u_{it}, and ξ_{it} are assumed to be uncorrelated. Under these statistical assumptions, all parameters can be identified by exploiting the covariance structure as shown in Blundell, Pistaferri and Preston (2008).

The estimation procedure is as follows. We first regress log income and log consumption on $z_{i,t}$ and a year dummy to remove the impact of the deterministic characteristics.[18] As for observable variables $z_{i,t}$, we use family characteristics reported in the survey data including age and age-squared of the household head, the number of family members, the number of working family members, the number of family members aged over 60, and the size of the city of residence. Other observable variables included are education, employment status, industry of employment, and size of employer, all of which are included for both household heads and spouses. We allow for some effects to vary over time by using interaction terms for variables and year dummies. Using the residuals from these regressions, we estimate the covariance matrix of $(u_1^c, u_2^c, ..., u_T^c, u_1^y, u_2^y, ..., u_T^y)$ where u_t^c and u_t^y are the residuals of the regressions for income and consumption respectively. Now we have $T(2T+1)$ distinct moments. Then we minimize the distance between the theoretical and empirical moments.

Results. Table 8 presents our results. The point estimate of the marginal propensity to consume out of transitory income for total households is 16%. We divide the sample according to the size of respondents' cash-on-hand holding, classifying households into two groups: those with average cash-on-hand or less (group I), and those with above average cash-on-hand (group II). The results show that households with less cash-on-hand are likely to exhibit higher MPC than those with more. We do not use a finer classification such as quartile grouping, as dividing the sample substantially increases measurement error due to the limited sample size. In addition, households with residential loans are more responsive to transitory income shocks than those without them. Both results are consistent with the theoretical predictions derived in the model and also the empirical results reported in the previous section. The table also provides confirmation of robustness with respect to the definition of consumption. When we limit consumption to nondurables, both the levels of and differences in MPC across various types of household

[17] When carrying out identification with T years of data on income and consumption levels, only $T-3$ variances of the permanent shock and $T-2$ variances of the transitory shock can be identified. We adopt the same assumptions for variances as in Gorodnichenko, Peter and Stolyarov (2010).

[18] We omit observations from respondents whose marital status changed during the sample period, who answered questionnaires three times or less, or who hold mortgages exceeding 100 million yen. We also omit respondents from the 2004 administration of JHPS since the survey question on household income changed from 2005. The sample period is thus 2005-2017.

Expenditures:	All	Nondurables
Total households	0.158***	0.148***
	(0.021)	(0.020)
Cash-on-hand I	0.164***	0.172***
	(0.032)	(0.033)
Cash-on-hand II	0.130***	0.110***
	(0.029)	(0.027)
With residential loan	0.177***	0.213***
	(0.048)	(0.046)
Without residential loan	0.151***	0.152***
	(0.024)	(0.023)
Hand-to-mouth[b]	0.203***	0.213***
	(0.056)	(0.046)
Non hand-to-mouth[b]	0.162***	0.152***
	(0.024)	(0.023)

Table 8: MPC estimates for Different Types of Households[a]

[a] Standard errors are in parenthesis. *, **, *** denote significance at the 10%, 5%, and 1% levels, respectively.
[b] The definition of hand-to-mouth households is provided in the Appendix A2.

remain broadly unchanged. The contrast between different types of household is clearer in the results for nondurable consumption.[19]

4 Concluding Remarks

In this paper, we theoretically and empirically examine the MPC heterogeneity of households in Japan. We build a heterogeneous-agent overlapping-generations general equilibrium model with an illiquid and indivisible housing asset. The model presumes a highly rigid housing market, which is an empirically realistic assumption in the case of Japan. We conduct a theoretical analysis and propose a quantitative framework for examining MPC heterogeneity, demonstrating that mortgage debtors exhibit high MPC and that households intending to upgrade (from renting to owning, or to a more upmarket home) may exhibit low MPC. We also adopt two empirical approaches to examine MPC heterogeneity using Japanese household data. Specifically, we utilize a unique survey that contains a self-reported measure of MPC in the first; and, in the second, an information-rich survey that allows us to identify MPC from statistical assumptions. Both results support the theoretical predictions derived in our model regarding the heterogeneous

[19] When we compute the MPC out of permanent income shocks, it is 0.51, which is much higher than the corresponding figure for transitory income shocks. Existing studies also find that MPC is substantially larger with respect to permanent shocks than transitory shocks: 0.64 versus 0.05 in Blundell, Pistaferri and Preston (2008).

responses of consumption according to cash-on-hand, housing status, and the amount of residential loans. More specifically, MPC is higher for households with less cash-on-hand and those with larger residential loans.

Our findings have three implications for policy and policy research. For distributional policy, as argued in existing studies regarding MPC heterogeneity, income transfers to households who cannot adjust consumption due to liquidity constraints is effective in maximizing the policy impact on aggregate consumption. In our context, transfers to households with large mortgages will tend to encourage consumption out of transitory income gains. Turning to housing market policy, increasing market liquidity would promote home sales, thus raising the expected return (or reducing the expected loss) of purchasing a home. In such an environment, the number of households taking out mortgages would increase, driving average MPC higher in the economy. Finally, our findings underline the importance of considering heterogeneity in quantifying policy effects. Concretely, the average impact of a fall in the mortgage rate on the aggregate economy is higher when we consider the higher MPC of households with residential loans.

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Appendix

A1. Simulated MPC averages over detailed characteristics

		cash-on-hand quartile			
	total	I	II	III	IV
total: all ages	0.131	0.188	0.114	0.105	0.116
owners	0.142	0.188	0.139	0.117	0.119
owners with mortgages	0.121	0.136	0.098	0.081	–
renters	0.113	0.189	0.072	0.089	0.113
total: working households	0.088	0.151	0.060	0.056	0.083
owners	0.110	0.176	0.090	0.070	0.091
owners with mortgages	0.146	0.186	0.098	0.081	–
renters	0.061	0.118	0.018	0.045	0.073
total: ages 24-39	0.080	0.140	0.043	0.047	0.063
owners	0.127	0.199	0.084	0.071	0.071
owners with mortgages	0.145	0.210	0.088	0.080	–
renters	0.059	0.111	0.020	0.041	0.060
total: ages 40-49	0.095	0.174	0.073	0.055	0.071
owners	0.118	0.176	0.093	0.072	0.079
owners with mortgages	0.159	0.192	0.111	0.087	–
renters	0.053	0.162	0.001	0.044	0.064
total: ages 50-63	0.091	0.154	0.087	0.065	0.089
owners	0.097	0.150	0.093	0.068	0.095
owners with mortgages	0.121	0.136	0.099	0.081	–
renters	0.076	0.190	0.042	0.056	0.079
total: ages 64-99	0.209	0.269	0.272	0.197	0.148
owners	0.186	0.207	0.247	0.174	0.142
owners with mortgages	–	–	–	–	–
renters	0.267	0.543	0.356	0.260	0.158

Table A.1: Simulated MPC

A2. Definition of hand-to-mouth households

We define hand-to-mouth households following Kaplan, Violante and Weidner (2014). Given monthly income y_m and liquid assets a, households are hand-to-mouth if $a < y_m/2$. JHPS/KHPS balance sheet data is as of sometime in February and the exact date of the answer is unknown. For simplicity, we assume that the data on liquid assets is as of the end of January. JHPS/KHPS income data in January are available until 2008 and annual income data are available for all periods. We therefore estimate the January income by calculating the ratio of January income to annual income for 2005-2008. Then we set January income by multiplying this ratio and annual income for 2009-2017. The share of hand-to-mouth households is 0.239.

A3. Definition of cash-on-hand in JHPS/KHPS

We estimate cash-on-hand at the start of January m_1 as follows. The data for the amount of liquid assets at the end of January a_1 and monthly consumption c are available. The relationship between m_1 and a_1 is

$$a_1 = m_1 + y - c - s,$$

where y is monthly income and s is monthly savings. Since the data for y and s are not available, we simply assume that $y - s = 0$. Then the estimate of the cash-on-hand is $\hat{m_1} = a_1 + c$.

A4. Descriptive Statistics

	observation	mean	standard deviation	minimum	maximum
Household income[a,d]	49,990	666.48	407.43	83	2420
Expenditure[a,d]	51,559	29.68	16.60	7.3	110.8
Nondurable expenditure[a,b,d]	47,285	24.59	13.07	5.6	81.1
Liquid assets[a,c,d]	52,932	1,069.67	1,902.78	0	56,000
Cash-on-hand[a,d]	51,674	1,383.69	1,955.55	0	56,600
Age	54,919	54.21	13.81	19	95
Family size	54,912	3.30	1.45	1	10

Table A.2: Descriptive statistics - JHPS/KHPS

[a] Figures are in units of ten thousands yen.
[b] Nondurable expenditure is defined as total expenditure minus rents for dwelling and land, furniture and household utensils, digital consumer electronics purchases, and transportation.
[c] Liquid assets comprise the sum of deposits and securities.
[d] Values are calculated after winsorizing the observations at 1% and 99%.

	Observation	mean	standard deviation	minimum	maximum
Propensity to consume out of transitory income	13,208	73.32	24.27	0	100
Cash-on-hand[a]	18,765	797.65	789.30	90	5500
Residential loan[a]	30,633	583.07	969.64	0	4000
Home ownership (dummy)	44,637	0.73	0.44	0	1
With residential loan (dummy)	30,633	0.38	0.49	0	1
Have a plan to purchase home in 5 years (dummy)	44,665	0.04	0.19	0	1
Have no plan to purchase home (dummy)	44,665	0.15	0.36	0	1
Age I ($<$ 34, dummy)	44,766	0.07	0.26	0	1
Age II ($<$ 49, dummy)	44,766	0.26	0.44	0	1
Age III ($<$64, dummy)	44,766	0.34	0.47	0	1
Age IV ($>$65, dummy)	44,766	0.33	0.47	0	1
Number of family members	44,597	3.26	1.25	2	7

Table A.3: Descriptive statistics - Survey of Household Finances

[a] Values are calculated after winsorizing the observations at 1% and 99%.