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Mortgage Debt and the Response to Fiscal Transfers

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Abstract

This paper studies how mortgage debt shapes the consumption response to cash transfers using an incomplete markets model with housing and long-term debt. Among homeowners, the model predicts those with mortgage debt have an average spending response six times larger than those without debt, and higher levels of leverage are associated with larger increases in spending. Responses in the model are found to be poorly correlated with income. By excluding homeowners with debt, conditioning transfers on having low income substantially reduces their efficacy in increasing aggregate spending. The opposite is predicted by a standard model of consumer spending without mortgages.

Keywords: mortgages · macro-policy · stimulus · marginal propensity to consume

JEL Classification: E21 · H31 · G21 · G51

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1 Introduction

Lump-sum cash transfers are occasionally used by policymakers with the goal of temporarily increasing consumption spending by households. These policies will be ineffective if the transfer is used to save or pay off debts instead of purchasing goods. Because of this, macroeconomic policies are usually evaluated in terms of householdsâ marginal propensity to consume (MPC), which measures the fraction of a transitory increase in income that is spent in the quarter that it is received. Accurately approximating the MPCs of households across different levels of income and wealth is crucial for assessing macroeconomic policy decisions. However, doing so is challenging because of the lack of high-quality panel data on expenditures and income, as well as the few times nationwide cash transfers have been used in practice.[1] This has led researchers to use models to predict how consumer spending will react to cash transfers.

Empirical studies of the 2001 and 2008 tax rebates found that consumers were on average highly sensitive to transfers, spending approximately twenty percent of the transfer in the quarter it was received.[2] Modern consumption-savings models generate realistically large MPCs by accounting for the high fraction of illiquid assets, like housing and retirement accounts, in household portfolios.[3] For tractability, this literature has generally abstracted from modeling the mortgage market, focusing only on the net value of housing equity instead of the relative stocks of mortgage debt and home values.

This paper contributes to the literature on the response to cash transfers by studying a model of consumer spending with an explicit mortgage market. Unlike short-term unsecured debt, mortgages involve large proportional costs to originate (“closing costs”) and require monthly minimum payments towards the loan balance. The distinction between debt and home values is important because households with similar housing equity can have very different levels of monthly payments and leverage. Minimum payments leave those who

[1] There have been only five examples of nationwide tax rebates being used in the United States, three of which occurred during the COVID-19 pandemic and the other two occurring in 2001 and 2008.

[2] See Kaplan and Violante (2014) and Kaplan, Violante and Weidner (2014) for reviews of empirical studies of the 2001 and 2008 tax rebates. Examples of studies of these two rebates include Johnson, Parker and Souleles (2006), Parker, Souleles, Johnson and McClelland (2013), and Misra and Surico (2014).

[3] Notable examples of these models include Kaplan and Violante (2014), Kaplan, Moll and Violante (2018), and Aguiar, Bils and Boar (2023). These models are extensions of traditional consumption-savings models, such as Bewley (1983), İmrohoroğlu (1989), Huggett (1993), and Aiyagari (1994). These models without illiquid assets were not able to generate realistically large MPCs.

have mortgages with less disposable income for consumption spending. Higher levels of housing leverage cause a higher fraction of monthly payments to be lost to interest instead of building equity, which creates stronger constraints on spending.

To reflect how these specific frictions impact the consumption response to transfers, this paper uses a standard incomplete markets model of consumer spending, but modified to allow for long-term debt contracts that require owning a house for collateral. Long-term debt in the model is amortized so that households are required to make minimum payments towards their stock of debt each period. As in reality, the fraction of a loan's minimum payments going towards housing equity increases with the tenure of the loan, so highly leveraged households lose more of their payments to interest. The model is able to generate large MPCs since adjustments in housing equity require paying large fixed costs to buy, sell, or refinance a house.

The model with mortgages predicts a very strong relationship between mortgage debt and marginal propensity to consume. Homeowners with positive debt are predicted to have a MPC six times larger on average than homeowners without debt. Also, higher levels of leverage are associated with higher MPCs. However, MPC is found to be poorly correlated with income. This is because homeowners with mortgages in the top half of the income distribution have larger MPCs compared to most households in the bottom half of the income distribution.[4]

Overall, the model with mortgages generates a similar average MPC when compared to a more standard model of consumer spending without mortgages, in the spirit of Kaplan and Violante (2014). However, the distribution of MPCs across households is very different in the two models, which results in different policy implications. In particular, MPCs in the standard model are much more correlated with income, which means conditioning transfers on having low income increases the level of spending per transfer. The opposite turns out to be true in the model with mortgages: restricting transfers based on income can substantially decrease the level of spending per transfer since such restrictions exclude many homeowners

[4]This paper studies the response to an unanticipated lump-sum transfer absent any fluctuations in macroeconomic conditions. However, poor macroeconomic conditions may alter employment risk and make liquidity constraints more acute for low income households and renters. The results of this paper should not be viewed as predicting overall responses to policy during a recession. Additionally, the model does not study differences in access to financial institutions and other types of credit that might make it more difficult for low income households to finance expenditures.

with high levels of debt. The standard model does not account for these highly sensitive households because it abstracts from how debt creates strong constraints on spending for middle to high income households. This suggests that mortgages play an important role in macroeconomic policy transmission, and abstracting from explicitly modelling the mortgage market may result in misguided policy predictions.

Related Literature Many papers have previously studied consumption-savings models with housing and mortgages, including Hedlund (2016), Favilukis, Ludvigson and Van Nieuwerburgh (2017), Hedlund, Karahan, Mitman and Ozkan (2017), Sommer and Sullivan (2018), Garriga and Hedlund (2020), Kaplan, Mitman and Violante (2020), Wong (2021), Eichenbaum, Rebelo and Wong (2022), Dong, Liu, Wang and Zha (2022), Jacobson (2022), Ferreira, Gálvez and Pidkuyko (2023), Hu (2023), Pidkuyko (2023), and Díaz, Jerez and Rincón-Zapatero (2024). This paper builds on this existing literature in three main ways. First, this paper uses a model with mortgages to study the response to cash transfers, as opposed to monetary policy transmission or outcomes in the housing market. Second, the model in this paper is estimated to target the fraction of hand-to-mouth households in the data. These are households who have close to zero liquid wealth, which makes them the most likely to respond strongly to receiving a transfer. Recent work by Kaplan and Violante (2022) and Aguiar, Bils and Boar (2023) has shown that matching the population share of hand-to-mouth households in consumption-savings models is crucial for generating realistic levels of households' marginal propensity to consume. This allows for policy-relevant analysis by ensuring that consumption responses are consistent with the data. Third, the policy implications of the model with mortgages are compared directly with the policy implications of a standard model of consumer spending without mortgages, similar to the one described in Kaplan and Violante (2014).

Additionally, several empirical studies have studied the relationship between long-term debt and consumption behavior. Using household survey data for the United States and the United Kingdom, Cloyne, Ferreira and Surico (2020) show that the aggregate response of consumption to interest rate changes is driven mainly by households with a mortgage. They also find renters change their spending less than homeowners with mortgages, and homeowners without mortgages do not adjust expenditures at all. Using administrative data from Norway, Yao, Fagereng and Natvik (2015) find that higher leverage is associated with larger propensity to spend out of transitory income shocks, even after controlling for income and net worth. Hedlund, Karahan, Mitman and Ozkan (2017) find a similar pattern using consumption and income data for the United States from the Panel Study of Income Dynamics. Misra and Surico (2014) find households with the highest propensity to spend after the 2001 and 2008 tax rebates were those that own real estate and have high levels of mortgage debt. Using data from a Chinese commercial bank, Agarwa, Deng, Gu, He, Qian and Ren (2022) show that homeowners with mortgages respond to unexpected changes in interest rate more than homeowners without mortgage obligations. Using loan-level micro-data for the United Kingdom, Cumming and Hubert (2022) find that consumption responds more strongly to monetary policy when the share of highly indebted households is large and house prices have recently decreased. Koşar, Melcangi, Pilossoph and Wiczer (2023) study the response to cash transfers during the COVID-19 pandemic and highlight how debt creates a trade-off between using a transfer to pay off debt or spend it on consumption goods.

The rest of the paper proceeds as follows: Section 2 describes the model environment. Section 3 explains how the parameters of the model are chosen and the data used to estimate the model. Section 4 summarizes the predictions of the model and how households respond to different sizes of transfers. Section 5 describes a standard model of consumer spending without mortgages and compares the policy implications to the model with mortgages described in Section 2.

2 Model

This section describes the model used to estimate consumption responses of households to transfers. The model is a discrete-time incomplete markets model that consists of a continuum of heterogeneous households, a housing market, and defaultable long-term debt collateralized by housing. A period in the model corresponds to one quarter.

The structure of the model is mainly drawn from models of consumer spending developed by Kaplan and Violante (2014) and Aguiar, Bils and Boar (2023), as well as macroeconomic models of housing and mortgage markets developed by Hedlund, Karahan, Mitman and Ozkan (2017) and Garriga and Hedlund (2020). Similar to the existing macroeconomic literature on consumer spending, this paper uses a life-cycle model estimated to match the population shares of households whose spending is constrained by low levels of wealth. However, instead of collapsing both housing wealth and debt into a single state variable, this paper explicitly models households' separate choices for housing and debt. To keep the model tractable, this paper studies a small open economy with perfectly elastic housing supply. This simplification allows the model to be solved on finer grids for individual state variables and therefore study the heterogeneous responses to cash transfers.

2.1 Households

Households have two stages of life: working and retirement. Working households can be either homeowners or renters. Both types of households are heterogeneous in liquid assets a, labor income y, level of inter-temporal elasticity of substitution $i \in \{1,2\}$, and whether they are flagged for bad credit $f \in \{0,1\}$. Homeowners have house size h and mortgage debt d as additional individual state variables. Liquid assets, house size, mortgage debt and being flagged for bad credit are endogenous state variables that are determined by households' choices in previous periods. Labor income y is a stochastic endowment that follows a first-order Markov process. Following Aguiar, Bils and Boar (2023), inter-temporal elasticity of substitution (IES) is allowed to be heterogeneous. IES is exogenously assigned, with a fraction p_1 of households having an elasticity of $1/\sigma_1$ and the remaining $1-p_1$ households having an elasticity of $1/\sigma_2$.

To maintain tractability with quarterly time periods, the model uses a two-stage overlapping generations structure as in Gertler (1999) and Cagetti and De Nardi (2006). Each period, with probability ϕ, a working household becomes retired and is replaced by a new working household with the same income y, but with zero assets or debt. This way, the measure of working households remains constant. Retired households receive a pension proportional to their after-tax labor income and an annuity based on the value of their net asset holdings at retirement. Retired households experience no uncertainty, so each household makes identical choices each period and saves nothing. Retired households survive to the next period with probability $1-\phi_R$.

2.2 Financial Markets

Households save using risk-free assets that are traded price $1/(1+r)$. Homeowners can also use their house as leverage to borrow from competitive risk neutral lenders who offer long-term debt with an option to default at any time.

2.2.1 Mortgages

For both new homeowners and existing owners who are refinancing, mortgages are priced based on each borrower's individual risk assessed at the time of origination. In particular, a borrower with income y, house size h, and IES type i, who originates a loan d' and saves a' in liquid assets, will receive $q_d^0(a', y, h, d', i)\, d'$ units of consumption goods when they originate a loan. The loan-specific mortgage price q_d^0 compensates the lender for origination costs κ_d as well as for the risk of the borrower defaulting, selling, refinancing, or retiring. For tractability, the pricing of default risk occurs only at origination.

During repayment, the mortgage contract specifies a minimum payment based on the balance of the loan and the value of the house.[5] In particular, each period households must make a payment m towards their mortgage that is greater than or equal to the minimum payment $\overline{m}(p_h h, d)$ so that the level of debt evolves as

$$d' = (1 + r_d)d - m, \; m \geq \overline{m}(p_h h, d)$$

Here, r_d is the interest rate on borrowing, which is related to the risk-free rate r by

$$1 + r_d = (1 + \zeta)(1 + r)$$

where ζ is a positive number representing the costs related to servicing a loan. This markup makes the cost of borrowing higher than the risk-free rate even when there is zero risk of default.

Instead of making a payment towards the loan, a household can choose to pay off their existing loan balance and originate a new mortgage, or they can default on the loan. If a borrower chooses to default, lenders ignore the skipped payment with probability $1 - \pi_1$, in which case the borrower stays in the house and carries their loan balance into the next period. Alternatively, with probability π_1, lenders foreclose on the house resulting in repossession of the house and complete debt forgiveness, but with the borrower being flagged for bad credit, $f = 1$. Borrowers who are flagged for bad credit are excluded from participating in the mortgage market until the flag is removed with probability π_0. After repossession, lenders sell the home at the market price, but lose a fraction $1 - \vartheta$ of the sales revenue to foreclosure costs.

[5] In reality, the minimum payment on a mortgage also depends on the size of the original loan and its tenure. The structure of minimum payments in the model is simplified to avoid needing to track these loan characteristics as additional state variables.

2.3 Housing

Households can either rent or own housing, from which they receive utility from housing services. Households who choose to rent (renters) choose housing that is contracted on a spot market each period at unit cost r_h.[6] Homeowners, by contrast, receive a constant stream of housing services from their house, which is chosen from a discrete set of values: $\mathcal{H} = \{h_1, \ldots, h_N\}$. Homeowners face proportional goods costs $\kappa_b p_h h$ and $\kappa_s p_h h$ when buying or selling a house, respectively. These costs represent fees charged by real estate brokers at the time of sale.[7]

To reflect segmentation between the rental and owner-occupied markets, large dwellings are only available for purchase and rental housing is restricted to be less than the smallest available house size h_1.[8] All housing in the model is solely occupied by the renter or homeowner; homeowners cannot rent a fraction of their house to tenants or own multiple houses simultaneously.

2.3.1 Rental Housing

Rental housing firms borrow funds at interest rate r_d to buy housing capital at the beginning of the period at unit price p_h. They sell the housing capital to renters at rate r_h and incur maintenance costs μp_h per unit of housing services. Then, at the end of the period, they sell their housing back to the market at price p_h. Therefore, the static problem of a rental housing firm is

$$\max_{H} \, (r_h - \delta_h p_h)H + p_h H - (1 + r_d) p_h H$$

[6] The model abstracts from long-term rental contracts. This is done so that the renters' problem is identical to a standard incomplete markets model without mortgages. This ensures that any differences in policy implications between this model and a standard model only come from different modelling choices in the owner-occupied housing market. The differing policy implications between this model and a standard model are discussed in section 5.

[7] These proportional transaction costs, together with mortgage origination costs, make it costly to acquire or adjust owner-occupied housing. In reality, households at different levels of income may face additional barriers to homeownership, such as heterogeneous employment risk and access to financial institutions. These are beyond the scope of this paper, but may be important in determining responses to policy.

[8] As in Garriga and Hedlund (2020), this assumption is made based on empirical analyses of the rental and owner-occupied markets that find little evidence of arbitrage, Glaeser and Gyourko (2007), distinct property characteristics, Halket, Nesheim and Oswald (2020), and tenure status flows that indicate a strong degree of segmentation, Bachmann and Cooper (2014).

which implies that equilibrium rental housing prices are given by

$$r_h = (r_d + \delta_h)\, p_h.$$

Equivalently, the price of renting can be interpreted as the household taking out a loan equal to the full value of the home, then paying only interest and rolling over the principal.[9]

2.4 Household Problems

The timing of events within a period is as follows:

1. Income and retirement shocks are realized
2. Homeowners choose to sell or keep their current house
3. Owners who keep their house decide to either
   (i) Make a payment on their existing mortgage
   (ii) Refinance by originating a new mortgage
   (iii) Default on their mortgage
      - With probability π_1, repossession occurs immediately and the household receives a flag for bad credit.
4. Any household who does not own a house chooses to either buy a house or rent
   - This includes both those who started the period without a house or owners who left their house by selling or defaulting earlier in the period
   - Households without a flag for bad credit can use debt to buy a house, while households flagged for bad credit need to pay the full value of the house at the time of purchase
5. Income is received. All households make consumption and savings decisions, and renters choose their level of housing.

Each household receives utility from non-housing consumption c and housing h according to the utility function $u(c,h)$. Utility flows are discounted at rate β. The rest of this section describes the problems faced by each type of household in the economy

[9] In reality, the relative cost of renting to owning varies across location, home size, and property type (single or multi-family). For tractability, this paper does not allow for different types of rental properties and assumes a constant price of renting.

2.4.1 Retirement

In retirement, households survive to the next period with probability $1-\phi_R$. Retired households receive a pension proportional to their after-tax labor income and an annuity based on the value of their net asset holdings at retirement. Income in retirement is therefore given by

$$Y_R(a,y,h,d) = B\left[y - T(y)\right] + \left[\frac{r(1+r)^{1/\phi_R}}{(1+r)^{1/\phi_R}-1}\right](a + \max\{p_h h - d, 0\}),$$

where B is the replacement rate for labor income in retirement.[10] Each period, a retired household's income is allocated between non-housing consumption and housing, which is rented at rate $r_d+\delta_h$ and is allowed to take any non-negative value.[11] Since there are no fluctuations in income after retirement, households will make identical choices each period and will save nothing. The value of retirement is given by

$$V_R(a,y,h,d,i) = \max_{c,h}\left\{(1-\beta)u(c,h)^{\sigma_i} + \beta\left[(1-\phi_R)V_R(a,y,h,d,i)\right]^{\sigma_i}\right\}^{\frac{1}{\sigma_i}}$$

subject to

$$c + (r_d+\delta_h)p_h h \leq Y_R(a,y,h,d)$$

2.4.2 Renters' Problems

Good Credit ($f=0$) Renters with good credit choose consumption c, housing h, and savings in liquid assets a' to solve their problem:

$$V^0_{rent}(a,y,i) = \max_{c,h,a'\geq 0}\left\{(1-\beta)u(c,h)^{\sigma_i} + \beta E\left[W^0_{rent}(a',y',i)^{1-\gamma}\right]^{\frac{\sigma_i}{1-\gamma}}\right\}^{\frac{1}{\sigma_i}}$$

subject to their budget constraint,

$$(1+\tau_c)c + r_h h + \frac{a'}{1+r} = a + (1-\tau_{ss})y - T(y),$$

[10]The annuity is computed by using the survival probability of $1-\phi_R$, which implies that a newly retired household is expected to live $1/\phi_R$ quarters.

[11]This is equivalent to taking out an interest only loan equal to the full value of a given house.

and rental housing being less than the smallest owner-occupied house size,

$$h \leq h_1,$$

as well as non-negativity constraints on their choices: $c, h, a' \geq 0$.[12] Here, τ_c is the linear tax rate on non-housing consumption expenditures, τ_{ss} is the linear social security tax on labor income, and $T(\cdot)$ is a nonlinear tax function for labor income. At the start of the next period, the household retires with probability ϕ, so the continuation value is computed as

$$W^0_{rent}(a,y,i) = (1-\phi)\max\{V^0_{rent}, V^0_{buy}\}(a,y,i) + \phi V_R(a,y,0,0,i)$$

where V^0_{buy} is the value of buying a house, which is computed as

$$V^0_{buy}(a,y,i) = \max_h \begin{cases} V_{orig}(a-\kappa_b p_h h, y, h, p_h h, i) & , \ \kappa_b p_h h \leq a \\ 0 & , \text{ else} \end{cases}$$

$V_{orig}(a,y,h,d,i)$ is the value of being a homeowner who had the option to originate a mortgage, which is defined in section 2.4.3.

Bad Credit ($f = 1$) In contrast to a household with good credit, a household flagged for bad credit cannot use debt to finance buying a house and needs to pay for the full value of the home using liquid assets held at the beginning of the period. A renter with bad credit chooses consumption c and savings in liquid assets a' to solve their problem:

$$V^1_{rent}(a,y,i) = \max_{c,h,a' \geq 0} \left\{ (1-\beta)u(c,h)^{\sigma_i} + \beta E\left[W^1_{rent}(a',y',i)^{1-\gamma}\right]^{\frac{\sigma_i}{1-\gamma}} \right\}^{\frac{1}{\sigma_i}}$$

[12]Uncollateralized short-term debt is not explicitly modeled in this paper. As described in section 3, it is assumed that households are able to insure against transitory income shocks, which stands in for consumption-smoothing with either short term credit or inter-household transfers. Nevertheless, non-zero borrowing limits were experimented with and were found to minimally affect the quantitative results. However, introducing a non-zero borrowing limit produces a counter-factually large concentration of short-term debt among the lowest income households, which suggests straightforward modifications to this model may imply incorrect dynamics for consumer credit. For these reasons, modelling uncollaterized debt is beyond the scope of this paper.

subject to

$$(1+\tau_c)c+r_h h+\frac{a'}{1+r}=a+(1-\tau_{ss})y-T(y)$$

and

$$h \leq h_1.$$

The only difference from the problem of a renter with good credit is that the continuation value accounts for the household being excluded from credit markets in future periods. The continuation value for a renter with bad credit is computed as

$$\begin{aligned} W^1_{rent}(a,y,i) = &(1-\pi_0)(1-\phi)\max\{V^1_{rent},V^1_{buy}\}(a,y,i) \\ &+(1-\pi_0)\phi V_R(a,y,0,0,i) \\ &+\pi_0 W^0_{rent}(a,y,i), \end{aligned}$$

where π_0 is the probability of a household with bad credit regaining access to debt markets and V^1_{buy} is the value of buying a house with bad credit,

$$V^1_{buy}(a,y,i)=\max_h \begin{cases} V^1_{own}(a-(1+\kappa_b)p_h h,y,h,i) & ,\ (1+\kappa_b)p_h h \leq a \\ 0 & ,\ \text{else} \end{cases}.$$

2.4.3 Homeowners with Good Credit

Every period, homeowners with good credit choose between three options: 1) pay their existing mortgage, 2) originate a new mortgage, or 3) default on their existing mortgage. Households who choose to default risk having their house repossessed and being excluded from debt markets in the future. Therefore, the value of owning a house with good credit is given by the maximum of these three options:

$$V^0_{own}(a,y,h,d,i)=\max\{V_{pay},V_{orig},\widetilde{V}_{def}\}(a,y,h,d,i)$$

where $\widetilde{V}_{def}$ is the expected value of defaulting, which is given by

$$\begin{aligned} \widetilde{V}_{def}(a,y,h,d,i) = &\pi_1 W^1_{rent}(a+\max\{\vartheta p_h h-d,0\},y,h,i) \\ &+(1-\pi_1)V_{def}(a,y,h,d,i) \end{aligned}$$

π_1 is the probability of repossession and getting flagged for bad credit, and $\vartheta p_h h$ is the value to the risk-neutral lender of repossessing a house of size h. If the value to the lender of repossessing the home exceeds the value of the outstanding debt, then the lender rebates the difference to the household.

Pay Existing Mortgage Homeowners who choose to pay their mortgage choose non-housing consumption c, savings in liquid assets a', and their mortgage payment m to solve their problem:

$$V_{pay}(x) = \max_{c,m,a',d' \geq 0} \left\{ (1-\beta)u(c,h)^{\sigma_i} + \beta E\left[W^0_{own}(x')^{1-\gamma}\right]^{\frac{\sigma_i}{1-\gamma}} \right\}^{\frac{1}{\sigma_i}}$$

subject to

$$(1+\tau_c)c + \delta_h p_h h + m + \frac{a'}{1+r} = a + (1-\tau_{ss})y - T\left(\max\{y - r_d d, 0\}\right)$$

$$d' = (1+r_d)d - m$$

$$m \geq \overline{m}(p_h h, d)$$

where

$$x = (a, y, d, h, i) \text{ and } x' = (a', y', h, d', i)$$

Households receive an income tax deduction for interest paid on their mortgage so taxes are paid on $\max\{y - r_d d, 0\}$ instead of y.[13] The continuation value of an owner with good credit is given by

$$W^0_{own}(x) = (1-\phi)\left[V^0_{own} + P^0_{sell}\right](x) + \phi V_R(x)$$

where P^0_{sell} is the option value of selling a house, which is the additional value households would receive from selling their house relative to staying. If selling is not optimal, the

[13]In reality, households can only deduct interest on loans up to $750,000. Loans larger than this are very rare in this model since income is normally distributed, so adding a realistic cap on interest deduction does not noticeably affect the results.

option value is zero. Therefore, $P^0_{sell}(x)$ is given by

$$P^0_{sell}(x) = \begin{cases} \max\left\{0, \max\{V^0_{rent}, V^0_{buy}\}(a_{sell}, y, i) - V^0_{own}(x)\right\} & , a_{sell} \geq 0 \\ 0 & , \text{else} \end{cases}$$

and $a_{sell} \equiv a + (1-\kappa_s)p_h h - d$ is the assets held after selling a house

Originate New Mortgage Homeowners who choose to originate a new mortgage choose non-housing consumption c, savings in liquid assets a', and the size of their new loan d' to solve their problem:

$$V_{orig}(x) = \max_{c,a',d' \geq 0} \left\{(1-\beta)u(c,h)^{\sigma_i} + \beta E\left[W^0_{own}(x')^{1-\gamma}\right]^{\frac{\sigma_i}{1-\gamma}}\right\}^{\frac{1}{\sigma_i}} - \chi\left(\frac{d'}{p_h h}\right)^{\nu}$$

subject to

$$(1+\tau_c)c + \delta_h p_h h + d + \frac{a'}{1+r} = a + q^0_d(a', y, h, d', i)d' + (1-\tau_{ss})y - T(y)$$

$$d' \leq \lambda p_h h \tag{1}$$

where

$$x = (a, y, d, h, i) \text{ and } x' = (a', y', h, d', i)$$

There are a few differences between this problem and the problem of a household paying an existing mortgage. First, the price of the new mortgage is given by q^0_d, which compensates for origination costs and risk of default on top of the mortgage interest rate r_d. Second, instead of being restricted to make a minimum payment, new debt is now constrained only by a maximum loan-to-value constraint (1), which constrains the household to only be able to take out a loan up to fraction λ of the house's value. Finally, households originating a new mortgage face a convex utility cost from originating a loan with a high loan-to-value ratio. This cost stands in for aversion to high leverage loans due to factors not explicitly featured in the model, such as fluctuations in home values and depreciation risk.[14] This cost is necessary to match the concentration of housing leverage in the data, and the parameters of this cost function are included in the estimation of the model.

[14] Depreciation risk refers to idiosyncratic risks (major repairs or renovations) as well as aggregate risks (storm damage and natural disasters) for which houses cannot be perfectly insured against.

Default and Avoid Repossession Homeowners who choose to default on their mortgage and avoid repossession choose non-housing consumption c and savings in liquid assets a' to solve their problem:

$$V_{def}(x) = \max_{c,a' \geq 0} \left\{ (1-\beta)u(c,h)^{\sigma_i} + \beta E\left[W^0_{own}(x')^{1-\gamma} \right]^{\frac{\sigma_i}{1-\gamma}} \right\}^{\frac{1}{\sigma_i}}$$

subject to

$$(1+\tau_c)c + \delta_h p_h h + \frac{a'}{1+r} = a + (1-\tau_{ss})y - T(y)$$

where

$$x = (a, y, d, h, i) \text{ and } x' = (a', y', h, d, i)$$

Households who default and avoid repossession simply continue to the next period as owners of the same home without making any payments towards their loan. Alternatively, if repossession occurs, households lose their home and become renters who are flagged with bad credit.

2.4.4 Homeowners with Bad Credit

Homeowners who are flagged for bad credit choose non-housing consumption c and savings in liquid assets a' to solve their problem:

$$V^1_{own}(x) = \max_{c,a' \geq 0} \left\{ (1-\beta)u(c,h)^{\sigma_i} + \beta E\left[W^1_{own}(x')^{1-\gamma} \right]^{\frac{\sigma_i}{1-\gamma}} \right\}^{\frac{1}{\sigma_i}}$$

subject to

$$(1+\tau_c)c + \delta_h p_h h + \frac{a'}{1+r} = a + (1-\tau_{ss})y - T(y)$$

where

$$x = (a, y, h, i) \text{ and } x' = (a', y', h, i)$$

The continuation value of an owner with bad credit is given by

$$\begin{aligned} W^1_{own}(a,y,h,i) = &(1-\phi)(1-\pi_0)\left[V^1_{own}+P^1_{sell}\right](a,y,h,i) \\ &+(1-\phi)\pi_0\left[V^0_{own}+P^0_{sell}\right](a,y,h,0,i) \\ &+\phi V_R(a,y,h,0,i) \end{aligned}$$

where $P^1_{sell}(x)$ is the option value of selling a house for a household with bad credit,

$$P^1_{sell}(x) = \max\left\{0, \max\{V^1_{rent}, V^1_{buy}\}(a+(1-\kappa_s)p_h h, y, i) - V^1_{own}(x)\right\}.$$

2.5 Pricing a Mortgage

Mortgage debt is sold by risk neutral lenders operating in a competitive market. Therefore, the price of a mortgage d' is given by equating the value of the debt contract to the expected present value of holding the debt:

$$q^0_d(a',y,h,d',i)d' = \frac{1}{(1+\kappa_d)(1+r_d)} E\left[(1-\phi)J_d(a',y',h,d',i)+\phi\min\{d',p_h h\}\right].$$

Here, q^0_d is the price of a new debt contract for d' and κ_d is the cost of originating a loan, which represents closing and servicing costs when creating a new loan. Additionally, $J_d(x)$ is the present value of giving a loan of size d to a household with individual state $x = (a,y,h,d,i)$, which is given by

$$J_d(x) = \begin{cases} \pi_1 \min\{\vartheta p_h h, d\} & \\ +(1-\pi_1)(1+\kappa_d)q^0_d(a'(x),y,h,d,i)\,d & ,V^0_{own} = \widetilde{V}_{def} \text{ and } P^0_{sell} \le 0 \\ m+(1+\kappa_d)q^0_d(a'(x),y,h,d'(x),i)\,d'(x) & ,V^0_{own} = V_{pay} \text{ and } P^0_{sell} \le 0 \\ d & , \text{ otherwise} \end{cases}$$

This is defined so that the lender receives 1) $\min\{\vartheta p_h h, d\}$ if the borrower defaults and repossession occurs, 2) nothing if the borrower defaults and repossession is avoided, 3) the borrower's payment m if they choose to remain in the same contract, or 4) the outstanding balance of the loan d if the borrower chooses to refinance or sell.

3 Parameterization

This section explains the parameterization of the model. First, the choice of parameters governing the income process is described. Then, parameters selected outside of the model are summarized. The final subsection explains the estimation of the remaining parameters inside the model using simulated method of moments.

3.1 Income Process

Log-income in the model is assumed to follow a first-order auto-regressive process with persistence parameter ρ,

$$\log y_t = \rho \log y_{t-1} + \omega_t, \tag{2}$$

where ω is the normally distributed innovation, $\omega_t \sim N(0, v_\omega)$.[15] In estimating the process, observed log-income in the data, $\log \hat{y}$, is assumed to be the sum of the persistent process (2) and a normally distributed transitory shock $\varepsilon_t \sim N(0, v_\varepsilon)$

$$\log \hat{y}_t = \log y_t + \varepsilon_t$$

The transitory shock represents both measurement error and insurable income shocks that affect income but not consumption. The variance of consumption in this model is consistent with transitory shocks being insurable since the variance of log consumption relative to income is slightly larger in the model than in the data even though there are no uninsurable transitory shocks to income. Allowing for uninsurable transitory shocks would produce much larger variance in consumption than what is observed. Previous work, such as Blundell, Pistaferri and Preston (2008) and Heathcote, Storesletten and Violante (2014), has found that households are able to insure well against transitory income shocks.

Values are computed for the persistence parameter ρ and the variances v_y and v_ε to match three moments: the ratio of 75th percentile of labor income to the 25th percentile, as well as the variance of two and four years of log income growth. The first moment is computed using

[15] A normally distributed income process like this one does not produce a realistically concentrated right tail in income or net worth. A more complex income process with "super-star" earnings states, as described by Castañeda, Díaz-Giménez and Ríos-Rull (2003), was experimented with in earlier versions of this paper but it was not found to have large effects on the distribution of MPCs. This is because the very top percentiles of income in both models have MPCs close to zero, so the right tail of the income and wealth distributions are mostly irrelevant for the results of this paper. However, including these households may become important if general equilibrium effects are considered.

Table 1: Summary of Income Parameters

Parameter	Value	Description
ρ	$0.965^{1/4}$	Persistance of Log Income Process
v_ω	$0.751\times(1-\rho^2)$	Variance of Log Income Process
v_ε	0.093	Variance of Transitory Income Shocks

data from the 2019 Survey of Consumer Finances (SCF),[16] while the moments of income growth come from the Panel Study of Income Dynamics (PSID) for the years 1999 through 2009.[17] The estimated values for the income process are summarized in Table 1.

3.2 External Parameters

The schedule of minimum payments $\overline{m}$ is chosen so that it is consistent with the amortization of 80 percent of the home's value at rate r_d for 30 years (120 quarters). Also, if the household owns more than 80 percent of their home's value in debt, the minimum payment is instead made proportional to amortization of the total value of debt.

$$\overline{m}(p_h h, d) = \min\left\{(1+r_d)d, \left[\frac{r_d(1+r_d)^{120}}{(1+r_d)^{120}-1}\right]\max\{0.8\times p_h h, d\}\right\}$$

This schedule has two desirable features: first, monthly payments are higher when households have less than 20 percent equity in their home, and second, monthly payments stay the same as households reduce their debt below 80 percent leverage. This schedule accounts for these features without needing to keep track of the tenure of the loan, which would greatly increase the computational cost of the problem. Existing models of housing, such as those used in Garriga and Hedlund (2020) and Hedlund, Karahan, Mitman and Ozkan (2017), do not include minimum monthly payments and only require households to pay the current interest on their loan. However, fixed minimum payments are very important in generating realistically large consumption responses by homeowners with debt.

Table 2 summarizes parameters that are set outside of the model and not used to target endogenous moments. The coefficient of risk aversion γ is set to 4 as in Kaplan and Violante (2014) and Aguiar, Bils and Boar (2023). The probability of retirement ϕ is set to 1/160 so that a household in the model works for 40 years in expectation. The probability of dying after retirement ϕ_R is set to 1/80 so that retirement lasts 20 years in expectation.

[16] Data retrieved from Board of Governors of the Federal Reserve Board (2019).

[17] In particular, the PSID sample is taken from Arellano, Blundell and Bonhomme (2018).

Table 2: Summary of External Parameters

Parameter	Value	Description
γ	4.0	Risk Aversion
ϕ	1/160	Probability of Retirement
ϕ_R	1/80	Probability of Dying after Retirement
r	2.4	Return on Liquid Assets (Annual $\times$100)
r_d	4.1	Rate on Borrowing (Annual $\times$100)
B	0.7	Replacement Rate for Retirement Income
δ_h	0.028	Proportional Homeownership Cost (Annual)
κ_d	0.035	Loan Origination Cost
κ_b	0.025	Proportional Cost of Buying a House
κ_s	0.05	Proportional Cost of Selling a House
ϑ	0.8	Value of House to Lender after Foreclosure
τ_c	7.0	Consumption Tax ($\times$100)
τ_y^0	15.0	Income Tax Level ($\times$100)
τ_y^1	15.1	Income Tax Progressivity ($\times$100)
τ_{ss}	7.65	Social Security Tax ($\times$100)

The interest rate on liquid assets r is set to 2.4 percent and the interest rate on home loans r_d is set to 4.1 percent, which are the average rates between 2010 and 2019 for 10 year treasury securities and mortgage loans, respectively. The value of maintenance costs μ is taken from Garriga and Hedlund (2020). The loan origination cost κ_d is set to 0.035 to reflect closing costs on home loans equal to between 3 and 4 percent of the value of the loan. The proportional costs of buying and selling a house are set to be consistent with the size of real estate commissions and other costs to a seller. The relative value of a house after foreclosure ϑ is set so that the sales revenue produces a 20 percent foreclosure discount on a repossessed property consistent with evidence from Pennington-Cross (2006). The tax rate on consumption τ_c is set to 7 percent to be approximately equal to the average level of sales taxes in the US. The linear social security tax rate on income is set to 7.65 percent, consistent with payroll taxes for entitlements in the US. Following Heathcote, Storesletten and Violante (2014), after-tax income is assumed to be a log-linear function of before-tax income so that the tax function is $T(y) = y - (1-\tau_y^0)y^{1-\tau_y^1}$. The parameter for the tax level τ_{y0} is set equal to 0.15 so that the median income pays 15 percent of their income in taxes and the value of the progressivity parameter τ_y^1 is borrowed from Heathcote, Storesletten and Violante (2014).

3.3 Model Estimation

The model is estimated using simulated method of moments where the model is iteratively solved and simulated under different combinations of parameter values until a chosen set of moments computed on simulated data is a minimum distance from their counterparts in the data.

The model is solved by standard value function iteration where value and choice functions are solved on discrete grids. The income process (2) is discretized using the Rouwenhorst method described by Kopecky and Suen (2010). The set of house sizes is chosen to take seven possible values on an equidistant grid between h_1 and $750,000 in 2019 US dollars.[18] A two-dimensional golden section search algorithm is applied to solve for optimal combinations of liquid savings and debt in a continuous space.[19] Then, the model is simulated using continuous values for income, where choice and value functions are approximated by linear interpolation.

Eight parameters are estimated inside the model to target eight moments. Table 3 summarizes the estimated parameters and their values as well as moments of the estimated model. The order of parameters and targeted moments in the first and second panels of Table 3 correspond to which parameter is most important in matching each moment. All targeted moments are computed based on households aged 25-60 using data from the 2019 Survey of Consumer Finances. Liquid wealth is computed as the sum of bonds, transaction accounts, and stocks minus credit card debt. Then, net worth is computed as liquid assets plus home equity, where home equity is the value of a household's house minus their outstanding mortgage debt.

The moments chosen for the estimation are chosen because they are important in ensuring that household portfolios are in line with reality. The first three moments ensure that average levels of total net worth, housing wealth, and debt are consistent with the data. The discount factor β and the utility parameters (ψ, η) are most important in matching these moments. The estimation targets the share of households whose net worth is less than their income from the previous year as well as the share of hand-to-mouth households, which are defined

[18] The maximum house size is chosen so that a positive but very small number of households choose it. Other values for the maximum house size were experimented with and the results are similar for any maximum house size above $600,000.

[19] Unlike the choice for house size, choices for savings and debt can be solved by golden-section search because the value functions are convex with respect to each of these choices.

Table 3: Summary of Estimated Parameters, Model with Mortgages

Estimated Parameters

Parameter	Value	Description
β	0.978	Discount Factor
η	0.081	Consumption Intratemporal Elasticity of Substitution
ψ	0.704	Utility Share, Non-housing Consumption
$1/(1-\sigma_1)$	0.526	Intertemporal Elasticity of Substitution (IES), $i=1$
p_1	0.644	Population Share of IES Type $i=1$
h_1	96.30	Minimum House Size (Thousands of 2019 US Dollars)
χ	0.030	Disutility from Originating a Loan, Level
ν	6.372	Disutility from Originating a Loan, Curvature

Targeted Moments

Model	Data*	Moment
0.85	0.79	Ratio Median Net Worth to Median Annual Income**
1.31	1.37	Avg. Housing Equity to Income Ratio ($(p_h h-d)/\bar{y}$)
3.52	3.84	Avg. House Value to Income Ratio ($p_h h/\bar{y}$)
0.57	0.59	Share Households with Net Worth Less Than Income
0.45	0.45	Share Households who are Hand-to-Mouth***
0.63	0.64	Homeownership Rate
0.29	0.23	Share Owners with Loan-to-Value Ratio over 0.75
0.08	0.08	Share Owners with Loan-to-Value Ratio over 0.9

Untargeted Moments

Model	Data*	Moment
0.74	0.70	Ratio Std. Log Spending to Log Income
0.16	0.11	Share Households who are Poor Hand-to-Mouth***
0.29	0.34	Share Households who are Rich Hand-to-Mouth***
0.53	0.53	Median Loan-to-Value Ratio
0.70	0.78	Share Owners with Loan-to-Value Ratio over 0.1
0.64	0.72	Share Owners with Loan-to-Value Ratio over 0.25
0.53	0.53	Share Owners with Loan-to-Value Ratio over 0.5

* Estimation data comes from the 2019 Survey of Consumer Finances. Expenditure data is from 1999-2009 PSID.

** Net worth is computed as the sum of liquid assets and housing equity: $A = a + p_h h - d$. Annual income is computed as the sum of income received in the previous four quarters: $\bar{y} = \sum_{s=t-3}^{t} y_s$.

*** A household is categorized as hand-to-mouth if their liquid assets are less than 1/24 of their annual income, corresponding to approximately two weeks of income: $a < \bar{y}/24$. Further, hand-to-mouth households are categorized as poor hand-to-mouth or rich hand-to-mouth if their net worth is less ($A \leq \bar{y}$) or greater ($A > \bar{y}$) than their annual income, respectively.

as households who hold less than two weeks of income in liquid assets.[20] These moments are included to match the shares of households who are likely to be constrained and generate realistically large marginal propensities to consume. The level and population share for type $i = 1$ of inter-temporal elasticity of substitution (IES) are most important in matching these moments. The IES for type $i = 2$ is chosen so that the average value of IES is equal to 1.5, which is the value used in Kaplan and Violante (2014): $p_1\left(\frac{1}{1-\sigma_1}\right) + (1-p_1)\left(\frac{1}{1-\sigma_2}\right) = 1.5$. The share of households who own their home is targeted to ensure the overall population shares are representative of the data. This moment is matched by setting the minimum house size h_1 from buying a house. The disutility parameters (χ, ν) are used to match the share of homeowners with loan-to-value ratios above 0.75 and 0.9.

The bottom panel of Table 3 shows how the model fits a selection of untargeted moments. The model closely matches the variance of log consumption and the median loan-to-value ratio in the data, while also producing reasonable shares of hand-to-mouth households with net worth less than or greater than their annual income.

4 Results of Model with Mortgages

The following sections summarize the results of the model and how households respond to receiving transfers of various sizes. First, the model estimates of marginal propensities to consume (MPCs) are described for renters and homeowners. Then, the relationship between debt and homeowners' MPC is explored.

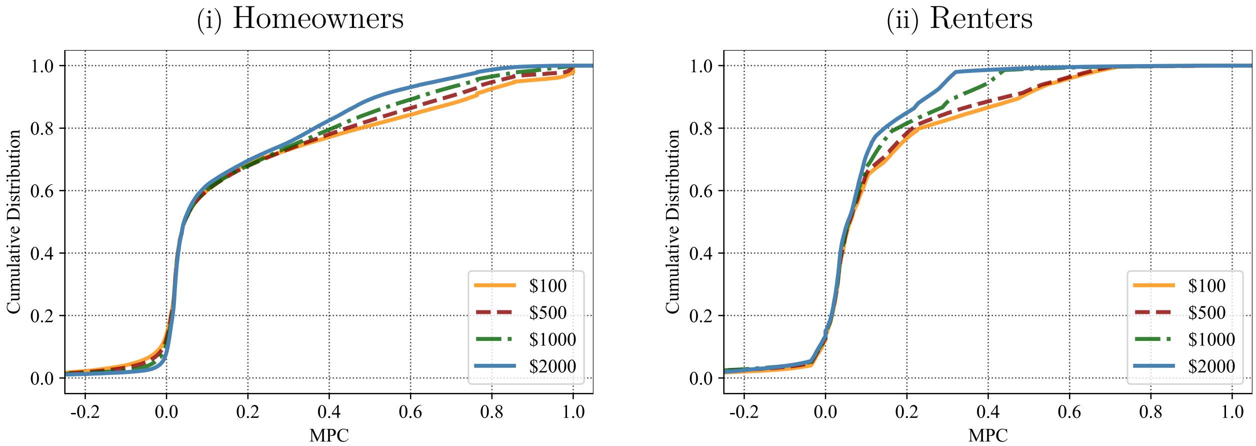
4.1 Estimates of Marginal Propensity to Consume

Results are obtained by simulating the economy for many periods until the distribution of households across individual state variables is stationary. Then, the recursive consumption functions are used to compute non-housing expenditures under an alternate level of wealth $a + tr$ where tr is the transfer payment to the household. The household's marginal propensity to consume $MPC(\cdot)$ is then computed for each household as the change in consumption divided by the size of the transfer,

$$MPC(a, \cdot) = \frac{c(a + tr, \cdot) - c(a, \cdot)}{tr}$$

[20]Specifically, a household is categorized as hand-to-mouth if its liquid assets are less than 1/24 of their income from the previous year. Two weeks is chosen because it is the typical length of time between receiving paychecks. This definition is simpler than the ones used by Kaplan, Violante and Weidner (2014) or Aguiar, Bils and Boar (2023), but captures a very similar group of households as their definitions.

Figure 1: Distribution of Marginal Propensities to Consume by Transfer Size, Model with Mortgages



Therefore, $MPC(\cdot)$ is the measure of what share of the transfer a household consumes in the quarter it is received. In the rest of this paper, I study only unanticipated transfers where households' choices in previous periods are made without the expectation of receiving the transfer.

Figure 1 shows the cumulative distribution of MPCs for four different transfer sizes.[21] The first plot shows the distribution of MPCs for homeowners while the second plot shows the distribution of MPCs for renters. MPCs for both homeowners and renters uniformly decrease with the size of the transfer. MPCs drop faster for renters since they have lower income on average, so increasing the transfer size creates a larger wealth effect for renters than owners. It can be seen that MPCs are highly concentrated, with about half of renters and homeowners having a MPC close to zero. This is consistent with empirical work by Misra and Surico (2014) who found that about half of households did not significantly adjust their spending in response to tax rebates in 2001 and 2008. Appendix 1.2 describes the concentration of spending responses for different transfer sizes. Essentially all of the aggregate increase in spending across transfer sizes is attributable to less than half of households, and over half the spending increase comes from less than 15% of households. More detailed summaries of the distribution of MPCs are available in Appendix 1.1.

Table 4 summarizes how the average MPC changes with the size of the transfer. The average MPC predictably decreases with transfer size, with the average MPC for renters falling faster

[21] Transfer sizes are denominated in 2019 US Dollars.

Table 4: Average Share of Transfer Spent in Quarter Received, Model with Mortgages

	Transfer Size					
	\$100	\$300	\$500	\$1000	\$2000	\$5000
All Households	0.17	0.17	0.16	0.15	0.13	0.11
Renters	0.13	0.13	0.12	0.09	0.08	0.06
Homeowners	0.20	0.20	0.19	0.18	0.16	0.14

than for homeowners. The overall average MPC is slightly smaller than empirical estimates found by Johnson, Parker and Souleles (2006) and Parker, Souleles, Johnson and McClelland (2013) for non-durable consumption responses to the 2001 and 2008 tax rebates. However, the average MPC in the model for transfers less than \$2000 is very similar to a standard incomplete markets model without mortgages, which will be explored in the next section.

4.2 Relationship Between Debt and MPC

Table 5 reports how MPC varies with the level of income and debt held by households. The top row reports the average MPC among homeowners for different ranges of loan-to-value (LTV) ratios in response to a \$500 transfer, while the second row reports the average MPC for different ranges of debt-to-income (DTI). On average, homeowners that hold any level of mortgage debt spend 24 percent of a \$500 transfer while homeowners without debt spend only 4 percent, so homeowners with mortgage debt spend on average six times as much as homeowners without debt. Higher levels of both LTV and DTI are associated with higher levels of MPC. For example, homeowners with LTVs over 0.75 have MPCs on average about three times larger than homeowners with LTVs between zero and 0.25.

The bottom panel of Table 5 reports how MPC and debt vary with household income. Unlike debt, average MPC does not change monotonically with income. The households with the highest MPCs are in either the bottom 10 percent or the top half of the income distribution. It can be seen that the households in the top half of the income distribution are very likely to be homeowners, and the households with the largest MPCs have relatively large levels of debt. This suggests that even though these households have relatively high income, they are more responsive to policy than most households in the bottom half of the income distribution because of their debt. This has important implications for policy since cash transfers are often targeted to low income households with the expectation that they will be more likely to spend a transfer. This model predicts the opposite: conditioning transfers

Table 5: Allocations by Debt Holdings and Income for \$500 Transfer, Model with Mortgages

	Range of LTV Ratio ($d/p_h h$), Homeowners					
	0.0	>0.0	$0.0-0.25$	$0.25-0.5$	$0.5-0.75$	>0.75
Average MPC	0.04	0.24	0.11	0.18	0.26	0.30

	Range of DTI Ratio (d/y), Homeowners					
	0	>0	$0-2$	$2-8$	$8-16$	>16
Average MPC	0.04	0.24	0.08	0.19	0.34	0.38

	Range of Income Percentile (y), All Households					
	<10	$10-25$	$25-50$	$50-75$	$75-90$	>90
Average MPC	0.24	0.11	0.13	0.19	0.18	0.16
Average LTV	0.01	0.02	0.22	0.46	0.46	0.42
Average DTI	0.15	0.43	3.58	5.53	4.68	3.60
Homeownership	0.08	0.16	0.51	0.89	0.97	0.97

on income will substantially decrease the aggregate spending response to a transfer since it will exclude many homeowners with debt. The model's prediction of how conditioning transfers on income affect the aggregate consumption response is shown in Figure 2 alongside the prediction of a standard two asset model.

5 Model Without Mortgages

In this section, the baseline model described in section 2 will be compared to a standard model of consumption responses to transfers without mortgages.

5.1 A Standard Two Asset Model

This section describes a two asset incomplete markets model similar to those used by Kaplan and Violante (2014) and Aguiar, Bils and Boar (2023). Households hold two types of assets: a liquid asset a and an illiquid asset b.[22] Households can adjust their level of liquid assets freely every period, but must pay a fixed cost κ to adjust their level of illiquid assets. As in the baseline model, there are two types of inter-temporal elasticity of substitution $i \in \{1, 2\}$. Similar to renters in the baseline model, households can rent housing services each period at price r_h, but there is no limit on the amount of housing that can be rented. At the beginning of the period, households choose whether to adjust their portfolio or not

[22] Illiquid assets correspond to housing equity in the previous model.

by paying the fixed cost, so their value is given by

$$V(a,b,y,i) = \begin{cases} \max\left\{\overline{V}(a,b,y,i), \widetilde{V}(a-\kappa,b,y,i)\right\}, & a \geq \kappa \\ \overline{V}(a,b,y,i) & a < \kappa \end{cases}$$

$\widetilde{V}(\cdot)$ is the value of being able to adjust their level of illiquid assets:

$$\widetilde{V}(x) = \max_{c,h,a',b' \geq 0} \left\{(1-\beta)u(c,h+\theta b)^{\sigma_i} + \beta E\left[W(x')^{1-\gamma}\right]^{\frac{\sigma_i}{1-\gamma}}\right\}^{\frac{1}{\sigma_i}}$$

subject to

$$(1+\tau_c)c + \frac{a'}{1+r} + b' + r_h h = a + (1+r_b)b + (1-\tau_{ss})y - T(y),$$

where

$$x = (a,b,y,i) \text{ and } x' = (a',b',y',i).$$

$\overline{V}(\cdot)$ is the value of not being able to adjust their level of illiquid assets:

$$\overline{V}(x) = \max_{c,h,a' \geq 0} \left\{(1-\beta)u(c,h+\theta b)^{\sigma_i} + \beta E\left[W(x')^{1-\gamma}\right]^{\frac{\sigma_i}{1-\gamma}}\right\}^{\frac{1}{\sigma_i}}$$

subject to

$$(1+\tau_c)c + \frac{a'}{1+r} + r_h h = a + (1-\tau_{ss})y - T(y)$$

where

$$x = (a,b,y,i) \text{ and } x' = (a',(1+r_b)b,y',i).$$

As in Kaplan and Violante (2014), households receive housing services from the sum of their rental housing and a fraction θ of their illiquid asset holdings. The continuation value is adjusted for the constant risk of retiring:

$$W(a,b,y,i) = (1-\phi)V(a,b,y,i) + \phi V^R(a,b,y,i),$$

where $R(\cdot)$ is the value of retirement, which is given by:

$$V^R(a,b,y,i) = \max_{c,h} \left\{ (1-\beta)u(c,h+\theta b)^{\sigma_i} + \beta \left[(1-\phi_R)V^R(a,b,y,i) \right]^{\sigma_i} \right\}^{\frac{1}{\sigma_i}}$$

subject to

$$c + r_h h = B\left[y - T(y)\right] + \left[\frac{r(1+r)^{1/\phi_R}}{(1+r)^{1/\phi_R} - 1} \right](a+b).$$

As with the model with mortgages, retired households will make identical choices each period and will save nothing since there are no fluctuations in income after retirement.

5.2 Parameterization

The utility function is chosen to be Cobb-Douglas: $u(c,h+\theta b) = c^{\psi}(h+\theta b)^{1-\psi}$. Values for κ, $\psi = 0.85$, and $\theta = 0.01$ are borrowed from Kaplan and Violante (2014), where κ is set to 1000 US dollars. Four parameters are estimated inside the model: the discount factor β, the inter-temporal elasticity of substitution σ_1, the population share of each type of IES p_1, and the return on illiquid assets r_b. The targeted moments are the same as in the estimation of the model with mortgages, but removing the four moments specific to the housing market. The results of the estimation are summarized in Table 15 of Appendix 1.3.

5.3 Comparison of Policy Implications

Table 6 summarizes the average MPCs generated by both the model with mortgages and the standard two asset model. The standard model predicts a larger decrease in MPC when going from a \$2000 transfer to \$5000, but less change in average MPC for transfers under \$2000. Overall, both models predict very similar levels of average MPC for transfers less than and equal to \$2000.

Table 6: Average Share of Transfer Spent in Quarter Received

	Transfer Size					
	\$100	\$300	\$500	\$1000	\$2000	\$5000
Model with Mortgages	0.17	0.17	0.16	0.15	0.13	0.11
Standard Model	0.15	0.15	0.15	0.15	0.13	0.06

However, the models have very different predictions on how MPC varies with income. Table

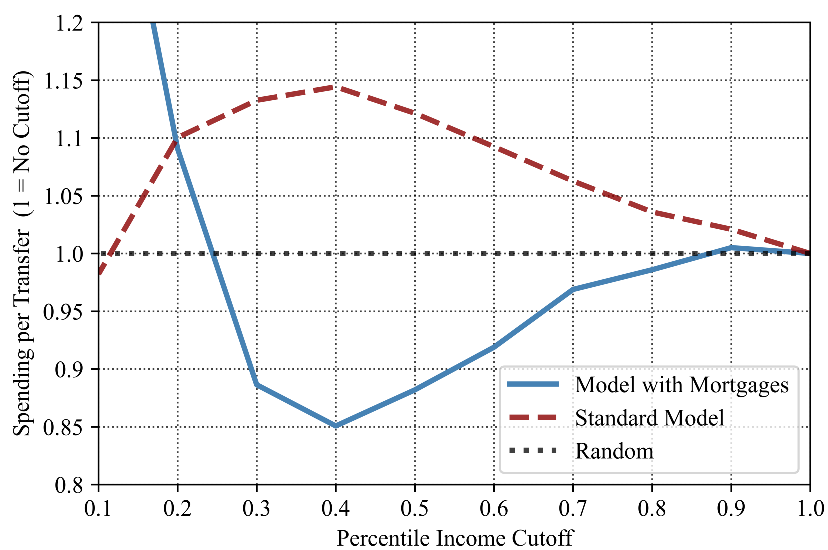
7 summarizes average MPCs within different percentiles of the income distribution. The three ranges of income with the largest levels of MPC are bolded for each model. The standard model predicts that the households with the highest MPC are all in the bottom half of the income distribution, while the model with mortgages predicts that most of the highest MPC households are homeowners in the top half of the income distribution. This suggests very different policy implications from the two models. This leads to very different policy implications from the two models, which is explored in Figure 2 below.

Table 7: Average MPC by Range of Income Percentile, \$500 Transfer

	Range of Income Percentile					
	< 10	$10-25$	$25-50$	$50-75$	$75-90$	> 90
Model with Mortgages	**0.24**	0.11	0.13	**0.19**	**0.18**	0.16
Standard Model	**0.15**	**0.18**	**0.17**	0.14	0.13	0.12

Figure 2 shows the predictions of each model for restricting transfers based on income. The solid blue line plots the spending per transfer predicted by the model with mortgages as the transfer is progressively given to a larger fraction of households, ordered by their income. The red dashed line plots the same for the standard model without mortgages. The black dotted line at the center of the figure represents the spending per transfer if transfers are limited to a random fraction of the population, which is constant.

Figure 2: Spending Per Transfer by Share of Homeowners Given \$500 Transfer



This figure demonstrates how not including mortgages can lead to misguided policy. For example, the standard model predicts giving a $500 transfer to only households in the bottom 40 percent of income would *increase* spending per transfer by about 15 percent relative to a randomly distributed transfer. Meanwhile, the model with mortgages predicts a 15 percent *decrease* in spending per transfer for the same policy. This is because the policy would exclude most homeowners, who would be more responsive to the transfer.

6 Conclusion

This paper developed a model to study how mortgage debt shapes the spending response of homeowners to receiving cash transfers. The model was estimated to target various moments of household debt, net worth, and liquidity. The model was used to estimate the consumption responses of households to receiving transfers at different levels of debt. The model predicts a very strong relationship between marginal propensity to consume (MPC) and mortgage debt, consistent with empirical evidence.

Homeowners with positive debt are predicted to have an average MPC six times larger than homeowners without debt, and higher levels of leverage are associated with higher MPCs. Unlike debt, MPCs are poorly correlated with income due to the large MPCs of homeowners. Because of this, targeting transfers only to households with low income is predicted to reduce the amount of spending per transfer by excluding homeowners with debt. This policy implication is the opposite of standard models of consumer spending that do not explicitly model mortgage debt. This suggests that not taking mortgages into account when modeling consumer spending may lead to incorrect predictions on the effects of macroeconomic policy decisions.

Although this paper only considers the response to surprise cash transfers, the estimates of MPCs have implications for many government policies. The households most responsive to receiving cash transfers will likely also be the most responsive to receiving additional disposable income through monetary policy or debt forbearance programs. The model framework described in this paper can be modified to study these other macroeconomic policies. Additionally, the model could be extended to account for inelastic housing supply to study how government policies may affect house prices and housing equity.

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A Appendix

1.1 Distribution of MPCs by Transfer Size

Tables 8 through 10 report detailed statistics on how the distribution of MPCs changes with the transfer size for renters and owners.

Table 8: Distribution of Marginal Propensity to Consume, All Households

	Share of Transfer Spent in Quarter Received						
Transfer Size	Average	P10	P25	P50	P75	P90	P95
\$100	0.17	−0.01	0.02	0.05	0.26	0.64	0.79
\$300	0.17	−0.01	0.02	0.05	0.26	0.62	0.76
\$500	0.16	−0.01	0.02	0.05	0.25	0.60	0.75
\$1000	0.15	−0.01	0.02	0.05	0.23	0.50	0.68
\$2000	0.13	0.00	0.02	0.05	0.19	0.43	0.58
\$5000	0.11	0.00	0.02	0.04	0.14	0.38	0.45

Table 9: Distribution of Marginal Propensity to Consume, Renters

	Share of Transfer Spent in Quarter Received						
Transfer Size	Average	P10	P25	P50	P75	P90	P95
\$100	0.13	−0.01	0.02	0.06	0.19	0.48	0.58
\$300	0.13	−0.01	0.02	0.06	0.18	0.48	0.58
\$500	0.12	−0.01	0.02	0.06	0.17	0.44	0.56
\$1000	0.09	−0.01	0.02	0.06	0.14	0.32	0.41
\$2000	0.08	−0.02	0.02	0.05	0.11	0.25	0.30
\$5000	0.06	−0.02	0.02	0.04	0.09	0.16	0.20

Table 10: Distribution of Marginal Propensity to Consume, Homeowners

	Share of Transfer Spent in Quarter Received						
Transfer Size	Average	P10	P25	P50	P75	P90	P95
\$100	0.20	−0.01	0.02	0.04	0.35	0.75	0.87
\$300	0.20	−0.01	0.02	0.04	0.34	0.73	0.84
\$500	0.19	−0.01	0.02	0.04	0.34	0.69	0.81
\$1000	0.18	0.00	0.02	0.04	0.32	0.62	0.76
\$2000	0.16	0.00	0.02	0.04	0.29	0.52	0.67
\$5000	0.14	0.01	0.02	0.04	0.27	0.43	0.49

1.2 Concentration of Spending Responses

Table 11 reports how much households in the model contribute to the total increase in aggregate spending if they are ordered by their MPC. Spending increases are found to be highly concentrated for both owners and renters. Reflecting the overall distribution of MPC, the concentration of spending for renters changes more with the size of the transfer than for owners. In the model, if it is possible to identify the half of households with the highest MPCs, giving the transfer to only those households would produce virtually the same spending increase as giving the transfer to all households. Even being able to identify the households with the top 15 percent of MPC will generate over half of the aggregate consumption increase compared to a universal transfer.

Table 11: Contribution to Total Response by Percentiles of MPC

	Share Contributed, $500 Transfer				
	Top 50	Top 25	Top 15	Top 10	Top 5
All Households	1.04	0.85	0.63	0.47	0.27
Homeowners	1.03	0.83	0.60	0.44	0.24
Renters	1.06	0.85	0.65	0.49	0.28

	Share Contributed, $2000 Transfer				
	Top 50	Top 25	Top 15	Top 10	Top 5
All Households	1.01	0.82	0.62	0.47	0.28
Homeowners	1.00	0.80	0.57	0.42	0.24
Renters	1.06	0.78	0.59	0.44	0.28

1.2.1 Concentrations by Transfer Size

Tables 12 through 14 report more detailed statistics on how the concentration of spending changes with the transfer size for renters and owners.

Table 12: Contribution to Total Response by Percentiles of MPC, All Households

	Share Contributed by Top Percentile of MPC				
Transfer Size	Top 50	Top 25	Top 15	Top 10	Top 5
$100	1.03	0.85	0.63	0.47	0.26
$300	1.03	0.85	0.63	0.47	0.26
$500	1.04	0.85	0.63	0.47	0.27
$1000	1.03	0.84	0.63	0.48	0.28
$2000	1.01	0.82	0.62	0.47	0.28
$5000	0.98	0.80	0.61	0.45	0.26

Table 13: Contribution to Total Response by Percentiles of MPC, Homeowners

	Share Contributed by Top Percentile of MPC				
Transfer Size	Top 50	Top 25	Top 15	Top 10	Top 5
$100	1.03	0.85	0.61	0.44	0.24
$300	1.03	0.84	0.61	0.44	0.24
$500	1.03	0.83	0.60	0.44	0.24
$1000	1.01	0.81	0.58	0.43	0.24
$2000	1.00	0.80	0.57	0.42	0.24
$5000	0.98	0.78	0.53	0.38	0.22

Table 14: Contribution to Total Response by Percentiles of MPC, Renters

	Share Contributed by Top Percentile of MPC				
Transfer Size	Top 50	Top 25	Top 15	Top 10	Top 5
$100	1.01	0.80	0.61	0.45	0.25
$300	1.04	0.83	0.64	0.47	0.26
$500	1.06	0.85	0.65	0.49	0.28
$1000	1.09	0.84	0.63	0.47	0.27
$2000	1.06	0.78	0.59	0.44	0.28
$5000	1.00	0.70	0.51	0.38	0.22

1.3 Estimated Parameters of Model without Mortgages

Table 15 summarizes the results of the estimation of the model without mortgage debt. The estimation targets the same moments as the model with mortgages except for the four moments specific to housing and mortgages.

Table 15: Summary of Estimated Parameters, Standard Model

Estimated Parameters

Parameter	Value	Description
β	0.988	Discount Factor
$1/(1-\sigma_1)$	0.807	Intertemporal Elasticity of Substitution (IES), $i = 1$
p_1	0.674	Population Share of IES Type $i = 1$
r_b	1.224	Return on Illiquid Assets (Annual × 100)

Targeted Moments

Model	Data*	Moment
0.80	0.79	Ratio Median Net Worth to Median Annual Income**
1.38	1.37	Average Housing Equity to Income Ratio $((p_h h - d)/\bar{y})$
0.59	0.59	Share Households with Net Worth Less Than Income
0.45	0.45	Share Households who are Hand-to-Mouth***

Untargeted Moments

Model	Data*	Moment
0.78	0.70	Ratio Std. Log Spending to Log Income
0.17	0.11	Share Households who are Poor Hand-to-Mouth***
0.28	0.34	Share Households who are Rich Hand-to-Mouth***

* Estimation data comes from the 2019 Survey of Consumer Finances. Expenditure data is from 1999-2009 PSID.

** Net worth is computed as the sum of liquid assets and housing equity: $A = a + p_h h - d$. Annual income is computed as the sum of income received in the previous four quarters: $\bar{y} = \sum_{s=t-3}^{t} y_s$.

*** A household is categorized as hand-to-mouth if their liquid assets are less than 1/24 of their annual income, corresponding to approximately two weeks of income: $a < \bar{y}/24$. Further, hand-to-mouth households are categorized as poor hand-to-mouth or rich hand-to-mouth if their net worth is less ($A \leq \bar{y}$) or greater ($A > \bar{y}$) than their annual income, respectively.