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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 over ten 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 many homeowners with debt, conditioning transfers on having low income reduces their efficacy in increasing aggregate spending. The opposite is predicted by a conventional heterogeneous agent model.

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 disposable income available to households. The effectiveness of these policies is usually evaluated in terms of households' 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 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

[1] There have been only five examples of nationwide tax rebates 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.

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 these housing finance frictions predicts a very strong relationship between mortgage debt and marginal propensity to consume. While the average MPC of homeowners without debt is close to zero, homeowners with positive debt have on average similarly large MPCs as renters. Further, a higher level of housing leverage is associated with a higher MPC. 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 relatively large MPCs compared to households in the middle of the income distribution.[4]

The implications of the model with housing finance frictions are compared to a conventional consumption-savings model motivated by the heterogeneous agent New Keynesian (HANK) literature. In particular, the alternative model features an illiquid asset representing housing equity, but it does not explicitly model institutional features of the housing market. Overall, the model with housing finance frictions generates a similar average MPC when compared to a model with housing modeled under the HANK convention. 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 conventional HANK model are highly correlated with income, which implies that conditioning transfers on having low income will increase the level of spending per transfer. Meanwhile, MPCs in the model with housing finance

[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.

frictions are U-shaped on average, being highest for households with incomes in the top half and very bottom of the income distribution. Therefore, restricting transfers based on income will instead decrease the level of spending per transfer, since such restrictions exclude many homeowners with high levels of debt. A conventional HANK model does not account for these highly responsive households because it abstracts from how debt creates strong constraints on spending for middle to high income households via minimum payments on debt. To highlight this point, MPCs are also computed in a version of the baseline model where minimum debt payments are set to zero. In this case, MPCs decrease with income on average, just as in the conventional HANK model. This suggests that mortgages play an important role in macroeconomic policy transmission, and abstracting from explicitly including housing finance frictions in models of consumer spending may result in inaccurate policy predictions.

Related Literature Many papers have previously studied consumption-savings models with housing finance frictions, 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 housing finance frictions 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 housing finance frictions are compared directly with the policy implications of a conventional consumption-savings model in line with the heterogeneous agent New Keynesian (HANK) literature. This literature builds on the two asset frameworks of Kaplan and Violante (2014) and Kaplan, Moll and Violante (2018). This includes models of monetary policy transmission, such as Bayer, Luetticke, Pham-Dao and Tjaden (2019), Auclert, Rognlie and Straub (2020), Luetticke (2021), Auclert, Bardóczy and Rognlie (2023), and Lee (2024), as well as non-monetary models that follow a similar modeling convention for household portfolios, such as Aguiar, Bils and Boar (2023).

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 of consumer spending with housing finance frictions. Section 3 describes a conventional model of consumer spending without mortgages. Section 4 explains how the parameters of both models are chosen and the data used to estimate each model. Section 5 summarizes the predictions of the model described in Section 2 and then compares the policy implications to the alternative model of housing described in Section 3.

2 Model with Housing Finance Frictions

This section describes a model with housing finance frictions that will be 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 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, the model described here is 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 long-term debt into a single state variable, the model features separate choices for housing and debt. For tractability, prices for housing and liquid assets are assumed to be exogenous and constant.[5]

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 b, labor income y, preference type $i \in \{1,2\}$, and if 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 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. Similar to Aguiar, Bils and Boar (2023), households' discount factors and inter-temporal elasticities of substitution (IES) are allowed to be heterogeneous.[6] These preference parameters are permanent and exogenously assigned, with fraction p_i of households having discount factor β_i and an IES of $1/(1-\sigma_i)$.

The model uses a two-stage overlapping generations structure as in Gertler (1999) and Cagetti and De Nardi (2006).[7] Each period, with probability ϕ, a working household becomes

[5]This simplification allows the model to be computed on finer grids for individual state variables and better study the heterogeneous responses of households to cash transfers.

[6]Preference heterogeneity is required to achieve realistic levels of inequality in net worth and liquidity.

[7]This structure is used to capture realistic life-cycle motives for accumulating housing equity while abstracting from age effects, as is common in heterogeneous agent business cycle models.

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 at 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 preference type i, who originates a loan d' and saves b' in liquid assets, will receive $q_d^0(b', y, h, d', i)\, d'$ units of consumption goods when they originate a loan. The loan-specific mortgage price q_d^0 compensates the lender for origination costs, as well as for the risk of the borrower defaulting, selling, refinancing, or retiring. For tractability, the mortgage pricing 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.[8] In particular, each period households must make a payment m towards their mortgage that is greater than or equal to the minimum payment $\overline{m}(h,d)$ so that the level of debt evolves as

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

Here, r_d is the interest rate on borrowing, which is strictly greater than the risk-free rate to capture 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

[8] 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.

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.

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. Homeowners, by contrast, receive a constant stream of housing services from their house h. Homeowners face proportional goods costs $\kappa_b h$ and $\kappa_s h$ when buying or selling a house, respectively. These costs represent fees charged by real estate brokers at the time of sale.[9] 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 H at the beginning of the period and incur proportional maintenance costs $\delta_h H$. They convert housing capital to housing services at rate μ and sell the housing services to renters at rate r_h.[10] Then, at the end of the period, they sell their housing capital back to the market. Therefore, the static problem of a rental housing firm is

$$\max_{H} \; r_h \mu H + H - (1 + r_d + \delta_h) H$$

[9] 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.

[10] The imperfect conversion of housing capital into housing services for renters reflects imperfect substitutability between rental and owner-occupied housing. As noted in Garriga and Hedlund (2020), 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

$$r_h = \frac{r_d + \delta_h}{\mu}.$$

Equivalently, the price of renting can be interpreted as a markup on the household taking out an interest-only loan equal to the full value of the home.[11]

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 between
   (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 housing services.

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

[11] 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

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

where B is the replacement rate for labor income in retirement.[12] 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.[13] 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

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

subject to

$$(1+\tau_c)c + (r_d+\delta_h)h \leq Y_R(b,y,h,d)$$

2.4.2 Renters' Problems

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

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

subject to their budget constraint,

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

[12] 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.

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

as well as non-negativity constraints on their choices: $c, h, b' \geq 0$.[14] 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

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

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

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

$V_{orig}(b,y,h,d,i)$ 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 b' to solve their problem:

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

subject to

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

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

[14]Uncollateralized short-term debt is not explicitly modeled in this paper. As described in section 4, 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.

continuation value for a renter with bad credit is computed as

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

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,

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

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:

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

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

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

π_1 is the probability of repossession and getting flagged for bad credit, and ϑh 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 b', and their mortgage payment m to solve their problem:

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

subject to

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

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

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

where $x = (b,y,d,h,i)$ and $x' = (b',y',h,d',i)$. 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.[15] 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 option value is zero. Therefore, $P^0_{sell}(x)$ is given by

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

and $b_{sell} \equiv b + (1-\kappa_s)h - d$ 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 b', and the size of their new loan d' to solve their problem:

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

[15] 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.

subject to

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

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

where $x=(b,y,d,h,i)$ and $x'=(b',y',h,d',i)$. 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_d^0, 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 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 future fluctuations in home values and depreciation risk.[16] 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.

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 b' to solve their problem:

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

subject to

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

where $x=(b,y,d,h,i)$ and $x'=(b',y',h,d,i)$. 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.

[16] 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.

2.4.4 Homeowners with Bad Credit

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

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

subject to

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

where $x = (b, y, h, i)$ and $x' = (b', y', h, i)$. The continuation value of an owner with bad credit is given by

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

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

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

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:

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

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 $x = (b, y, h, d, i)$, which is given by

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

This is defined so that the lender receives 1) $\min\{\vartheta h, d\}$ 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.[17]

3 Housing According to HANK

This section describes a model where housing is modeled similar to the heterogeneous agent New Keynesian (HANK) literature. In the model, households hold two types of assets: a liquid asset b and an illiquid asset a. Instead of explicitly modelling housing finance frictions, housing wealth is represented only by illiquid assets. Households can adjust their level of liquid assets freely every period, but must pay an adjustment cost to change their stock of illiquid assets. As in the model with housing finance frictions, there are two preference types, $i \in \{1, 2\}$. Housing services come from either renting housing at unit price or from illiquid assets, which provide θa units of housing services per period. At the beginning of the period, households choose whether to adjust their portfolio or not by paying the associated adjustment costs. Their value is given by the maximum of the values of not adjusting, $\overline{V}(\cdot)$, and adjusting, $\widetilde{V}(\cdot)$:

$$V(a, b, y, i) = \max\left\{\overline{V}(a, b, y, i), \widetilde{V}(a, b, y, i)\right\}$$

[17] Under this formulation, the price of a new loan depends explicitly on the preference type of each household. Although it is unrealistic to assume a lender can observe a household's preferences directly, this stands in for the various financial and credit information acquired during the loan underwriting process. Moreover, since this economy features no price or depreciation risk in housing, default risk at the time of loan origination is generally very low, and heterogeneous mortgage pricing has virtually no effect on the quantitative implications of the model compared to simply setting the price to be $\frac{1}{(1+r_d)(1+\kappa_d)}$ for all states.

The value for a household not adjusting their portfolio, $\overline{V}(\cdot)$, is given by

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

subject to their budget constraint,

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

where $x = (a, b, y, i)$ and $x' = (a', (1+r_b)b, y', i)$. The continuation value of households 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 $V_R(\cdot)$ is the value of retirement, which is given by

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

subject to

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

As before, retired households will make identical choices each period and save nothing since there are no fluctuations in income after retirement. Alternatively, the value of a household being able to adjust their level of illiquid assets, $\widetilde{V}(\cdot)$, is given by

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

subject to their budget constraint,

$$(1+\tau_c)c + h + \frac{b'}{1+r} + a' = b + (1+r_a)a + (1-\tau_{ss})y - T(y) - \kappa_0 - \kappa_1 \left| \frac{d}{a} \right|^{\kappa_2} a,$$

where $x = (a, b, y, i)$, $x' = (a', b', y', i)$, and $d \equiv a' - (1+r_a)a$ is the amount the household deposits into illiquid assets. Here, the adjustment cost is the sum of a fixed component κ_0 and a component that changes with the size of the deposit in illiquid assets. The first component resembles the adjustment costs used in Kaplan and Violante (2014) while the second component is similar to the costs used in Kaplan, Moll and Violante (2018). This paper allows for both types of adjustment costs and the parameters are included in the estimation of the model.

4 Parameterization

This section explains the parameterization of the two models. 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.

4.1 Income Process

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

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

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

The transitory shock represents both measurement error and insurable income shocks that affect income but not consumption. The variance of consumption in both models is consistent with transitory shocks being insurable since the ratios of the variances of log consumption and log income are found to be about ten percent larger than in the data, even though there are no uninsurable transitory shocks to income. Allowing for uninsurable transitory shocks in the model 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 most households are able to insure well against transitory income shocks.

Values are computed for the persistence parameter ρ and the variances v_ω and v_ε to match three moments: the ratio of the 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 data from the 2019 Survey of Consumer Finances (SCF),[18] while the moments of income growth come from the Panel Study of Income Dynamics (PSID) for the years 1999

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

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

through 2009.[19] The estimated values for the income process are summarized in Table 1.

4.2 External Parameters

The schedule of minimum payments $\overline{m}$ is chosen so that it is consistent with the amortization of 80 percent of a 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.

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

This schedule has two desirable features: first, minimum payments are higher when households have less than 20 percent equity in their home reflecting mortgage insurance required in reality, and second, minimum 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.[20]

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. 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 δ_h is taken from Garriga and Hedlund (2020). The loan origination cost κ_d is set to 0.035 to reflect closing costs on

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

[20]This convention for minimum payments only works in this case because the price of housing is constant. Otherwise, the purchase price of the house would need to be stored as an additional individual state variable.

Table 2: Summary of External Parameters, Model with Mortgages

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	2.8	Proportional Homeownership Cost (Annual $\times 100$)
κ_d	3.5	Loan Origination Cost ($\times 100$)
κ_b	2.5	Proportional Cost of Buying a House ($\times 100$)
κ_s	5.0	Proportional Cost of Selling a House ($\times 100$)
ϑ	0.8	Value of House to Lender after Foreclosure
τ_c	7.0	Consumption Tax ($\times 100$)
τ_{y0}	15.0	Income Tax Level ($\times 100$)
τ_{y1}	15.1	Income Tax Progressivity ($\times 100$)
τ_{ss}	7.65	Social Security Tax ($\times 100$)

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 $T(y) = y - (1 - \tau_{y0})y^{1-\tau_{y1}}$. The parameter for the tax level τ_{y0} is set equal to 0.15 so that the median household pays 15 percent of their income in taxes and the value of the progressivity parameter τ_{y1} is borrowed from Heathcote, Storesletten and Violante (2014).

4.3 Estimation

The model with housing finance frictions (HFF model) and the model with adjustment costs under the heterogeneous agent New Keynesian convention (HANK model) are each 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.

Table 3: Estimated Parameters

Variable	HFF	HANK	Description
β_1	0.986	0.978	Discount Factor, Preference Type $i = 1$
β_2	0.974	0.977	Discount Factor, Preference Type $i = 2$
$\frac{1}{1-\sigma_1}$	0.762	0.860	Intertemporal Elasticity of Substitution (IES), $i = 1$
p_1	0.446	0.710	Population Share of IES, $i = 1$
ψ	0.726	-	Utility Share, Non-housing Consumption
η	0.122	-	Consumption Intratemporal Elasticity of Substitution
$1/\mu$	1.317	-	Markup on Rental Housing
χ	1.069	-	Disutility from Originating a Loan, Level ($\times 100$)
ν	8.110	-	Disutility from Originating a Loan, Curvature
κ_0	-	4.418	Fixed Portfolio Adjustment Cost ($\times 100$)
κ_1	-	4.238	Proportional Portfolio Adjustment Cost, Level ($\times 100$)
κ_2	-	1.056	Proportional Portfolio Adjustment Cost, Curvature
r_a	-	2.450	Return on Illiquid Assets (Annual $\times 100$)

The models are solved using 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) into a nine state Markov chain. The set of possible house sizes in the HFF model is made to be a discrete equidistant grid ranging from \$50,000 to \$800,000 (in 2019 US Dollars) with a step length of \$50,000, which includes 16 house sizes. The endpoints of the house size grid are chosen because they represent the 5th and 95th percentiles of self-reported home values in the 2019 SCF. A two dimensional golden-section search algorithm is applied to solve for optimal combinations of asset choices in a continuous space.[21] Then, models are simulated using continuous values for income, where choice and value functions are approximated by linear interpolation.

Nine parameters are estimated for the HFF model and eight parameters are estimated for the HANK model.[22] Table 3 summarizes the estimated parameters and their values, while Table 4 summarizes the targeted moments for each model. The utility function in the HFF model is specified as a CES aggregate of non-housing consumption and housing services,

$$u^{HFF}(c,h) = (\psi c^{\eta} + (1-\psi)h^{\eta})^{1/\eta}$$

while utility in the HANK model is assumed to be Cobb-Douglas, as in Kaplan and Violante

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

[22] The estimation of the HFF model is over-identified, using 13 moments for 9 parameters, while the estimation of the HANK model is exactly identified, using 8 moments for 8 parameters.

Table 4: Summary of Targeted Moments and Model Fit

Data*	HFF	HANK	Moment
0.04	0.30	0.10	Ratio P25 Net Worth to Median Annual Income**
0.79	0.83	0.79	Ratio Median Net Worth to Median Annual Income
2.39	2.59	2.49	Ratio P75 Net Worth to Median Annual Income
5.54	5.82	5.58	Ratio P90 Net Worth to Median Annual Income
0.59	0.57	0.58	Share Households Wealth Constrained***
0.58	0.62	0.59	Share Hand-to-Mouth, Wealth Constrained
0.27	0.35	0.28	Share Hand-to-Mouth, Not Wealth Constrained
1.37	1.61	1.27	Mean Housing Equity to Income Ratio ($(h-d)/\bar{y}$)
3.84	3.74	-	Mean House Value to Income Ratio ($h/\bar{y}$)
0.64	0.67	-	Homeownership Rate
0.53	0.52	-	Share Owners with Loan-to-Value Ratio over 0.5
0.23	0.30	-	Share Owners with Loan-to-Value Ratio over 0.75
0.08	0.04	-	Share Owners with Loan-to-Value Ratio over 0.9

* Estimation data comes from the 2019 Survey of Consumer Finances.
** Net worth is computed as the sum of assets and housing equity: $\bar{w} = b + h - d$. Annual income is income received in the previous four quarters: $\bar{y} = \sum_{s=t-3}^{t} y_s$.
*** Households are wealth constrained if their net worth is less than their annual income ($\bar{w} < \bar{y}$). Households are hand-to-mouth if their liquid assets are less than 1/24 of annual income, corresponding to approximately two weeks of income: $b < \bar{y}/24$.

(2014),

$$u^{HANK}(c, h + \theta a) = c^{\psi}(h + \theta a)^{1-\psi}.$$

The utility parameters for the HFF model are included in the estimation, while the utility parameters for the HANK model are borrowed from Kaplan and Violante (2014): $\psi = 0.85$ and $\theta = 0.01$. In both models, the inter-temporal elasticity of substitution (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): $p_1\left(\frac{1}{1-\sigma_1}\right) + (1 - p_1)\left(\frac{1}{1-\sigma_2}\right) = 1.5$.

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 housing equity, where housing equity is the self-reported value of a household's home minus their outstanding mortgage debt. The moments chosen for the estimation are chosen because they ensure that the distributions of total net worth, housing wealth, liquidity, and debt are consistent with the data. In particular, 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 as households who hold less than two weeks of income in liquid assets.[23] 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 parameters governing heterogeneous preferences are most important in matching these moments.

5 Quantitative Analysis

The following sections summarize the predictions of each model on how households respond to receiving transfers of various sizes. First, estimates of marginal propensities to consume (MPCs) from the model with housing finance frictions (HFF model) are summarized. Then, the relationship between debt and MPC in the HFF model is explored. Finally, the policy implications of the HFF model are compared with those of the alternate model (HANK model) where housing is represented by a single illiquid asset, as in the heterogeneous agent New Keynesian literature.

5.1 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 $b + tr$ 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,

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

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

Table 5 summarizes how the average MPC in the HFF model changes with the size of a transfer.[24] The overall average MPC is consistent with empirical estimates found by Johnson, Parker and Souleles (2006) and Parker, Souleles, Johnson and McClelland (2013)

[23] 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.

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

Table 5: MPC Statistics by Transfer Size and Ownership Status, HFF Model

		Transfer Size				
		\$100	\$500	\$1000	\$2000	\$5000
All Households	Mean	0.27	0.22	0.20	0.18	0.16
	Median	0.12	0.11	0.11	0.10	0.08
	P90	0.75	0.60	0.59	0.51	0.43
Homeowners	Mean	0.24	0.21	0.19	0.17	0.15
	Median	0.03	0.03	0.04	0.04	0.03
	P90	0.83	0.70	0.61	0.49	0.43
Renters	Mean	0.33	0.26	0.23	0.21	0.17
	Median	0.45	0.36	0.29	0.22	0.16
	P90	0.60	0.57	0.57	0.55	0.47

for non-durable consumption responses to the 2001 and 2008 tax rebates. The average MPCs for both homeowners and renters predictably decrease with transfer size, with the average MPC for renters falling faster than for homeowners.[25] It can be seen that MPCs are highly concentrated, with half of households having MPCs around 0.1 or less and half of homeowners having MPCs 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 B 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 about half the spending increase comes from 15% of households. More detailed summaries of the distribution of MPCs are available in Appendix A.

5.2 Relationship Between Debt and MPC

Table 6 reports how MPC varies in the HFF model 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 without any mortgage debt spend only 2 percent of a \$500 transfer. Meanwhile, homeowners that hold any level of mortgage debt spend an average of 27 percent, similar to the 26 percent

[25] 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.

Table 6: MPC of Homeowners by Debt Holdings ($500 Transfer), HFF Model

LTV Ratio ($L \equiv d/h$)	Mean MPC	DTI Ratio ($D \equiv d/y$)	Mean MPC
No Debt ($L = 0.0$)	0.02	-	-
Positive Debt ($L > 0.0$)	0.27	-	-
$0.0 < L \leq 0.25$	0.04	$0 < D \leq 2$	0.04
$0.25 < L \leq 0.5$	0.13	$2 < D \leq 6$	0.20
$0.5 < L \leq 0.75$	0.32	$6 < D \leq 12$	0.36
$L > 0.75$	0.38	$D > 12$	0.36

spent by renters. 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 ten times larger than homeowners with LTVs between zero and 0.25.

Table 7 reports how MPC varies with household income. Unlike debt, MPC does not change monotonically with income on average. The households in the bottom 20 percent and the top 40 percent of the income distribution have the highest average MPCs. Meanwhile, the median household in the bottom quintile has a far greater MPC than those in the top half of the income distribution. By looking at the 90th percentile of MPC by quintile of income, it can be seen that the high average MPC of upper income households is generated by a minority of households with especially large MPCs. Furthermore, the households in the top half of the income distribution are much more likely to be homeowners. Table 8 shows how households' level of debt changes on average with their MPC. It can be seen that the households with the largest MPCs are predominately homeowners with relatively large levels of debt. These homeowners with high MPCs generate the large average MPCs for middle to high income households shown in Table 7. 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 on income will decrease the aggregate spending response to a transfer since it will exclude many highly responsive homeowners with debt.

5.3 Comparison Between HFF and HANK Models of Housing

Table 9 summarizes the average MPCs generated in both the HFF model and the conventional HANK models. Overall, both models predict similar levels of average MPC

Table 7: MPC by Income Quintile ($500 Transfer), HFF Model

	Income Quintile (y), All Households				
	< 20	$20 - 40$	$40 - 60$	$60 - 80$	> 80
Mean MPC	0.23	0.19	0.19	0.24	0.27
Median MPC	0.35	0.08	0.05	0.07	0.07
P90 MPC	0.39	0.52	0.56	0.75	0.78
Share Owners	0.43	0.61	0.73	0.77	0.80

Table 8: Debt Holdings by MPC ($500 Transfer), HFF Model

	Range of MPC, All Households				
	< 0.05	$0.05 - 0.2$	$0.2 - 0.4$	$0.4 - 0.6$	> 0.6
Mean LTV	0.19	0.27	0.24	0.41	0.73
Mean DTI	2.16	3.24	2.98	5.18	7.95
Share Owners	0.80	0.58	0.35	0.55	0.99

for transfers less than $1000. The HANK model predicts a faster decrease in average MPC as the size of transfers increases. In both models, MPCs are highly concentrated, with the median usually being less than half the average level.

However, the two models have very different predictions on how MPC varies with income. Table 10 summarizes average MPCs within different quintiles of the income distribution. The three quintiles of income with the largest levels of MPC are bolded for each model. The HANK model predicts that the households with the highest MPC are all in the bottom half of the income distribution. This is consistent with MPCs in the HANK model being driven mainly by the ability of households to afford portfolio adjustment costs. Higher income households respond less to additional income because they can more easily afford to adjust their asset holdings. Meanwhile, as previously shown in Table 7, the highest MPC households in the HFF model are on average in the top half of the income distribution. This pattern is driven by homeowners with high levels of debt who have large constraints on their spending from the large associated minimum payments. To highlight this point, an alternate version of the HFF model is solved where minimum mortgage payments are set to zero for all households ($\overline{m}(\cdot) = 0$).[26] The results of this model are reported in the last

[26] The parameters of the alternative HFF model without minimum payments are not re-estimated. Even so, the model still fits well the targeted moments used to estimate the HANK model. The simulated moments of the alternative HFF model are reported in Appendix C.

Table 9: MPC by Transfer Size and Model

		Transfer Size				
Model		\$100	\$500	\$1000	\$2000	\$5000
HANK	Mean	0.26	0.19	0.16	0.13	0.10
	Median	0.07	0.07	0.06	0.06	0.05
	P90	0.79	0.55	0.43	0.32	0.23
HFF	Mean	0.27	0.22	0.20	0.18	0.16
	Median	0.12	0.11	0.11	0.10	0.08
	P90	0.75	0.60	0.59	0.51	0.43

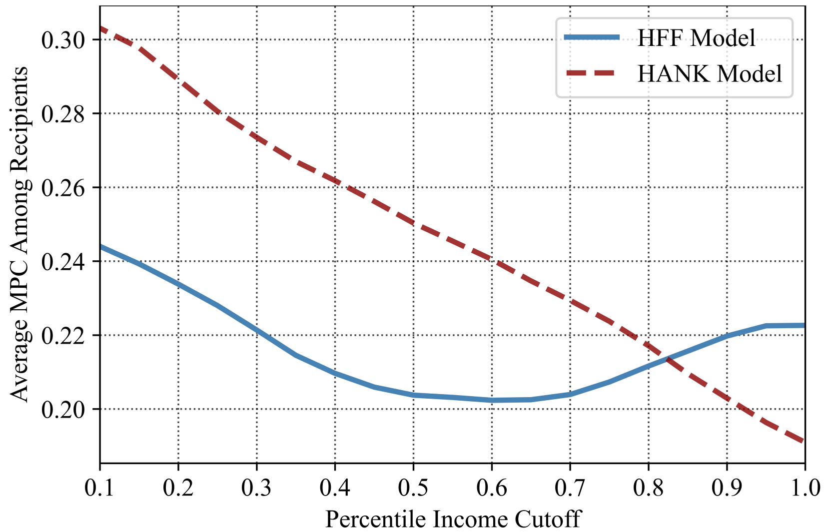
line of Table 10. It can be seen that MPCs in the HFF model without minimum payments decrease in income on average, just as in the conventional HANK model.

Table 10: Average MPC by Income Quintile (Relative to Total), \$500 Transfer

	Range of Income Percentile				
Model	< 20	$20-40$	$40-60$	$60-80$	> 80
HANK	**1.51**	**1.23**	**1.04**	0.77	0.45
HFF	**1.05**	0.83	0.84	**1.08**	**1.20**
HFF ($\overline{m}=0$)	**1.71**	**1.00**	**1.01**	0.68	0.59

The differing relationships between income and MPC in the HFF and HANK models suggests very different policy implications. Figure 1 shows the predictions of each model for average MPC when restricting transfers based on income. The solid blue line plots the average MPC—among recipients of the transfer—predicted by the HFF model 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 HANK model.

Figure 1: Average MPC by Share of Households Given $500 Transfer



This figure demonstrates how not including mortgages in household balance sheets can lead to very different policy implications. For example, the HANK model predicts giving a $500 transfer to only households in the bottom 60 percent of income would *increase* spending per transfer by about 25 percent relative to a universal transfer. Meanwhile, the HFF model predicts spending per transfer would *decrease* by about 10 percent for the same policy by excluding many homeowners who would be relatively 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 over ten 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 certain 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 conventional consumption-savings models that do not explicitly model mortgage debt. This suggests that not taking mortgages into account when modeling consumer spending may lead to inaccurate 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 framework described in this paper could be modified to study these other macroeconomic policies.

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Appendix

A Distribution of MPCs by Transfer Size

Tables 11 through 12 report how the distribution of MPCs changes with the transfer size.

Table 11: Distribution of Marginal Propensity to Consume, All Households

Transfer Size	Mean	P10	P25	P50	P75	P90
$100	0.27	−0.01	0.01	0.12	0.60	0.75
$500	0.22	0.00	0.01	0.11	0.40	0.60
$1000	0.20	0.00	0.01	0.11	0.36	0.59
$2000	0.18	0.00	0.01	0.10	0.35	0.51
$5000	0.16	0.00	0.01	0.08	0.33	0.43

Table 12: Distribution of Marginal Propensity to Consume, Homeowners

Transfer Size	Mean	P10	P25	P50	P75	P90
$100	0.24	−0.01	0.01	0.03	0.54	0.83
$500	0.21	0.00	0.01	0.03	0.43	0.70
$1000	0.19	0.00	0.01	0.04	0.37	0.61
$2000	0.17	0.01	0.01	0.04	0.37	0.49
$5000	0.15	0.01	0.01	0.03	0.35	0.43

Table 13: Distribution of Marginal Propensity to Consume, Renters

Transfer Size	Mean	P10	P25	P50	P75	P90
$100	0.33	−0.02	0.03	0.45	0.60	0.60
$500	0.26	−0.02	0.04	0.36	0.39	0.57
$1000	0.23	−0.02	0.04	0.29	0.30	0.57
$2000	0.21	−0.02	0.03	0.22	0.27	0.55
$5000	0.17	−0.01	0.03	0.16	0.27	0.47

B Concentration of Spending Responses

Tables 14 through 16 report 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, and the concentration remains similar across transfer sizes.

Table 14: Contribution to Total Response by Percentile of MPC, All Households

	Share Contributed by Top Percentile of MPC				
Transfer Size	Top 50	Top 25	Top 15	Top 10	Top 5
$100	1.04	0.68	0.45	0.33	0.17
$500	1.03	0.69	0.48	0.35	0.20
$1000	1.02	0.70	0.48	0.35	0.20
$2000	1.01	0.69	0.47	0.34	0.19
$5000	0.99	0.69	0.46	0.33	0.18

Table 15: Contribution to Total Response by Percentile of MPC, Homeowners

	Share Contributed by Top Percentile of MPC				
Transfer Size	Top 50	Top 25	Top 15	Top 10	Top 5
$100	1.07	0.82	0.55	0.38	0.20
$500	1.05	0.80	0.56	0.40	0.22
$1000	1.04	0.78	0.54	0.40	0.22
$2000	1.03	0.74	0.50	0.36	0.21
$5000	1.01	0.72	0.47	0.33	0.18

Table 16: Contribution to Total Response by Percentile of MPC, Renters

	Share Contributed by Top Percentile of MPC				
Transfer Size	Top 50	Top 25	Top 15	Top 10	Top 5
$100	0.89	0.46	0.27	0.18	0.09
$500	0.89	0.52	0.35	0.24	0.12
$1000	0.89	0.57	0.39	0.27	0.14
$2000	0.89	0.61	0.42	0.30	0.16
$5000	0.88	0.62	0.44	0.32	0.17

C Fit of HFF Model without Minimum Payments

Table 17 reports the fit of the HFF model without minimum payments. All parameters are unchanged from the original HFF model.

Table 17: Summary of Targeted Moments and Model Fit

Data*	HFF	$\overline{m}=0$	HANK	Moment
0.04	0.30	0.13	0.10	Ratio P25 Net Worth to Median Annual Income**
0.79	0.83	0.56	0.79	Ratio Median Net Worth to Median Annual Income
2.39	2.59	2.45	2.48	Ratio P75 Net Worth to Median Annual Income
5.54	5.82	5.95	5.59	Ratio P90 Net Worth to Median Annual Income
0.59	0.57	0.64	0.59	Share Households Wealth Constrained***
0.58	0.62	0.62	0.59	Share Hand-to-Mouth, Wealth Constrained
0.27	0.35	0.21	0.28	Share Hand-to-Mouth, Not Wealth Constrained
1.37	1.61	1.51	1.27	Mean Housing Equity to Income Ratio $((h-d)/\bar{y})$

* Estimation data comes from the 2019 Survey of Consumer Finances.
** Net worth is computed as the sum of assets and housing equity: $A = a + p_h h - d$. Annual income is income received in the previous four quarters: $\bar{y} = \sum_{s=t-3}^{t} y_s$.
*** Households are wealth constrained if their net worth is less than their annual income ($A < \bar{y}$). Households are hand-to-mouth if their liquid assets are less than 1/24 of annual income, corresponding to approximately two weeks of income: $a < \bar{y}/24$.