

Heterogeneous Spillovers of Housing Credit Policy *

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Abstract

We study the spillovers from government intervention in the mortgage market on households' consumption. After an expansionary mortgage market operation, the consumption response of homeowners with mortgage debt is large and significant, while the consumption response of homeowners without the mortgage debt is small and insignificant. Non-homeowners also increase their consumption but less than mortgagors. We also find that expansionary policy significantly increases consumption inequality of mortgagors. We explain these facts through the lens of a life-cycle model with incomplete markets and endogenous housing choice. Reduction in credit rates creates extra wealth for the mortgagors while reduction in interest rates shifts this wealth towards consumption. Increase in wealth is bigger for those with larger mortgage- this exacerbates consumption inequality.

JEL classification: E21, E44, R38, G28

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1 Introduction

Activity in secondary mortgage markets boosts mortgage lending, lowers mortgage rates and influences prices on other financial markets ([Fieldhouse, Mertens and Ravn, 2018](#)). In this paper we study how this activity affects the largest component of GDP, household consumption. We show that households' financial position is crucial in understanding the spillovers from the activity in secondary mortgage markets to private consumption. We proxy households' financial position through housing tenure status. First, we show empirically, that following an expansionary policy change to the secondary mortgage markets, homeowners with mortgage debt increase their spending substantially, while homeowners without the mortgage debt do not react to policy change. Non-homeowners also increase their consumption but less than mortgagors. We also show that the same expansionary policy significantly increases consumption inequality of mortgagors. Second, in order to explain this empirical evidence, we present a life-cycle model with incomplete markets in the vein of [Huggett \(1996\)](#), which we extend to include endogenous housing choice. In our policy experiment, we change both interest and mortgage rates as well as the spread between the two. Lower mortgage rates imply lower mortgage payments for the mortgagors and hence a rise in long-term permanent income for this group. Lower interest rates imply that part of this extra income goes to consumption rather than saving. In the model, the wealth is a function of house size and thus the mortgage size. Lower mortgage payments generate a higher increase in wealth that in turn increases inequality among the mortgagors.

In our empirical exercise, we explore the link between expansionary credit policy changes and an increase in households' expenditure. In particular, we focus on credit policy changes through exogenous governmental intervention in the mortgage markets via various federal housing agencies, and mortgage assets purchases of these agencies. For the most part, credit policy changes are a reaction to business cycle conditions (the most recent QE3 being the prime example). In order to analyze the response of consumption to any of these policy changes, it is, therefore, important to isolate the non-cyclically motivated policy changes that are free of any confounding influences of the business cycle (such as long-term objectives of increasing the homeownership). We combine the exoge-

nous non-cyclically motivated events from [Fieldhouse and Mertens \(2017\)](#) with mortgage purchases of two largest federal housing agencies (Fannie Mae and Freddie Mac). We then use the former as an instrument in regressions of households' consumption on measures of agency purchase activity. We measure consumption using household-level data from the Consumer Expenditure Survey and the Survey of Consumer Finances. If credit market interventions were neutral ([Meltzer, 1974](#); [Greenspan, 2005](#); [Lehnert, Passmore and Sherlund, 2008](#)) an increase in agency purchases should have little impact on private consumption. Instead, we find that expansionary credit policy leads to an increase in private consumption of mortgagors and an increase in consumption inequality for this group.

In our theoretical exercise, we use a structural model to identify the transmission mechanism we found in our reduced-form analysis. We model the credit policy change experiment by replicating the aggregate macroeconomic effect of mortgage market interventions documented in [Fieldhouse, Mertens and Ravn \(2018\)](#). In particular, we focus on change in both interest and mortgage rates as well as on change in the spread between the two. Our first finding is that lower mortgage rates imply lower mortgage payments for the mortgagors and a rise in long-term permanent income for this group. Since the opportunity cost of saving goes down when the interest rates drop - mortgagors consume this extra income instead of saving. The results we find are in line with [Cloyne, Ferreira and Surico \(2018\)](#), who argue that the behavior of mortgagors resembles that of wealthy hand-to-mouth households and empirically document a similar response of individual consumption to expansionary monetary policy shock. Indeed, in the model, mortgagors hold little liquid wealth, outstanding mortgage debt and illiquid asset in the form of the house. We then analyze the response of other types of households: renters and outright homeowners. Similarly to mortgagors, renters' utility from consumption outweighs that of saving, and they consume more once the new credit policy is at hand. For outright homeowners, who are mostly older than renters and mortgagors, bequest motive outweighs that of dissaving one, and they barely increase consumption and save instead. Using the same policy experiment, we also reproduce the increase in consumption inequality. In the model, net wealth depends on assets and on mortgage outstanding (that is zero for both renters and outright homeowners). When the mortgage payments

go down, the overall mortgage balance decreases and thus we observe the increase in wealth. This increase is larger for the households with a bigger mortgage (and therefore bigger house), generating a heterogeneous response of consumption increase within the mortgagors' group.

Related Literature. In exploring the link between exogenous credit policy changes and individual consumption our paper adds to both empirical and theoretical literature on housing and mortgage markets. From the empirical side, we relate to four strands of literature. Firstly, we analyze the US federal government interventions into the mortgage markets. For the most part the literature focused on governments' intervention in terms of tax policies. Recent studies include [Chambers, Garriga and Schlagenhauf \(2009\)](#); [Hilber and Turner \(2014\)](#); [Floetotto, Kirker and Stroebel \(2016\)](#); [Sommer and Sullivan \(2018\)](#), among others. [Fieldhouse, Mertens and Ravn \(2018\)](#) is the most recent study that instead analyzes the interventions to the federal housing agencies, rather than any tax policies. In this paper, we use exogenously identified policy interventions from [Fieldhouse, Mertens and Ravn \(2018\)](#); unlike [Fieldhouse, Mertens and Ravn \(2018\)](#), however, we analyze the transmission mechanisms through which the policy operates using the US household survey data.

Secondly, this paper is related to literature that analyzes the interaction between federal housing agencies and other markets. The most recent studies include [Gonzalez-Rivera \(2001\)](#); [Naranjo and Toevs \(2002\)](#); [Lehnert, Passmore and Sherlund \(2008\)](#); [Hancock and Passmore \(2011, 2014\)](#) as well as [Fieldhouse, Mertens and Ravn \(2018\)](#). We focus specifically on the effect of mortgage purchases of governmental housing agencies on consumption of different types of households using a novel identification strategy.

Thirdly, our paper is related to the literature on the role of household balance sheet channels in the transmission of monetary and fiscal policy shocks. These include [Iacoviello \(2005\)](#); [Eggertsson and Krugman \(2012\)](#); [Luetticke \(2015\)](#); [Greenwald \(2016\)](#); [Hedlund et al. \(2016\)](#); [Cloyne, Ferreira and Surico \(2018\)](#); [Kaplan, Moll and Violante \(2017\)](#); [Auclert \(2017\)](#); [Bilbiie \(2017\)](#), to name a few. [Coibion et al. \(2017\)](#) also uses US household level data to study the effect of conventional monetary policy on income and consumption inequality. Like in [Cloyne, Ferreira and Surico \(2018\)](#), we use the households' housing

tenure status to proxy their asset and debt position.

Finally, this paper is related to literature that analyzes the effects of monetary policy shocks on inequality. [Coibion et al. \(2017\)](#) uses US household level data to study the effect of conventional monetary policy on income and consumption inequality. We follow [Coibion et al. \(2017\)](#) methodology to construct the measure of expenditure inequality between all types of households as well as within each housing tenure group. Unlike [Coibion et al. \(2017\)](#) we focus on the effect of credit policy shocks on expenditure inequality.

From the theoretical side, our model resembles the recent literature that extends [Huggett \(1996\)](#) model to incorporate housing decision and aggregate housing and mortgage markets. To name a few, we build on the models of [Kaplan, Mitman and Violante \(2018\)](#); [Favilukis, Ludvigson and Van Nieuwerburgh \(2017\)](#); [Sommer and Sullivan \(2018\)](#), that analyze heterogeneous agents life-cycle economies with uninsurable income risk in which households make a housing and mortgage choice. Unlike these papers, however, we do not focus on the aggregate implications of different macroeconomic shocks but rather analyze the individual households' behavior.

Structure of the Paper. The rest of the paper is structured as follows. Section 2 sets out the empirical model and presents the impulse response analysis. Section 3 develops a [Huggett \(1996\)](#) type of life-cycle economy with endogenous housing choice and uninsurable idiosyncratic risk. Section 4 calibrates the model and describe the properties of the baseline economy. Section 5 analyzes the effect of mortgage market intervention within the model framework and discusses transmission mechanisms. Finally, section 6 concludes.

2 Empirical Framework

2.1 Institutional Background and Identification of Exogenous Policy Changes

US mortgage market is the largest capital market in the world and is the dominant source of credit for American households. It finances key component of household wealth and

aggregate spending - housing. By the 3rd quarter of 2017, the total mortgage debt in the US was about \$8.7 trillion. In comparison, auto, credit card and student debt combined was about \$2.3 trillion.

The US mortgage market is also quite unique. The US federal government is heavily involved in the mortgage market (especially in terms of residential mortgage purchases) through various agencies: Government-Sponsored Enterprises (GSEs) and Government Agencies. We focus on the involvement of the government through the GSEs. In particular, we focus on two largest GSEs: Fannie Mae, funded in 1938 and publicly traded since 1968, and Freddie Mac, funded in 1970. GSEs were chartered by Congress to support secondary mortgage markets and are subject to favorable tax and regulatory treatment. These agencies acquire mortgages through advance commitments to buy loans from mortgage lenders which are delivered once the loans are originated in the primary market; they are not allowed to do any direct lending. Over time, the agencies played an increasingly active role in the residential mortgage markets. As Figure 1 indicates, in 2004 Fannie Mae and Freddie Mac held almost 20% of all mortgage debt.

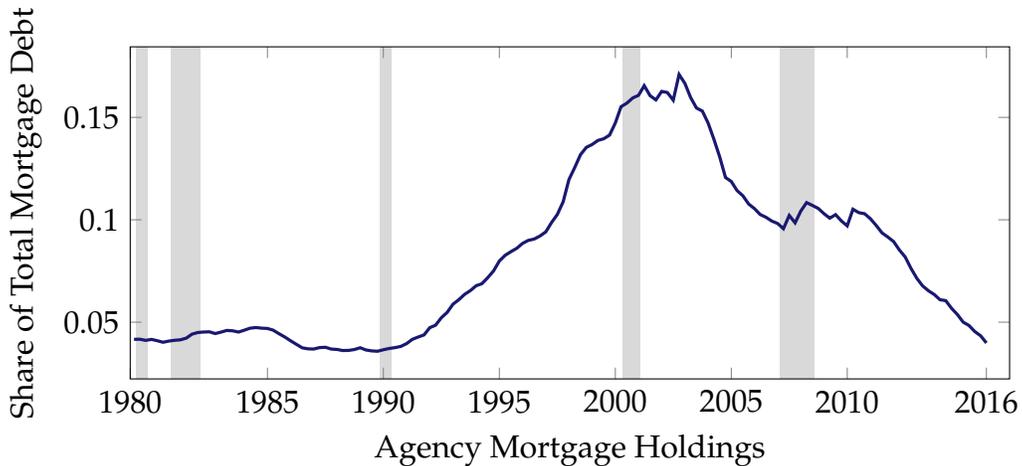


Figure 1: Agency mortgage holdings as a percent of total mortgage originations. Data is between 1980 and 2016. Grey areas represent NBER recessions.

In the empirical section of this paper we focus on the portfolio purchases of the housing agencies, shown in solid blue line in Figure 2, and how it affects expenditure of households with different debt position. Unfortunately, simply correlating measures of agency activity with households' expenditure ignores potential endogeneity problems.

On one hand, Fannie Mae and Freddie Mac respond to market conditions, and thus act pro-cyclically. On the other hand, Fannie Mae and Freddie Mac have a public mission to provide stability on the mortgage markets, and thus act counter-cyclically. Ignoring these potential problems makes the causal inference invalid.

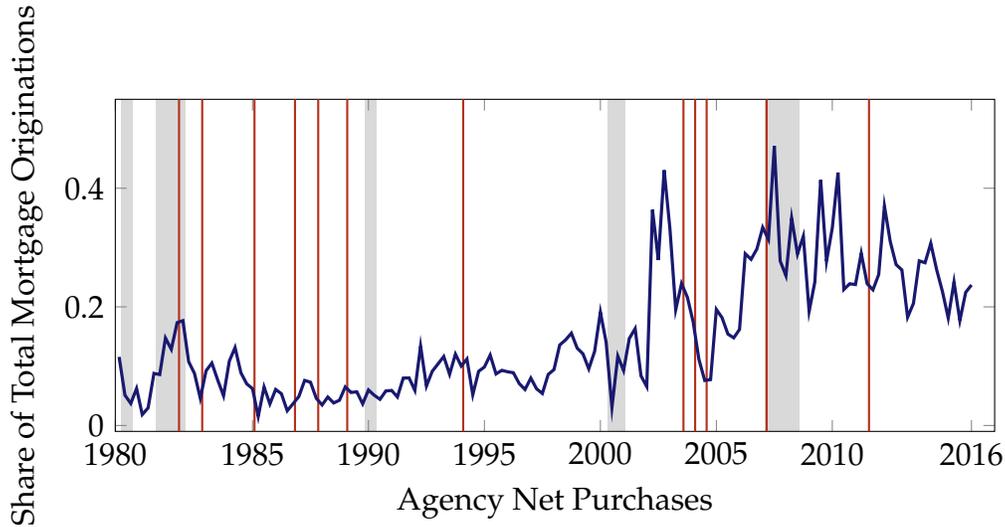


Figure 2: FNMA & FHLMC net purchase for portfolio investment. Data is between 1980 and 2016. Grey areas represent NBER recessions.

To account for the endogeneity in agency market activity we use narrative identification approach and use major regulatory policy events as an instrument for agency purchase activity. [Fieldhouse and Mertens \(2017\)](#) document significant policy changes that are expected to affect agency portfolios and isolate those events (which they call non-cyclical events) that are free of confounding influences in the spirit of [Romer and Romer \(2004\)](#) and [Ramey \(2011\)](#). These policy changes are indicated by vertical red lines in Figure 2. We quantify these changes as a percentage of the average annualized level of originations in the preceding year. As most of the policy interventions after 2006 were related to 2007/2008 financial crisis and were mostly cyclically motivated, we limit the analysis to pre-crisis sample.

2.2 Impulse Response Specification

To evaluate the effect of agency purchase activity on households' income and consumption we conduct an impulse response analysis of shock to agency mortgage purchase. We

use a local projections instrumental variable approach where we use the narrative instrument identified in the previous section for identification.

We start with assessing whether the narrative policy changes do lead to significant changes in net agency purchases. Our first-stage regression specification is of the form

$$\frac{\sum_{j=0}^h p_{t+j}}{X_t} = \tilde{a}_h + \tilde{c}_h \frac{\tilde{m}_t}{X_t} + \tilde{d}_h(L)Z_{t-1} + \tilde{u}_{t+h}, \quad (1)$$

where p_t is the agency's net purchase, X_t trend in real mortgage originations, \tilde{m}_t is non-cyclically motivated narrative measure in real dollars, and Z_t is a set of controls (defined below). $\tilde{d}_h(L)$ denotes the polynomial of order 4. We pick the value of horizon h for which out instrument is the strongest. For that, we run regression (1) for horizons $h = 1$ (one quarter) to $h = 20$ (five years) and pick h that maximizes the robust F-statistics on the excluded instrument for each h . The results indicate that the narrative measure is a strong instrument for agency purchasing activity for horizons between 1 and 3 quarters after the policy events, with robust F-test statistics exceeding 10. The F-statistics are low for longer horizons. Given these results we restrict the analysis to horizons between 1 and 3 quarters. Specifically, we focus on the agency purchase activity 2 quarters after the shock, as the robust F-statistic is the highest and equal to 15. Figure B.1 in Appendix B shows the robust F-statistics on the excluded instrument in each of the first-stage regressions (1) for horizons $h = 1$ (one quarter) to $h = 20$ (five years).

We now proceed to identifying the effect of agency purchase activity on variable of interest. Our goal is to identify the response to shocks to expectations of future agency purchasing activity. For a given outcome variable y_t , we estimate the response at horizon h using

$$\frac{y_{t+h} - y_{t-1}}{y_{t-1}} = a_h + b_h \left(\frac{4}{2} \times \frac{\sum_{j=0}^2 p_{t+j}}{X_t} \right) + d_h(L)Z_{t-1} + u_{t+h}, \quad (2)$$

where

$$\frac{4}{2} \times \frac{\sum_{j=0}^2 p_{t+j}}{X_t} \quad (3)$$

denotes annualized agency commitments made over a 2 quarter period expressed as a ratio of long-run trend in annualized originations X_t ; we choose an 2 quarter horizon to measure expected future purchases because at this horizon the robust F-statistic associated with the narrative instrument in the first-stage regression is the largest.

The regression in (2) estimates the quarter $h \geq 0$ response to a time 0 news shock to agency purchases. Expected agency purchases are proxied by agency net purchases made over the next half a year. To address endogeneity, we use the indicator of non-cyclical policy events, deflated by the core PCE price index and scaled by trend originations X_t , as the instrument. The IV estimates of b_h in (2) can be interpreted as the response associated with a percent increase in the agency net purchase that becomes anticipated h periods before.

The control variables Z_t include the lagged growth rates of the core PCE price index, a nominal house price index, and total mortgage debt, the log level of real mortgage originations, housing starts, and lags of several interest rate variables: the 3-month T-bill rate, the 10-year Treasury rate, the conventional mortgage interest rate, and the BAA-AAA corporate bond spread. They also include lags of agency net purchases and commitments as a ratio of X_t as well as the unemployment rate and the growth rate of real personal income. See Appendix A for a detailed description of the data sources and definitions.

2.3 Measuring Expenditure Data

We use households' expenditure on non-durable goods and services as a response variable y_t in equation (2). To construct our measure of expenditure we use the interview section of the Consumer Expenditure Survey (CEX) between 1980 and 2007.¹ We define *non-durable goods and services* as food, alcohol, tobacco, fuel, light and power, clothing and footwear, personal goods and services, fares, leisure services, household services, non-durable household goods, motoring expenditure and leisure goods. We adjust the food at home between 1982 and 1987 following [Aguiar and Bils \(2015\)](#). We also define households' income as a amount of income before tax in the past 12 months. After 2005, BLS started imputing missing income observations. Before 2004 we impute missing income observations as in [Coibion et al. \(2017\)](#). We exclude households that are in either top 1% or bottom 1% of either the non-durable expenditure or income level. We also exclude the households who report zero food expenditure. Finally, we exclude households who's household head is below 25 and over 74 years old. We also keep the households that do

¹Data between 1980 and 1995 is obtained from ICPSR through UK Data Service. Post-1995 data is publicly available at the Bureau of Labor Statistics (BLS) website.

not change the housing tenure status between the interviews.

2.4 The Effect of Agency Purchases on Expenditure: Pseudo-Cohort Analysis

In this section we document the response of households' expenditure to news shock to agency purchases, proxied by agency net purchases made over next half a year.

As documented by [Fieldhouse, Mertens and Ravn \(2018\)](#), an increase in mortgage purchases by the agencies boosts mortgage lending and lowers mortgage rates. It is, therefore, important to distinguish between those households who own the house with a mortgage and those without. Agency purchases also influence house prices and expand homeownership, therefore the effect on those households who own the house and those who do not might be different. The CEX survey, on top of containing rich income and expenditure data, contains information on housing tenure status. We utilize this information and group the households into three categories based on their tenure status in the spirit of [Cloyne, Ferreira and Surico \(2018\)](#). The categories are *renters*, *mortgagors* and *outright owners*. Unfortunately, given the rotating panel nature of the CEX survey it is not possible to follow individual households for more than four quarters over which they are observed. We, therefore, employ a grouping estimator to aggregate individual observations into pseudo-cohorts by housing tenure as in [Browning, Deaton and Irish \(1985\)](#).

We then look at the response of households' expenditure, based on their housing tenure status, to a 1% increase in net purchase by the agencies, anticipated 2 quarters in advance, under the specification in (2) using non-cyclically motivated narrative measure as an instrument. Figure 3 plots the coefficients b_h from equation (2) over the horizon $h = 1$ (one quarter) to $h = 8$ (two years) along with 90% and 95% confidence intervals. We see from the figure, that after a news shock to agency net purchases the only group that significantly increases their expenditure are the mortgagors, for horizon between three and seven quarters, while the change in expenditure for renters and owners is insignificant for all horizons. Moreover, a year after the shock we document a clear ranking of the responses: mortgagors react the most (about 0.03 basis points), followed by renters (about 0.015 basis points), and finally homeowners (close to zero).

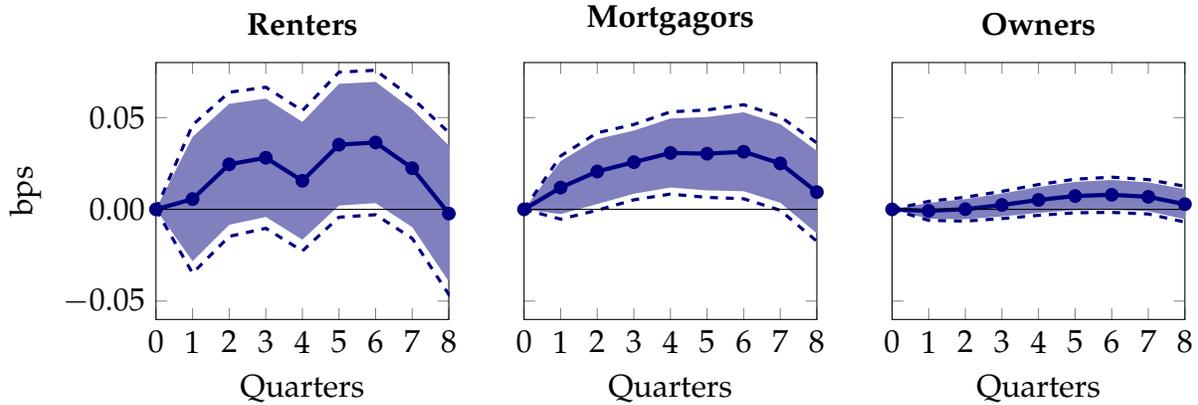


Figure 3: Impulse response of expenditure to an additional to a 1% increase in net purchase by FNMA & FHLMC, anticipated 2 quarters before. Blue areas and broken lines represent 90% and 95% confidence intervals, respectively.

2.5 Response of Expenditure Inequality

In Section 2 we documented the evidence that following a news shock to agency purchase activities there is a heterogeneous response between housing tenure groups. We now look at what happens with expenditure within each of the groups. For that we construct Gini coefficient of level of expenditure on non-durable goods and services in the spirit of Coibion et al. (2017). Our measure of inequality is raw, not controlling for any household characteristics like the number of household members, age, education, etc. The only control characteristic that we take is the housing tenure status.

Figure 4 plots the response of Gini coefficient (measured between 0 and 100) to a 1% increase in net purchase by agencies, anticipated 2 quarters before. Top left panel plots the response of Gini coefficient to a news shock for all the households in the data. We can see the positive and significant increase (at 90% significance level) in expenditure inequality one quarter after the shock by about quarter of percentage point. Expenditure inequality within renters group (top right panel) does not respond significantly. We can neither see a significant increase in expenditure inequality within the homeowners group (bottom right panel). With regards to expenditure inequality within the mortgagor group (bottom left panel), there is a positive and significant (both at 90% and 95% significance level) increase of inequality by almost half percentage point. This suggests that overall increase in expenditure inequality is mostly driven by increase within the mortgagors. In

the next section we will analyze what characteristics of households (depending on their income level and their housing tenure status) and of mortgagors in particular (depending on the length of their mortgage) drives the heterogeneous response of expenditure and expenditure inequality between the three groups of households.

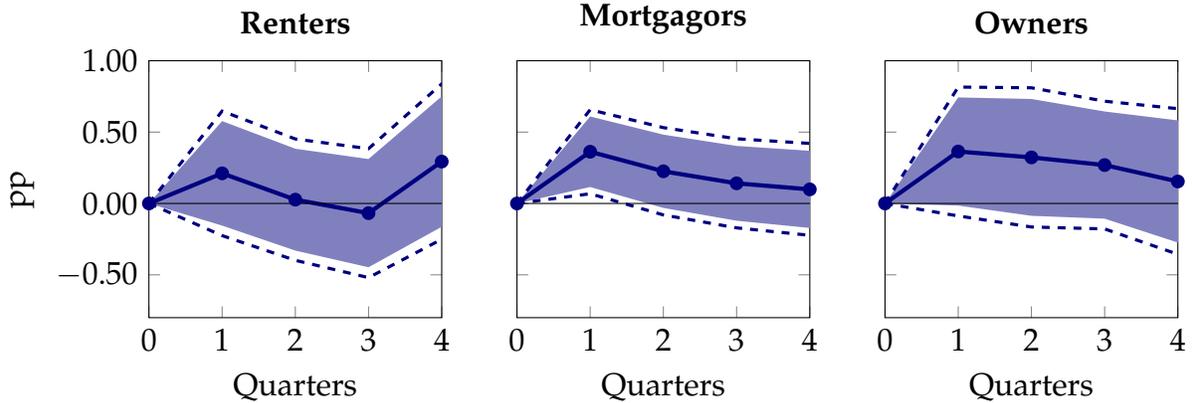


Figure 4: Impulse response of expenditure Gini to a 1% increase in net purchase by FNMA & FHLMC, anticipated 2 quarters before. Blue areas and broken lines represent 90% and 95% confidence intervals, respectively.

3 A Life-Cycle Model with Housing Markets

In the previous section we documented the causal effect of news shock to agency mortgage purchases. Unfortunately, with the data available it is not possible to exactly identify the transmission mechanism through which the effects work. To understand which channel is exactly responsible for increase in expenditure for mortgagors only, and increase in the inequality for that group, in this section we develop a [Huggett \(1996\)](#) type of heterogeneous agent life-cycle model with uninsurable risk, endogenous housing choice and aggregate mortgage market shocks. Through the lens of this model we explain the empirical evidence we found in the previous sections and analyze which channels contribute to the results indicated.

3.1 Demographics, Preferences and Labor Income

Demographics Time is discrete and economy is populated with continuum of finitely-lived households. Age is indexed by $j = 1, \dots, J$. Households work for first $J_r - 1$ periods and are retired until period J . Life span is certain and all households die after age J .

Preferences Expected lifetime utility of the households is given by

$$\mathbb{E}_0 \left[\sum_{j=1}^J \beta^{j-1} u(c_j, s_j) + \beta^J v(a_J) \right], \quad (4)$$

where c_j denotes the consumption of non-durable goods at age j and s_j denotes the consumption of housing services at time j , β is the discount factor and a_j is the bequest. The only source of uncertainty in the economy is the idiosyncratic income shock (described below). We assume that utility function u takes the following functional form

$$u(c, s) = \frac{[(1 - \phi)c^{1-\gamma} + \phi s^{1-\gamma}]^{\frac{1-\theta}{1-\gamma}} - 1}{1 - \theta} \quad (5)$$

while the bequest function v is given as

$$v(a) = \psi \frac{(a + \underline{a})^{1-\theta} - 1}{1 - \theta}, \quad (6)$$

where ϕ denotes taste for housing, $1/\gamma$ measures the elasticity of substitution between non-durable consumption and housing services, $1/\theta$ is the IES, ψ measures the strength of bequest motive while \underline{a} measures how luxurious is the bequest.

Labor Income Working-age households receive exogenous income y_j given by

$$y_j = \Theta \chi_j \exp(\epsilon_j), \quad (7)$$

where Θ is the aggregate labor productivity, χ_j is the deterministic age profile and ϵ_j is the idiosyncratic component that follows first-order Markov process. Government runs a pay as you go social security system. After retirement, households receive social security benefits

$$y_j = \rho_{ss} y_{J_r}, \quad j > J_r,$$

where ρ_{ss} is a replacement rate and y_{J_r} are their earnings in the last working period. Finally, let Y_j denote the age-dependent transition of earning from age j to age $j + 1$ conditional on income y_j .

3.2 Housing

Households can either rent or own the house. Houses are characterized by their size, which is given by a discrete set. Let $\tilde{\mathcal{H}}$ denote the set of houses available for rent, while \mathcal{H}

denotes the set of owner-occupied houses. We assume that the per-unit price of house is equal to p_h while the rental price of housing unit is denoted by ρ_h .

To distinguish house owners from house renters, we assume that housing generates service flow equal to the size of the house, i.e. $s = h$, where $h \in \tilde{\mathcal{H}}$, while owning a house generates an extra utility for the household, such that $s = \omega h$, where $\omega > 1$ and $h \in \mathcal{H}$.

Owner-occupied housing carries a per-period maintenance cost $\delta_h p_h h$ that fully offsets physical depreciation of the house, and tax cost $\tau_h p_h h$. There is a transaction cost equal to $\kappa_h p_h h$ associated with buying or selling the house. Changing the size of the rented house does not incur any transaction costs.

3.3 Assets, Mortgages and Market Arrangements

Liquid Assets Households can save in one-period bonds, a , with a exogenous interest rate given by r_a . Non-homeowners are not allowed any unsecured borrowing and their borrowing constraint is given by

$$a \geq 0 \tag{8}$$

Homeowners, on the other hand, have access to home equity line of credit (HELOC), that we model as a one-period non-defaultable bonds. They can borrow up to a fraction λ_a of the value of the house at the interest rate equal to r_a and their borrowing constraint is given by

$$a \geq -\lambda_a p_h h \tag{9}$$

In the baseline version of the model we set $\lambda_a = 0$, so that no borrowing is allowed for any type of households. Let q_a denote the price of bond, such that $q_a = 1/(r_a + 1)$

Mortgages House purchase can be financed by a mortgage. A household that takes out a new mortgage with principal balance m' receives from a lender $q_m m'$ units of the numeraire good. The mortgage price q_m is such that $q_m < 1$. In the benchmark setting of the model we assume that all mortgages are long-term, subject to interest rate r_m and have to be repaid over the remaining life of the borrower. We assume that mortgage rate r_m is given by

$$r_m = (1 + \iota)r_a, \tag{10}$$

where ι controls the spread between r_a and r_m . Down-payment for a borrower who takes out a mortgage of size m' to buy a house of size h' is

$$p_h h' - q_m m' \quad (11)$$

Mortgage origination is also subject to a fixed origination cost κ_m . When taking out a mortgage, households have to satisfy two constraints. The first one is the maximum loan-to-value constraint: the initial mortgage size must be less than a fraction λ_m of the value of the house being purchased

$$m' \leq \lambda_m p_h h' \quad (12)$$

The second constraint is the maximum payment-to-income constraint: the first minimum mortgage payment must be less than a fraction λ_π of the income at time of purchase

$$\pi_j^{min}(m') \leq \lambda_\pi y_j, \quad (13)$$

where we define the minimum payment function $\pi_j^{min}(m')$ using a constant amortization formula

$$\pi_j^{min}(m') = \frac{r_m(1+r_m)^{J-j}}{(1+r_m)^{J-j} - 1} m' \quad (14)$$

that assumes that the borrower is required to make $J - j$ payments π that exceed minimum payment requirement after mortgage origination. The remaining mortgage principle evolves according to

$$m' = m(1+r_m) - \pi \quad (15)$$

We also assume that households are allowed to refinance the existing mortgage. When refinancing (taking out a new mortgage), households have to repay the existing mortgage balance, pay the fixed mortgage origination cost, and satisfy both loan-to-value and payment-to-income constraints. Households are also allowed to sell the house, given that they repay the remained of the mortgage as well as transaction costs. Finally, households can default on the mortgage, if they cannot satisfy the minimum payment requirement. Households that choose to default incur the utility cost of ξ and are forced to rent the smallest available dwelling that period.

3.4 Government

In the model, government receives revenues from the property tax τ_h and progressive income tax $\mathcal{T}(y, m)$ that depends on income y and mortgage holdings m . It is assumed that households can deduct the interest paid on mortgages against their taxable income. We assume that tax function \mathcal{T} takes the form

$$\mathcal{T}(y, m) = \tau_y^0 (y - r_m \min\{m, \bar{m}\})^{1-\tau_y^1} \quad (16)$$

where τ_y^0 and τ_y^1 measure the progressivity of the tax system and \bar{m} denotes the maximum allowed deductible mortgage. On the spending side, the government finances social security system for the households. The government runs a balanced budget, with services G (not valued by the household) adjusting to absorb any difference between government income and spending.

3.5 Dynamic Problem of the Household

We now describe the dynamic problem of the households. There are two types of households in the economy: homeowners and non-homeowners. Let V_j^n denote the value function of non-homeowner at age j and let V_j^h denote the value function of the homeowner at age j . When non-homeowner enters the economy at age j he has two choices - either remain non-homeowner in the next period (rent a house) or become a homeowner next period (buy a house). Let V_j^r and V_j^o denote the value function of renters and buyers, respectively. Non-homeowners essentially solve the following problem

$$V_j^n(\mathbf{x}_j^n) = \max \left\{ V_j^r(\mathbf{x}_j^n), V_j^o(\mathbf{x}_j^n) \right\} \quad (17)$$

where \mathbf{x}_j^h denotes the vector of state variables of the non-homeowner, described below. When home-owner enters the economy he has four different choices. He can either continue paying the existing mortgage (let V_j^p denote the value function of the mortgage payer), repay the existing mortgage and get a new mortgage (let V_j^f denote the value function of the mortgage refiner), repay the remaining mortgage and sell the house (let V_j^s denote the value function of the seller) or default on the mortgage payments (let V_j^d denote the value function of mortgage payer who defaults). Every period, the home-

owner solves the following problem

$$V_j^h(\mathbf{x}_h) = \max \left\{ V_j^p(\mathbf{x}_j^h), V_j^f(\mathbf{x}_j^h), V_j^s(\mathbf{x}_j^h), V_j^d(\mathbf{x}_j^h) \right\} \quad (18)$$

where \mathbf{x}_j^h denotes the vector of state variables of the homeowner, described below.

Non-homeowners of age j enter the period with holding of liquid assets a_j and exogenous income y_j . Homeowners of age j , on the other hand, also enter the period with outstanding balance on the mortgage m and house h . When $m > 0$ we refer to homeowners as the mortgagor, whereas when $m = 0$ we refer to them as outright owners. Thus

$$\mathbf{x}_j^n = (a_j, y_j) \quad (19)$$

$$\mathbf{x}_j^h = (a_j, m_j, h_j, y_j) \quad (20)$$

We now describe in detail the problem of each household in a recursive form. From here on the state and control variables with no subscript denote the current age/period variables, i.e. $a_j = a$, while state and control variables with ' superscript denote the next period/age variables, i.e. $a_{j+1} = a'$.

Renters The households of age j that enter the period as non-homeowners and decide to rent next period, choose the level of consumption today (c), the level of liquid savings next period (a') and the size of the rented dwelling for the next period (\tilde{h}'). In recursive form, their problem can be written as

$$V^r(\mathbf{x}^n) = \max_{c, a', \tilde{h}'} u(c, s) + \beta \mathbb{E}_\epsilon \left[V^{n'}(\mathbf{x}^{n'}) \right] \quad (21)$$

where the expectation is taken with respect to next period idiosyncratic income shock ϵ' .

Renters solve the above problem subject to the following constraints:

$$c + \rho_h \tilde{h}' + q_a a' \leq a + y - T(y, 0) \quad (22)$$

$$a' \geq 0$$

$$s = \tilde{h}', \quad \tilde{h}' \in \tilde{\mathcal{H}}$$

$$y' \sim Y(y)$$

where the equations above are budget constraint, borrowing constraint, housing services production and income evolution, respectively. Let $\mathbb{1}^r(\mathbf{x}^n)$ denote the decision of non-homeowner with state variables \mathbf{x}^n to rent a house.

Buyers The households of age j that enter the period as non-homeowners and decide to buy a house, choose the level of consumption today (c), the level of liquid savings next period (a'), the size of the house to buy (h'), and the level of mortgage to take out. In recursive form, their problem can be written as

$$V^o(\mathbf{x}^n) = \max_{c, b', h', m'} u(c, s) + \beta \mathbb{E}_\epsilon \left[V^{h'}(\mathbf{x}^{h'}) \right] \quad (23)$$

where the expectation is taken with respect to next period idiosyncratic income shock ϵ' .

Renters solve the above problem subject to the following constraints:

$$c + q_a a' + p_h h' + \kappa_m \leq a + y - T(y, 0) + q_m m' \quad (24)$$

$$m' \leq \lambda_m p_h h'$$

$$\pi^{\min}(m') \leq \lambda_\pi y$$

$$a' \geq 0$$

$$s = \omega h', \quad h' \in \mathcal{H}$$

$$y' \sim Y(y)$$

where the equations are the budget constraint, LTV constraint, PTI constraint, borrowing constraint, housing services production, and income evolution, respectively. Let $\mathbb{1}^o(\mathbf{x}^n)$ denote the decision of non-homeowner with state variables \mathbf{x}^n to buy a house, with

$$\mathbb{1}^r(\mathbf{x}^n) + \mathbb{1}^o(\mathbf{x}^n) = 1$$

Mortgage payers The households of age j that enter the period as homeowners with a given level of mortgage m and house size h , and decide to make the payment towards the mortgage balance, choose the level of consumption today (c), the level of liquid savings next period (a'), and the size of payment (π). In recursive form, their problem can be written as

$$V^p(\mathbf{x}^h) = \max_{c, b', \pi} u(c, s) + \beta \mathbb{E}_\epsilon \left[V^{h'}(\mathbf{x}^{h'}) \right] \quad (25)$$

where the expectation is taken with respect to next period idiosyncratic income shock ϵ' . Mortgage payers solve the above problem subject to the following constraints:

$$\begin{aligned}
c + q_a a' + (\delta_h + \tau_h) p_h h' + \pi &\leq a + y - T(y, m) \\
m' &= (1 + r_m) m - \pi \\
\pi &\geq \pi^{\min}(m) \\
a' &\geq -\lambda_a p_h h \\
s &= \omega h', \quad h' = h \in \mathcal{H} \\
y' &\sim Y(y)
\end{aligned} \tag{26}$$

where the equations are the budget constraint, mortgage balance evolution, PTI constraint, borrowing constraint, housing services production, and income evolution, respectively. Let $\mathbb{1}^p(\mathbf{x}^h)$ denote the decision of homeowner with state variables \mathbf{x}^h to make a payment towards the mortgage.

Mortgage refiners The households of age j that enter the period as homeowners with a given level of mortgage m and house size h , and decide to refinance the existing mortgage, choose the level of consumption today (c), the level of liquid savings next period (a'), and the level of new mortgage (m'). In recursive form, their problem can be written as

$$V^f(\mathbf{x}^h) = \max_{c, b', m'} u(c, s) + \beta \mathbb{E}_\epsilon \left[V^{h'}(\mathbf{x}^{h'}) \right] \tag{27}$$

where the expectation is taken with respect to next period idiosyncratic income shock ϵ' . Mortgage refiners solve the above problem subject to the following constraints:

$$\begin{aligned}
c + q_a a' + (\delta_h + \tau_h) p_h h' + (1 + r_m) m + \kappa_m &\leq a + y - T(y, m) + q_m m' \\
m' &\leq \lambda_m p_h h' \\
\pi^{\min}(m') &\leq \lambda_\pi y \\
a' &\geq -\lambda_a p_h h \\
s &= \omega h', \quad h' = h \in \mathcal{H} \\
y' &\sim Y(y)
\end{aligned} \tag{28}$$

where the equations are the budget constraint, mortgage balance evolution, PTI constraint, borrowing constraint, housing services production, and income evolution, respectively. Let $\mathbb{1}^f(\mathbf{x}^h)$ denote the decision of homeowner with state variables \mathbf{x}^p to refinance the existing mortgage.

Sellers The households of age j that enter the period as homeowners with a given level of mortgage m and house size h , and decide to sell their house in the current period, choose the level of consumption today (c), the level of liquid savings next period (a') and the size of the rented dwelling for the next period (\tilde{h}'), as they will remain non-homeowners for the following period.

$$V^s(\mathbf{x}^n) = \max_{c, b', \tilde{h}'} u(c, s) + \beta \mathbb{E}_\epsilon \left[V^{n'}(\mathbf{x}^{n'}) \right] \quad (29)$$

where the expectation is taken with respect to next period idiosyncratic income shock ϵ' . House sellers solve the above problem subject to the following constraints:

$$\begin{aligned} c + \rho_h \tilde{h}' + q_a a' &\leq a_s + y - T(y, 0) \\ a' &\geq 0 \\ s &= \tilde{h}', \quad \tilde{h}' \in \tilde{\mathcal{H}} \\ y' &\sim Y(y) \end{aligned} \quad (30)$$

where a_s denotes the current level of assets plus the proceedings from selling the house net of transaction costs and mortgage balance, given by

$$a_s = a + (1 - \delta_h - \tau_h - \kappa_h) p_h h - (1 + r_m) m. \quad (31)$$

Let $\mathbb{1}^s(\mathbf{x}^h)$ denote the decision of homeowner with state variables \mathbf{x}^p to sell the house.

Defaulters The households of age j that enter the period as homeowners with a given level of mortgage m and house size h , might decide to default on their mortgage if they aren't able to make the minimum payment towards the mortgage balance. If they default, they choose the level of consumption today (c) and the level of liquid savings next period (a'); they are forced to rent the minimum dwelling available for renting and are not allowed to buy a house for another period. In recursive form, their problem can be written

as

$$V^d(\mathbf{x}^n) = \max_{c, b', \tilde{h}'} u(c, s) - \zeta + \beta \mathbb{E}_\epsilon \left[V^{n'}(\mathbf{x}^{n'}) \right] \quad (32)$$

where ζ denotes the utility penalty and the expectation is taken with respect to next period idiosyncratic income shock ϵ' . Renters solve the above problem subject to the following constraints:

$$c + \rho_h \tilde{h}_{min} + q_a a' \leq a + y - T(y, 0) \quad (33)$$

$$a' \geq 0$$

$$s = \tilde{h}_{min}, \quad \tilde{h}_{min} \in \arg \min \tilde{\mathcal{H}}$$

$$y' \sim Y(y)$$

Let $\mathbb{1}^d(\mathbf{x}^h)$ denote the decision of homeowner with state variables \mathbf{x}^h to default on the mortgage, with

$$\mathbb{1}^p(\mathbf{x}^h) + \mathbb{1}^f(\mathbf{x}^h) + \mathbb{1}^s(\mathbf{x}^h) + \mathbb{1}^d(\mathbf{x}^h) = 1$$

3.6 Definition of Equilibrium

Our definition of equilibrium consists of households' consumption decision rules

$$\left\{ c^r(\mathbf{x}^n), c^o(\mathbf{x}^n), c^p(\mathbf{x}^h), c^f(\mathbf{x}^h), c^s(\mathbf{x}^h), c^d(\mathbf{x}^h) \right\} \quad (34)$$

savings decision rules

$$\left\{ a^r(\mathbf{x}^n), a^o(\mathbf{x}^n), a^p(\mathbf{x}^h), a^f(\mathbf{x}^h), a^s(\mathbf{x}^h), a^d(\mathbf{x}^h) \right\} \quad (35)$$

mortgage decision rules

$$\left\{ m^o(\mathbf{x}^n), m^f(\mathbf{x}^h), \pi(\mathbf{x}^h) \right\} \quad (36)$$

and housing choice rules

$$\left\{ \tilde{h}^r(\mathbf{x}^n), h^o(\mathbf{x}^n), h^p(\mathbf{x}^h), h^f(\mathbf{x}^h), \tilde{h}^s(\mathbf{x}^h) \right\} \quad (37)$$

and government expenditure G , such that

1. Households' policy function solve problems (21), (23), (25), (27), (29) and (32) given prices p_h and ρ_h

2. Government expenditure G clears governmental budget constraint

We next describe the value of the model parameters that we use to calculate the equilibrium.

4 Parametrization

We set the parameters of the model to be consistent with key cross-sectional features of the U.S. economy using the 2001 wave of SCF. A subset of parameters are set exogenously without the need to solve for the steady-state of model. The target model-implied and data moments are reported in Table 1.

Targeted Moments		
Moment	Model Value	Empirical Value
Net worth to income ratio	5.8	5.5
Ratio of net worth 75/50	1.6	1.5
Homeownership rate	0.63	0.66
Default rate	0.002	0.005
House size of owners to renters	1.5	1.5

Table 1: Targeted moments in the parametrization

Demographics and Preferences The model period is set to one year. Households enter the economy in age 21, retire at age 65 and live until age 81. This corresponds to $J_r = 44$ and $J = 60$. The elasticity of substitution between consumption and housing services is set to 1.25, corresponding to $\gamma = 0.8$ and is based on the estimates from Piazzesi, Schneider and Tuzel (2007). We use the same strategy as Kaplan, Mitman and Violante (2018) set risk aversion parameter ϑ equal to 2 so that the EIS is 0.5. The properties of the baseline model are robust to change in ϑ as long as EIS is less than 1. The discount factor β is set equal to 0.964, implying the average net worth to income ratio of 5.8, slightly above empirical value of 5.5 from SCF. To control to which extent bequest is perceived as luxury good, we set $\underline{a} = 7.7$. The strength of the bequest motive is controlled by ψ , which we set equal to match the ratio of net worth at age 75 to net worth at age 50 (to proxy the importance of bequests as a saving motive). For ψ equal to 7, the model-implied ratio is 1.6, compared to

1.5 in the SCF. The extra utility from owned housing, ω , is set to be equal to 1.015, to match the average homeownership rate. The model-implied homeownership rate is 63 percent compared to 66 percent in the data. The dis-utility from defaulting, ζ , is set equal to 5. The model-implied default rate is about 0.2 percent, compared 0.5 percent in the data. Finally, we set the share of utility from housing ϕ equal to 0.16, that matches the share of housing in total consumption expenditure in NIPA. These are summarized in Table 2.

Demographics and Preferences		
J	Length of life	60
J_r	Working life	44
γ	1/EIS	0.8
ϑ	Risk aversion	2
β	Discount factor	0.964
\underline{a}	Bequest as luxury	7.7
ψ	Strength of bequest	7
ω	Utility from homeownership	1.015
ζ	Disutility from default	5
ϕ	Share of housing in utility	0.16

Table 2: Parameter values (demographics and preferences)

Labor Income and Government Expenditure The deterministic component of labor earnings, χ_j , is calculated using the data on labor earnings from 2001 wave of the SCF. The productivity parameter, Θ , is set to be equal to 1. The stochastic component of earnings is modeled as an AR(1) process with mean 0.75 and standard deviation 0.08. Standard deviation of the initial distribution of income is set to 0.04. We set the social security replacement rate to 60 percent. This matches the initial distribution of income at age 21 as well as the rise in variance of log earnings of 2.5 between age 21 and 64 from 2001 wave of SCF. The parameters of the tax function (16), τ_y^0 and τ_y^1 , are set to 0.75 and 0.151, respectively and are based on estimates from [Heathcote, Storesletten and Violante \(2017\)](#) for the US. Parameter τ_y^0 measures the average level of taxation and parameter τ_y^1 measures the degree of progressivity of the US tax and transfer system. The maximum level of tax-deductible mortgage, \bar{m} , is set to correspond to \$1 million. The property tax τ_h is set to 1 percent, which is the median tax rate across the US. These are summarized in Table 3.

Labor Income and Government Expenditure		
χ_j	Deterministic life-cycle profile	—
Θ	Productivity	1
τ_y^0	Income tax parameter	0.75
τ_y^1	Income tax parameter	0.151
ρ_{ss}	Replacement rate	0.6
\bar{m}	Mortgage deduction limit	20*
τ_h	Property tax	0.01

* A unit of the final good corresponds to \$50000, which is the median income in the 2001 wave in SCF.

Table 3: Parameter values (labor income and government expenditure)

Housing We fix the grid for the owner-occupied houses (\mathcal{H}) and rented houses ($\tilde{\mathcal{H}}$), so that households are only allowed to choose to buy or rent of the dwellings from the grid. The minimum size of the owner-occupied dwelling is set to 1.5 to represent the ratio of the average house size of owners to renters (Chatterjee and Eyigungor, 2015). The depreciation rate of housing is set equal to 1.5 percent to match the annual depreciation rate of the housing stock from the BEA. Transaction cost of selling the house, κ_h , is set to 8 percent, which is the average value reported in Quigley (2002). These are summarized in Table 4.

Liquid Assets and Mortgages We set the interest rate r_a exogenously equal to 3 percent, and the spread parameter ι equal to 33 percent. This implies the mortgage rate r_m of about 4 percent. These values are consistent with the gap between the average rate on 30-year fixed-term mortgages and the 10-year T-Bill rate for the US. The implied price of bond, q_a is equal to 0.97. The mortgage origination cost, κ_m , is set to equivalent of \$ 2000, corresponding to the sum of application, attorney, appraisal and inspection fees. In the baseline version of the model we set the unsecured borrowing parameter, λ_a equal to 0. The minimum down payment requirement q_m is set to 15 percent and controls the overall market tightness. This number is consistent with recent estimates by Sommer and Sullivan (2018) and Kaplan, Mitman and Violante (2018). These are summarized in Table 4.

Housing, Liquid Assets and Mortgages		
δ_h	Depreciation rate	0.015
κ_h	Transaction cost	0.08
r_a	Interest rate	0.03
ι	Spread	0.33
r_m	Mortgage rate	0.04
q_a	Price of bond	0.97
κ_m	Mortgage origination cost	0.04*
λ_a	Maximum borrowing limit	0
q_m	Down payment requirement	0.15

* A unit of the final good corresponds to \$50000, which is the median income in the 2001 wave in SCF.

Table 4: Parameter values (liquid assets and mortgages)

4.1 Properties of the Baseline Model

In this subsection we describe the life-cycle properties of the baseline model with parametrization specified in Tables 2-4. Figure 5 displays the lifetime profiles for several key model variables. Panel A plots the mean labor and pension income (solid black line) and non-durable consumption (dashed black line). Households increase their consumption until about age 30, and then keep it constant until the end of the lifetime. Panel B displays the mean lifetime savings profile of the households. As the households have the bequest motive - they do not dis-save towards the end of the lifetime and leave the portion of the savings as a bequest for the future generations. Panel C displays the mean mortgage balance in the economy. Households take out the mortgage later in life, when they are about 30 years old, so that the payment-to-income constraint (13) is satisfied. As the income is stochastic, some households do not take out the mortgage until later in life. Finally, Panel D displays the average homeownership rate in the economy. Some households (that receive good income shock early in life) buy house early, while the others postpone the purchase until later in life. Households that had a sequence of bad income shocks towards the end of the lifetime sell their house and choose to rent instead, and use the selling proceedings to smooth consumption and leave towards bequest.

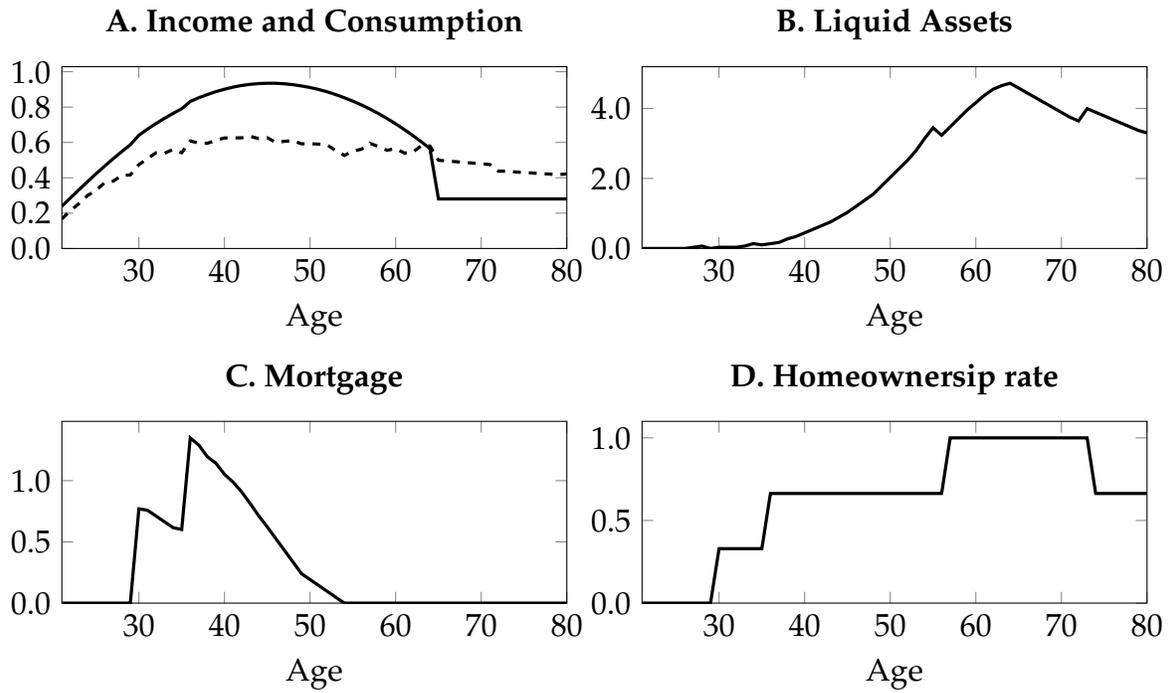


Figure 5: Mean life-cycle profiles in the baseline model. Panel A displays mean income (black solid line) and consumption (black dashed line). Panel B displays mean holdings of liquid asset. Panel C displays mean mortgage balance. Panel D displays mean homeownership rate.

5 Mortgage Market Intervention Experiment

We next perform a mortgage market intervention experiment in the baseline model using the empirical evidence on the effects of governmental mortgage markets interventions on interest and mortgage rates.

5.1 Macroeconomic Effects of Mortgage Market Intervention

In their paper, [Fieldhouse, Mertens and Ravn \(2018\)](#) document the macroeconomic effects of news shock to agency mortgage purchases. They find that following a shock, the interest rates as well as the mortgage rates decrease, as does the spread between of mortgage rates over the interest rates. Panels A and B in figure 6 plots the response of mortgage and interest rates, respectively, along with one standard deviation confidence intervals. Panel C in figure 6 plots the response of spread between the two along with one standard deviation confidence intervals. We see that interest and mortgage rates (panels A and B) decline significantly immediately after the shock and remain low for at least two years. Spread between the two (panel C) declines significantly 3 quarters after the shock and remains negative and significant for half a year.

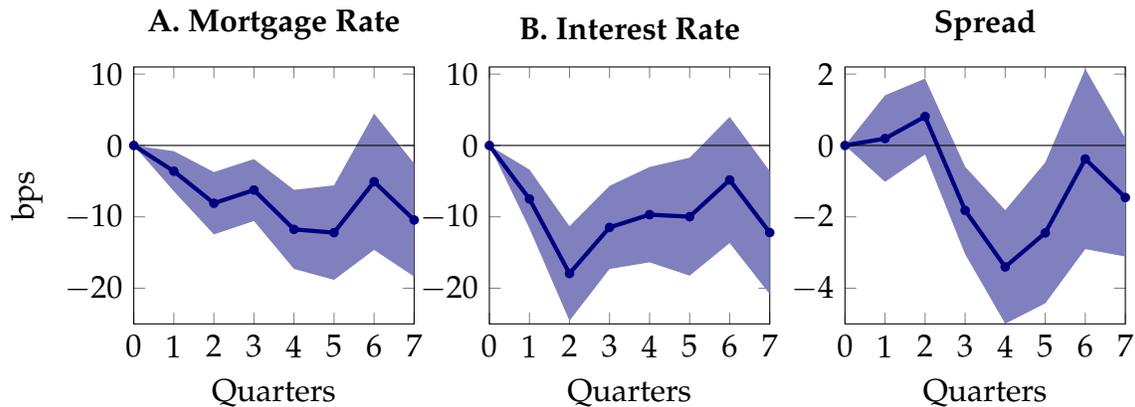


Figure 6: Impulse response of mortgage rate (Panel A), interest rate (Panel B), and spread (Panel C) to an additional to a 1% increase in net purchase by FNMA & FHLMC, anticipated 2 quarters before. Blue areas represent 68% confidence intervals.

5.2 Transitional Dynamics and Transmission Mechanism

To understand the transmission mechanism through which mortgage market intervention operates, we perform the following policy experiment. Suppose that in period 0 the economy is in the steady state, where interest rates and mortgage rates are fixed, and so is the spread between the two. Between period 0 and period 1 (a year in the model), there is an exogenous intervention to the mortgage markets such that interest rate r_a goes down. To account for the fact that empirical evidence suggests the drop in mortgage rates as well as the drop in spreads, and using

$$r_m = (1 + \iota)r_a$$

we also assume that spread parameter ι also declines. In period 1, households enter the period with new interest and mortgage rates, and adjust their choice of consumption, mortgage balance, and liquid savings using the new policy functions. Figure 7 displays the simplified timeline of the policy experiment.

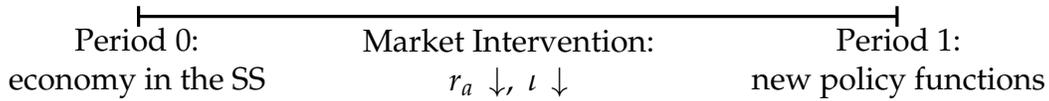


Figure 7: Timeline of the policy experiment

We then analyze whether the policy experiment can reconcile the empirical evidence presented in section 2.4. Empirically, we found that exogenous intervention to mortgage markets makes households with the mortgage significantly increase their consumption expenditure, followed by a positive (but insignificant) increase in consumption expenditure of renters. The policy intervention has the smallest (and insignificant) increase of consumption expenditure for outright homeowners. We identify the same three groups of people in the model: renters (either renters that choose to rent, or homeowners that sell their house or default on the mortgage), mortgagors (either mortgagors who make payments towards positive mortgage balance or refinancers) and outright owners (household that own the house and have zero mortgage outstanding). We then calculate the change in

consumption expenditures for these types of households. We report the results of policy experiment in Table 5.

Tenure	Change in Consumption
Renters	7%
Mortgagors	13%
Outright Owners	2%

Table 5: Response of consumption expenditure to mortgage market intervention

Following an exogenous change in interest rate and in spread parameter, the group that responds the most to policy change is the mortgagor group. After a cut in the interest and mortgage rates, they increase consumption by 13%. Renters also respond positively to change in the interest rates, increasing their consumption by 7% relative to initial steady state. Outright homeowners, on the other hand, react the least to the policy change, and increase their consumption by only 2%.

Our second empirical result, reported in Section 2.5 states that expenditure inequality increases significantly for mortgagors while there is no significant increase for the other two groups of households. To compare the empirical results with those of the model, we calculate the model-implied Gini coefficient before and after the policy experiment took place for all three groups of households. We then look at the change of Gini coefficient after the policy. We report the results of policy experiment in Table 6.

Tenure	Change in Gini
Renters	1.8%
Mortgagors	17%
Outright Owners	-0.6%

Table 6: Response of expenditure Gini to mortgage market intervention

Following an exogenous change in interest rate and in spread parameter, the expenditure Gini increases significantly for mortgagors. After a cut in the interest and mortgage rates, the consumption inequality measure increases by 17%. For renters and outright homeowners the change in expenditure inequality is small, 1.8% and -0.6%, respectively. This response goes in line with the empirical evidence reported in Section 2.5.

We next analyze what is the transmission mechanism that policy operates through and what drives the increase in consumption reported in Table 5. The decrease in the interest rate has a straightforward effect on consumption of all households - as the interest rates drop, the opportunity cost of savings goes down and households choose to consume the extra income instead. For the outright homeowners (who are also older), the bequest motive plays a higher role, and those with high level of savings decide to keep the savings. The households with the lower savings instead to decide to sell their house and also keep it as a bequest. Both renters and mortgagors act as a typical hand-to-mouth consumers: lowering the interest rate makes them save less and consume more. So why do mortgagors and renters react differently? The mortgage market intervention also affects the mortgage rate and the spread between the mortgage and interest rate. Mortgagors minimum payment requirement, given by equation (14), depends on the mortgage rate r_m . Lowering the rate r_m (due to lowering in r_a and ι) relaxes the payment constraint for the mortgagors. So on top of the effect coming directly from lower interest rates, they also receive extra income from lower minimum payment.

6 Conclusions

We study the heterogeneous impact of expansionary credit policies by combining exogenous policy changes in US federal housing agencies mortgage holdings with household level data from the Consumer Expenditure Survey and the Survey of Consumer Finances. We group households into pseudo-cohorts based on their housing tenure status: renters, mortgagors and homeowners. We show that following an increase in agency purchases, households with mortgage increase their spending, while outright homeowners and renters do not adjust their expenditure significantly. We explain this evidence through the lens of a [Huggett \(1996\)](#) type of heterogeneous life-cycle model with endogenous housing choice and idiosyncratic income risk. We calibrate the mortgage market intervention to be consistent with empirical evidence and show that lower interest rate partially explains small increase in expenditure of renters. We also show that bequest motive outweighs the effect of lower interest rate for outright homeowners. Finally, and more importantly, we also show that lower mortgage rates as well as the change in spread

between the rates explains the high observed increase in expenditure for mortgagors.

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A Agency and Market Data

Residential mortgage debt is the sum of home mortgages and multifamily residential mortgages from the Federal Reserve's Financial Accounts of the United States. *Nominal GDP* is from the National Income and Product Accounts. *Agency mortgage holdings* is the sum of the retained mortgage portfolios of Fannie Mae and Freddie Mac. Between 1980 and 2003, the data on retained mortgage portfolio is available from various issues of Federal Reserve Bulletin. After 2003 the data is from monthly volume summaries combined with annual OFHEO/FHFA reports. *Residential mortgage originations* before 1997 is from monthly releases of the Survey of Mortgage Lending Activity from the HUD. After 1997 the data on originations is available from Datastream (series USMORTORA). *Net portfolio purchases* is the sum of corresponding series for Fannie Mae and Freddie Mac. Individual series before 2003 are available from various issues of Federal Reserve Bulletin. After 2003 the data is from Fannie Mae's and Freddie Mac's monthly volume summaries. *Conventional mortgage rate* is the 30-year fixed-rate conventional conforming mortgage rate, available at Freddie Mac mortgage market survey. *Housing starts* is obtained from FRED database at the Federal Reserve Bank of St. Louis (series HOUST). *House prices* is measured by the Freddie Mac house price index (FMHPI) available on Freddie Mac's website. *Nominal price level* is obtained from FRED database at the Federal Reserve Bank of St. Louis (series PCEPILFE). *Personal income* is obtained from FRED database at the Federal Reserve Bank of St. Louis (series PI). *Unemployment rate* is obtained from FRED database at the Federal Reserve Bank of St. Louis (series UNR). *Short- and long-term interest rates* are 3-month and 10-year Treasury rates, obtained from FRED database at the Federal Reserve Bank of St. Louis (series TB3MS and GS10). *BAA and AAA corporate bond rates* are the Moody's seasoned BAA and AAA yields, obtained from FRED database at the Federal Reserve Bank of St. Louis (series BAA and AAA).

B Testing for Exclusion Restrictions

Below we present the plot of robust F-statistics on the excluded instrument of the first-stage regressions of cumulative agency net purchases given by equation (1) for different

horizons h . Horizontal dashed line represents the threshold level of 10.

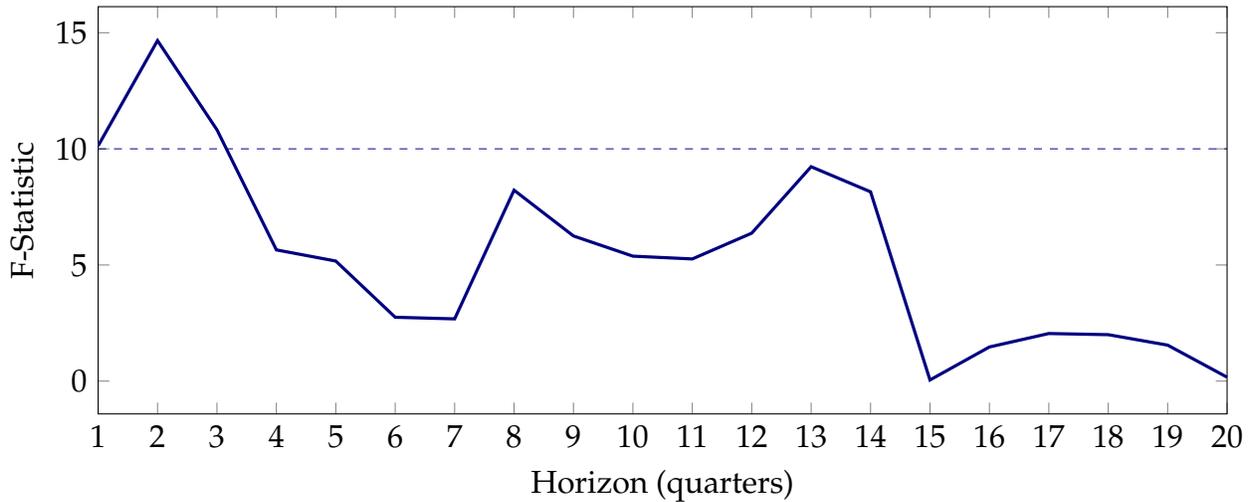


Figure B.1: **First Stage Robust F-statistic.** Figure displays robust F-statistics on the excluded instrument of the first-stage regressions of cumulative agency net purchases.

C Additional Impulse Response Analysis

C.1 SCF Data

We obtain the Survey of Consumer Finances from the Board of Governors of the Federal Reserve System website. We use nine surveys between 1983 and 2007. We apply the same data restrictions as for the Consumer Expenditure Survey. We collect information on households' date of birth, the housing tenure status and the length of mortgage remaining. We then construct five birth cohorts (see Table C.1) and match the information on average mortgage length remaining with the CEX data.

C.2 Pseudo-Cohort Construction

For households with mortgage debt, the length of the mortgage debt that remains to be repaid is an important factor in determining their expenditures. For example, people with longer mortgage remaining might benefit more from the cut in mortgage rates, as their lifetime value of debt is now lower. The CEX survey, unfortunately, does not contain rich information on mortgage length and structure. The SCF survey, on the other hand, contains information on mortgage origination, value and length remaining. As SCF survey

is a triennial survey, we again use synthetic panel techniques to group individual households into groups. To follow more or less homogeneous group over time and to merge the mortgage information contained in SCF with income and expenditure information in CEX, we define groups by the year of birth of the household head, or cohorts, similarly to [Attanasio, Kovacs and Molnar \(2017\)](#). We define cohorts over five year bands, using 1989 as a benchmark, as reported in [Table C.1](#). We then calculate the average length of mortgage remaining for each cohort for each wave in SCF survey and merge it with the CEX survey on a cohort basis.

Cohort	Year of Birth	Age in 1989
1	1965 - 1974	15 - 24
2	1955 - 1964	25 - 34
3	1945 - 1954	35 - 44
4	1935 - 1944	45 - 54
5	1925 - 1934	55 - 64

Table C.1: Cohort Definition

We divide households into two groups, based on length of mortgage remaining - those with mortgage remaining below 18 years, which we call a group with *short mortgage*, and those above, which we call a group with *long mortgage*. We choose these categories to maximize the number of households in each group.

Mortgage refinancing decision is another important factor in determining their expenditure. For example, those that decide to refinance their existing mortgage for the one with the lower rate can benefit from smaller mortgage payments and allocate extra cash to expenditure. On the other hand, the costs associated with refinancing might be too high for the household to decide to refinance existing mortgage, reaching almost 3% of the of the household's initial mortgage balance (see [Hurst and Stafford \(2004\)](#)). CEX survey includes information on mortgage refinancing decision starting from 1994. We extrapolate the information between 1980 and 1993 using the k-nearest neighbor algorithm, to classify the households into those who *refinance* and those who *don't refinance* using a set of household characteristics.

Similarly, we group the households by their decision to borrow against their house using a home equity line of credit (HELOC). While households that decide to use HELOC

can enjoy extra cash, they also face another debt on top of their existing mortgage debt. Similarly to the refinancing decision described above, we extrapolate the household's decision to take out HELOC to the whole sample using k-nearest neighbor algorithm. We group households into two groups: those that *take HELOC* and those that *do not take HELOC*.

Finally, we also group households based on their pre-tax income. We define two groups - *poor* households, that are in the bottom 50% of the income distribution, and *rich* households, that are in the top 50% of the income distribution.

C.3 Response of Expenditure Along the Mortgage Length Distribution

We group the mortgagors into those with a *short* mortgage - where the remaining mortgage debt matures in less than 18 years - and with a *long* mortgage - where the remaining mortgage debt matures 18 or more years. The idea behind this classification is quite straightforward: following an expansion in agency portfolio activity, both the short term, the long term, and the mortgage rates fall (see [Andrew Fieldhouse, Karel Mertens and Morten O Ravn, 2018](#)); mortgagors with a long mortgage might anticipate a long-term effects of reduction in value of their mortgage, and thus benefit more. Indeed, we can confirm this intuition by looking at [Figure C.1](#). As figure indicates, following a shock, mortgagors with short mortgage (left panel) increase their expenditure slightly (reaching a peak of about 0.01 basis points), whereas the mortgagors with long mortgage exhibit a strong and significant increase between 3 and 6 quarters following a shock (reaching a peak of about 0.05 basis points).

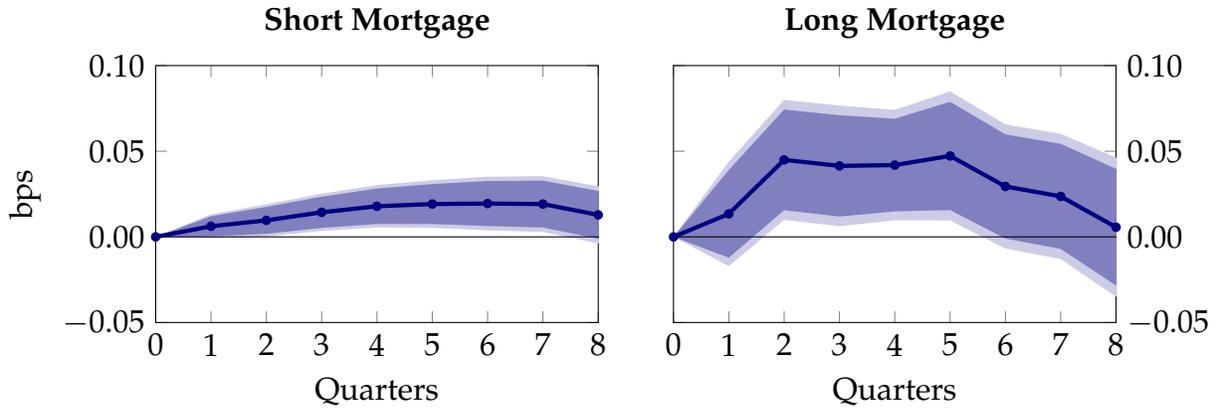


Figure C.1: Impulse response of expenditure to an additional to a 1% increase in net purchase by FNMA & FHLMC, anticipated 2 quarters before. Blue areas and broken lines represent 90% and 95% confidence intervals, respectively.

C.4 Response of Expenditure Based on Refinancing Decision

We group households into those that decide to refinance and those that do not. We find that refinancing decision does no matter for the households. Indeed, as Figure C.2 indicates, both households that decide to refinance (left panel) and those that do not (right panel) increase their expenditure by almost the same amount, reaching a peak of almost 0.05 basis points a year following a shock.

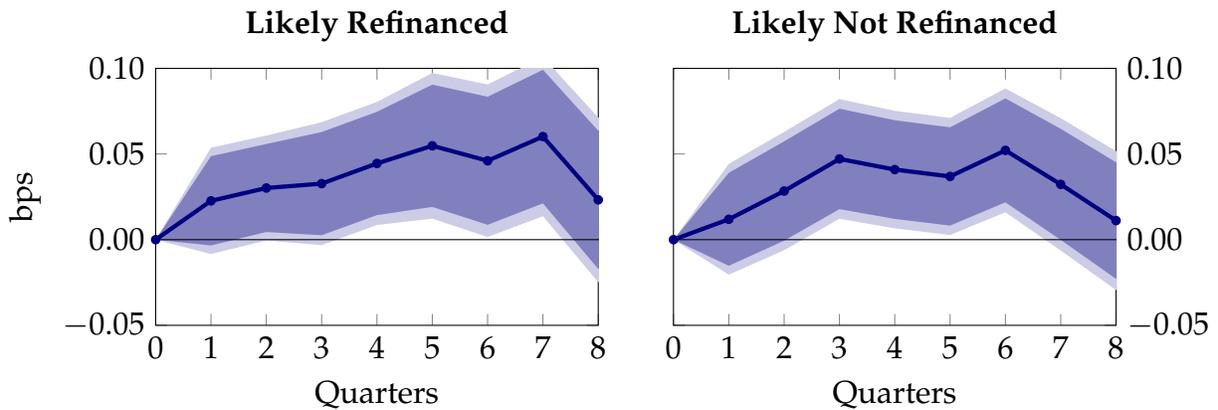


Figure C.2: Impulse response of expenditure to an additional to a 1% increase in net purchase by FNMA & FHLMC, anticipated 2 quarters before. Blue areas and broken lines represent 90% and 95% confidence intervals, respectively.

C.5 Response of Expenditure and HELOC

We now analyze whether a households' decision to take out a home equity line of credit matters. Figure C.3 plots the response of expenditure of households that do take out HELOC (left panel) and those that do not (right panel). Following a shock, those households that do not take out an extra debt increase their expenditure significantly, again reaching a peak of about 0.05 basis points a year after, while for those that do take out HELOC the increase is insignificant.

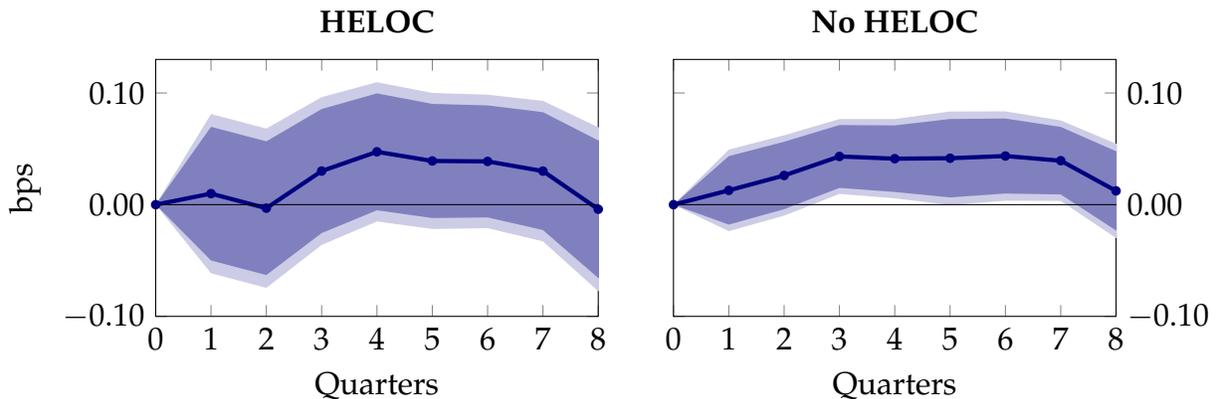


Figure C.3: Impulse response of expenditure to an additional to a 1% increase in net purchase by FNMA & FHLMC, anticipated 2 quarters before. Blue areas and broken lines represent 90% and 95% confidence intervals, respectively.

C.6 Response of Expenditure Along the Income Distribution

Finally, we use the definition of income from before and divide the households into two categories: *poor* households that are in the bottom 50% of income distribution, and *rich* households, that are in the top 50% of income distribution. As before, we also divide households by housing tenure status. This way we have six different groups of households: renters, mortgagors and homeowners, each of whom are either poor or rich.

The mortgagors, however, show a different result. As Figure C.4 indicates, the increase in expenditure among rich mortgagors (right panel) is higher, following a shock, and is significant between 5 and 7 quarters (with a 90% confidence), while the response of the poor mortgagors is quantitatively lower, and is only significant after quarter 6 (with a 90% confidence). This indicates that there is indeed a heterogeneous within the mortgagors group that is consistent with an increase in expenditure inequality within the mortgagors

group.

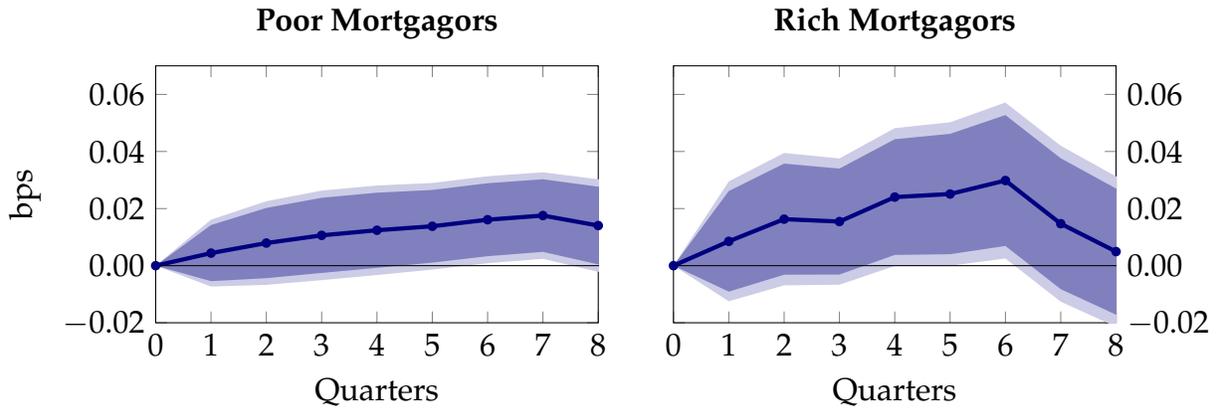


Figure C.4: Impulse response of expenditure to an additional to a 1% increase in net purchase by FNMA & FHLMC, anticipated 2 quarters before. Blue areas and broken lines represent 90% and 95% confidence intervals, respectively.