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The Heterogeneous Effect of Monetary Policy Shocks: Evidence for US Households*

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Abstract

This paper contributes to the growing research on the heterogeneous effects of monetary policy. Using smooth local projections, we estimate the response of consumption expenditure to monetary policy shocks across different groups of households. Our findings show that the expenditures of older households are more responsive to monetary policy shocks than those of young households, indicating the existence of a life-cycle wealth effect. Moreover, households with a mortgage show larger adjustments compared to outright homeowners, reflecting the influence of their balance sheet composition. Additionally, lower-skilled households exhibit larger consumption responses in comparison to high-skilled households. These findings suggest the relevant influence of the income composition channel, earnings heterogeneity, and balance sheet composition channel in the transmission of monetary policy.

Resumen

En este trabajo, usando proyecciones locales suavizadas, estimamos la respuesta del consumo de diferentes grupos de hogares ante un mismo shock de política monetaria. Contribuimos así a la creciente línea de investigación de los efectos heterogéneos que podría producir la política monetaria sobre el consumo privado. Nuestras estimaciones muestran que los shocks de política monetaria tienen un impacto mayor sobre el gasto de los hogares de mayor edad en comparación con más hogares jóvenes, lo que indica la existencia de un efecto de riqueza relacionado con el ciclo de vida. Además, los hogares que tienen deuda hipotecaria exhiben un mayor ajuste en su consumo cuando se compara con los hogares que ya pagaron su hipoteca, sugiriendo un efecto de composición de la hoja de balance de los hogares. Al mismo tiempo, los hogares con menor escolaridad exhiben respuestas de consumo más grandes en comparación con los hogares con mayores niveles de escolaridad. Estos hallazgos sugieren la relevancia de los diversos canales de composición del ingreso, la hoja de balance y la heterogeneidad de ingresos de los hogares en la transmisión de la política monetaria.

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1 Introduction

How monetary policy impacts the real economy is one of the most important questions in the field of macroeconomics. For decades, Central Banks around the world have used monetary policy tools, such as interest rate adjustments and unconventional monetary measures, to influence economic activity and promote price stability. While there is widespread agreement that changes in interest rates can have a significant impact on aggregate variables, the distributional effect of monetary policy and the heterogeneous responses of households across the income distribution is a less studied topic that has gained greater attention in recent years. Particularly, the severity of the economic recession and the slow recovery that followed have underscored the relevance of incorporating household and firm heterogeneity into the monetary policy analysis (Yellen 2016). Moreover, the debate on monetary policy and inequality has garnered increased attention in recent times, especially with the marked rise in income and wealth inequality in advanced economies. As a result, there is a growing debate on whether alternative mechanisms may be just as vital for the transmission of monetary policy. Hence, a more profound understanding of the transmission mechanisms of monetary policy is imperative for Central Banks.

These developments have generated interest among macroeconomists in exploring the implications of household heterogeneity for monetary policy. Many questions arise from this framework, such as: What is the effect of monetary policy on consumption, income, and saving across the distribution of households? What role does household heterogeneity play in the transmission mechanism? Through which channels are households affected by policy rate changes? Is there a significant heterogeneity in their reactions? What is the role of household portfolios and borrowing constraints? Recent works have tried to address these questions from a theoretical point of view, particularly with the development of heterogeneous agents (HA) and New Keynesian (NK) economies. These models, known as HANK models, provide a more precise representation of household consumption behavior and are capable of generating realistic distributions of income, wealth, and household balance sheets, albeit to a lesser degree. Among the most influential works, we can find Kaplan, Moll, and Violante (2018), Auclert (2019), Bilbiie (2020) and Luetticke (2021). In these models, households exhibit a high marginal propensity to consume out of temporary income shocks and this may vary with a household's financial position.

However, there is a clear lack of empirical evidence, since most empirical evaluations of mon-

etary policy have traditionally focused on the responses of macroeconomic aggregates. In the case of the United States, the distributional effects of monetary policy have gained attention in recent years, due to the important increase in income and expenditure inequality. Particularly, Coibion et al. (2017) uses US household data to show that expansionary conventional monetary policy shocks result in short-term increases in output and lead to sustained reductions in income, labor earnings, consumption, and expenditure inequalities, but the authors do not explore the heterogeneous response of households. In the last few years, few works have taken advantage of rich administrative data of Scandinavian countries to estimate the effect of pass-through from policy rates (to market interest rates) on household income, as is the case of Holm, Paul, and Tischbirek (2021) and Andersen, Johannesen, Jørgensen, and Peydró (2022), which has made it possible to explore in detail the transmission channels of monetary policy. In general terms, it is possible to agglomerate the channels through which monetary policy can lead to the redistribution of income and spending into two main channels, the income and wealth channels. The former is related to the fact that households differ in terms of their primary source and level of income, thus, the monetary policy can have distributional effects as different sources of income and levels of earnings respond differently to monetary policy shocks. While, the wealth channel points out that households not only differ in their level of wealth but also in the composition of their wealth, therefore, the monetary policy has the potential to impact the value of assets and liabilities, which could lead to a redistribution effect on household wealth due to the heterogeneous nature of these effects. Hence, these dimensions of heterogeneity can generate different responses to monetary policy changes both on direct impact and through general equilibrium feedback.

The previous papers reflect the relevance of these channels in the transmission of monetary policy, highlighting its effects on inequality dynamics and the heterogeneous responses of households. In this sense, the purpose of this work is to make a contribution to the growing empirical research on the heterogeneous effects of monetary policy. Specifically, we want to examine the reaction of household expenditure to monetary policy shocks across different groups of households. Using household-level data extracted from the U.S. Consumer Expenditure Survey (CEX), we classify households into different cohort groups or categories following the methodology proposed by Deaton (1985). Using as a reference the age of the household's head, we classify households into young (25–34 years), middle (35–64), and old (65+). The CEX survey offers a rich set of household characteristics, which allow us to include in the analysis the hous-

ing tenure condition of the household. Following Wong (2019), we distinguish between outright homeowners without mortgage debt, households that have a mortgage, and renters. Finally, we include in our analysis the education level attained by the head of the household.

Our goal is to uncover the mechanisms through which monetary policy impacts consumption inequality. To do so, we compute a monetary policy shock following the narrative procedure introduced by Romer and Romer (2004) (henceforth R&R), which allows us to separate the endogenous response of monetary policy to information about the economy from the exogenous shocks. Moreover, we include in our analysis two high-frequency identified shocks, the one proposed by Gertler and Karadi (2015) and the one suggested by Jarociński and Karadi (2020) (henceforth G&K and J&K, respectively). After recovering these monetary policy shocks, we run a Smooth Local Projection and a Local Projection estimation, following the methodology introduced by Jordà (2005) and Barnichon and Brownlees (2019), in order to recover the impulse response functions of consumption expenditure. Our results provide robust evidence of heterogeneous responses for US households. The evidence reveals that monetary policy shocks have a more pronounced (and delayed) impact on the aggregate consumption of older (65+ years) households compared to middle-aged (35-64 years) and young (24-34 years) households. The monetary policy easing induces a statistically significant and relatively large increase of 0.6% in aggregate expenditure for the elderly. At the same time, we observe a positive response from mortgagors, with consumption increasing by approximately 0.5%, in line with the hypothesis that liquidity-constrained households should increase their consumption after a negative monetary policy shock. While middle-aged households without complete high school experience an immediate surge of 1.5% in expenditure. These results are robust to different specifications and controls. Our findings suggest the relevant influence of the income composition channel, earnings heterogeneity, and balance sheet composition channel in the transmission of monetary policy.

The remainder of the paper is organized as follows. The next section further discusses the theoretical and empirical literature, including the transmission channels of monetary policy. Section 3 gives an overview of the data, and Section 4 describes the empirical strategy. In section 5, we present the empirical results, analyze the key findings, and discuss their implications. While section 6 presents the robustness checks. Section 7 concludes the paper.

2 Literature Review

2.1 Theoretical Literature

From a theoretical perspective, the Heterogeneous Agent New-Keynesian (HANK) model has emerged as the primary model for examining the heterogeneous effects of monetary policy. In these models, households exhibit a high marginal propensity to consume out of temporary income shocks and this may vary with a household's financial position. The so-called HANK models are able to provide a more precise representation of household consumption behavior and are capable of generating realistic distributions of income, wealth, and household balance sheets, although to a limited extent.

The most influential paper in this literature is the one written by Kaplan et al. (2018). The model has three building blocks, uninsurable idiosyncratic income risk, nominal price rigidities, and assets with different degrees of liquidity, which allow it to reproduce a representative cross-section distribution of household portfolios, wealth distribution, and consumption behavior. The findings suggest that the indirect effects of an unexpected monetary easing on household consumption, the one that operates through a general equilibrium increase in labor demand, is more relevant than the direct effect (intertemporal substitution) in comparison to Representative Agent New-Keynesian (RANK) models. In HANK models, the indirect effects account for over two-thirds of the consumption response, contrasting with RANK models where this effect is insignificant, with approximately 95% of the consumption response attributed to intertemporal substitution or direct effect.

On the other hand, Auclert (2019) underscores the significance of wealth distribution for understanding the redistributive effects of monetary policy. In the model, three channels impact aggregate consumption when "winners" and "losers" have different marginal propensities to consume, the earnings heterogeneity channel from unequal income gains, a Fisher channel from unexpected inflation, and an interest rate exposure channel from real interest rate changes. Particularly, the interest rate exposure is negative for agents with negative liquid wealth. While agents with positive liquid wealth have a positive interest rate exposure and are negatively affected by a reduction in interest rates due to a loss of financial income. Auclert, Rognlie, and Straub (2020) also decompose the total response of monetary policy into direct and indirect effects. Their findings reveal that the indirect effects hold significantly more weight than the direct effects, uncovering a central role for investment in the transmission mechanism of monetary pol-

icy, as larger marginal propensities to consume tend to amplify the investment response.

Aditionally, Luetticke (2021) stress a similar mechanism through which monetary policy can impact wealth and income distribution. Under a HANK model with asset-market incompleteness, idiosyncratic income risk, and sticky prices, the monetary transmission works through the response of investment, which is crucially shaped by redistribution. In this sense, monetary contractions redistribute to wealthy households, who have a higher marginals propensities to invest and a low marginal value of liquidity, which dampens the response of investment. This work highlights the critical role of heterogeneity in the composition of household portfolios in the transmission of monetary policy.

2.2 Empirical Literature

Given the scarce micro-data and the limited information on wealth and income distribution, particularly in the top 1%, most of the empirical evidence has traditionally focused on the identification of monetary policy shocks and the responses of macroeconomic aggregates (Romer and Romer (2004), Gertler and Karadi (2015), Nakamura and Steinsson (2018), Jarociński and Karadi (2020), and Swanson (2021)). Nonetheless, in recent years, a growing empirical literature estimates the impact of pass-through from policy rates to market interest rates on household consumption and inequality. This literature exploits rich administrative data, providing crucial empirical evidence that supports the predictions of the theoretical models.

In this sense, Holm et al. (2021) estimates the dynamic responses of income and consumption to monetary policy at a high level of disaggregation using detailed Norwegian tax data of households. In particular, they divide the population into equal-size groups according to their location in the liquid asset distribution. Interestingly, the results suggest that consumption and income responses to an easing in the monetary policy exhibit a U-shaped form across the wealth distribution. The larger response in each group occurs with a substantial delay, 4 or 5 years after the monetary policy shock.

In a similar fashion, Andersen et al. (2022) studies the heterogeneity by household income to understand the interplay between monetary policy and inequality. Using micro-data for Denmark, the authors find that all income levels benefit from a lower policy rate in terms of disposable income, asset values, wealth, and consumption. However, there is a monotonically increasing effect of the monetary policy shocks on disposable incomes along the income distribution, where

households at higher income levels generally benefit more. Interestingly, the authors consider households along the within-age total income distribution, finding a hump-shaped relation between the effects on disposable income and age[1].

In the case of the United States, the distributional effects of monetary policy have gained attention in recent years, due to the important increase in income and expenditure inequality[2]. Coibion et al. (2017) uses US household data to show that expansionary conventional monetary policy shocks result in short-term increases in output and lead to sustained reductions in income, labor earnings, consumption, and expenditure inequalities. The authors point out several channels through which the monetary policy can have a distributional and heterogeneous effect on income and expenditure. Particularly, household income composition appears to be an important ingredient in explaining the distributional influence of monetary policy. While the larger responses of consumption by high net-worth households in comparison to low net-worth households suggest that household balance sheets composition is playing an important role in the monetary transmission mechanism. Albrizio, Estefania, and Furceri (2021) uses a similar approach, but considering the Zero-Lower-Bound period in US. Their findings are similar to the ones posted by Coibion et al. (2017), exogenous monetary policy tightening tends to decrease economic activity and increase inequality, but these effects are larger in comparison to monetary expansions, implying a relevant non-linear influence of monetary policy.

Regarding the heterogeneous responses of households to monetary policy innovations, Wong (2019) uses data from the Consumer Expenditure Survey and finds a larger consumption response for homeowners who refinance or enter new loans, which is concentrated among younger people. In this sense, the consumption elasticities of young people are larger than the ones of the average person and matter for the aggregate response. At the same time, Cloyne, Ferreira, and Surico (2020) exploits a similar dataset for the United Kingdom, focusing on the differences between groups of households with and without mortgages. The findings indicate that mortgagors exhibit a greater expenditure response compared to homeowners. This suggests that mortgagors face higher liquidity constraints relative to homeowners, resulting in changes in their interest payments due to movements in the real interest rate. This, in turn, leads to a more pronounced impact on expenditure for mortgagors.

[1]The effects are negligible for the young (below 35 years) and the old (above age 75), while for the middle-aged people, the effects are roughly the same.

[2]In their seminal paper, Saez and Zucman (2016) finds that wealth concentration has continuously increased since 1978. The share of wealth owned by the top 1% families reached 42% in 2012, mainly driven by the increase in the top 0.1% wealth share, which increased from 7% in 1978 to 22% in 2012.

The previous papers reflect the relevance of monetary policy for inequality dynamics and heterogeneous responses of households. In this paper, we are focusing particularly on the heterogeneous feedback of household expenditures, because it has a direct implication in understanding the effects of monetary policy shocks on the aggregate economy. In this vein, it is crucial to identify which household characteristics and channels are operating behind the heterogeneous responses to monetary policy. In the next section, we discuss the main transmission channels highlighted by the literature.

2.3 Transmission Channels

The literature has identified several channels through which distributional effects of monetary policy occur, drawing upon newer theoretical models that incorporate elements such as sticky prices, incomplete markets, and heterogeneity among households and firms [3]. The foundation of all distributional channels of the monetary policy lies in the diverse dimensions of household heterogeneity (income, wealth age, and marginal propensity to consume, among others). Nonetheless, the identification is usually complex, because these dimensions often overlap. For instance, education level is correlated with income and wealth level, and it also changes over a person's life-cycle. Due to these heterogeneities in the levels and compositions of income and wealth, households can be deferentially impacted by the effects of monetary policy actions [4].

In general terms, we can agglomerate the channels through which monetary policy can lead to the redistribution of income and spending into two main channels:

1. **Income Channels**: Households differ in terms of their primary source and level of income. Monetary policy can have distributional effects as different sources of income and levels of earnings respond differently to monetary policy shocks.

    1.1 *Income composition channel*: Different sources of income (labor income, business, financial, and cash transfers) can exhibit a differential response to monetary policy. For instance, monetary policy easing may benefit richer households more and increase income. Richer households receive a larger share of their income from business and financial (capital) income, which is typically more responsive to monetary policy than labor income (Gornemann, Kuester, and Nakajima (2021)).

[3] See e.g Kaplan et al. (2018), Auclert (2019), Violante (2021), Bhandari, Evans, Golosov, and Sargent (2021) Amberg, Jansson, Klein, and Picco (2022), McKay and Wolf (2023), and Acharya, Challe, and Dogra (2023)

[4] Bonifacio et al. (2022) offers a deep analysis regarding the distributional effects of monetary policy and the main mechanisms through which monetary policy easing affect income and wealth, particularly after the Covid-2019 crisis.

1.2 *Earnings distribution heterogeneity*: At the same time, households also differ in terms of where their earnings fall in the overall distribution. In this sense, labor earnings' response to the monetary stance is asymmetric. Monetary policy easing may reduce income and consumption inequality by stimulating economic activity and lessening the impact of an economic downturn (Heathcote, Perri, and Violante (2010)).

2. **Wealth Channels**: On the other hand, households not only differ in their level of wealth (net positive or negative wealth) but also in the composition of their wealth. Monetary policy has the potential to impact the value of assets and liabilities. As a result, it can lead to a redistribution effect on household wealth due to the heterogeneous nature of these effects.

   2.1 *Balance sheet composition channel*: The composition of a household's portfolio plays a crucial role in determining the impact of monetary policy on their consumption and income. For example, changes in interest rates can affect assets (stocks and bonds) differently based on their type and duration. Similarly, the impact of unexpected interest rate changes and the associated effects on exchange rates on debt service and loan balances depends on the type of liabilities and their maturity. As Bonifacio et al. (2022) points out, the net effect of asset and liability side effects on wealth then is ambiguous, then monetary policy easing may decrease or increase wealth and consumption inequality.

   2.2 *Savings distribution channel*: As Auclert (2019) suggests, unexpected inflation revalues nominal balance sheets, with nominal creditors losing and nominal borrowers gaining. Moreover, borrowers typically are less patient and have a greater marginal propensity to consume. Under the savings redistribution channel, monetary policy easing may reduce wealth and consumption inequality.

   2.3 *Interest rate exposure channel*: The measure of a household's balance sheet exposure to interest rates is the difference between all maturing assets and liabilities at a given point in time. For instance, the budget constraint of debtors is directly influenced by changes in interest rates, specifically through adjustments in interest payments.

   2.4 *Financial segmentation channel*: In general terms, individuals engaged in financial markets stand to gain from expansionary monetary policy shocks. As these market participants typically earn higher incomes compared to those not involved in financial

markets, expansionary monetary policy can potentially exacerbate inequality through this channel.

2.5 *Inflation channel*: The increase in expected inflation resulting from an expansionary monetary policy diminishes the purchasing power of households that heavily rely on cash holdings for their expenditures, particularly low-income households. This generates an implicit regressive tax on consumption (Erosa and Ventura (2002)) and leads to an increase in consumption inequality.

Hence, these dimensions of heterogeneity can generate different responses to monetary policy changes both on direct impact and through general equilibrium feedback. In summary, the income sources households depend on, the quantity and composition of their assets and liabilities, and their involvement in financial activities are key factors that contribute to heterogeneous responses throughout the life-cycle.

3 Data

3.1 Consumer Expenditure Survey

The household data come from the interview samples of the Consumer Expenditure Survey (CEX), which is provided by the Bureau of Labor Statistics[5]. This survey contains detailed information on expenditures of non-durable goods and services, durable goods (excluding housing and rental-related costs), and household income of US households. The CEX is a well-known dataset that has quarterly information on around 10.000 households. Moreover, the survey provides information on demographics, household size, the year of birth of the household head, mortgage payments for households with outstanding debt, and rental payments for renters. This dataset has been used extended in the literature (Krueger and Perri (2006), Coibion et al. (2017), Wong (2019), Albrizio et al. (2021) and Pidkuyko (2022)).

The CEX survey is a rotating panel of households that are selected to be representative of the US population and is used for constructing the weights of the Consumer Price Index (CPI). In particular, each household is interviewed about their expenditures for up to four consecutive quarters. We convert the data into quarterly series using the date of the interview. Our sample starts in 1982 and ends in 2018. In Table 2, we show the number of households for a selected

[5]Data from 1990 onwards in publicly available in the BLS webpage, the information prior to 1990 is obtained from the Inter-university Consortium for Political and Social Research (ICPSR).

sample of years[6].

Table 1: Number of households per year

Year	Households
1982	4,816
1985	5,653
1990	6,553
1995	6,786
2000	10,773
2005	10,041
2010	9,429
2015	7,837
2018	7,457

Notes: This table shows the number of households for selected years. Estimations are based on CEX survey.

In this work, the main variable of interest is the household's expenditure. Total expenditure includes both durable (housing, transport, education, etc.), non-durable (food, alcohol, clothing, entertainment) consumption, and services. We deflate the total expenditure by the Consumer Price Index (CPI) in order to convert the nominal data into real series.

As we have mentioned, the CEX survey is a rotating panel, which poses limitations for conducting comprehensive panel-data analysis, especially when aiming to analyze the time series of monetary policy shocks. Nonetheless, we propose to address this issue by implementing a pseudo-panel identification (Deaton (1985)) using household characteristics. The rationale behind this methodology is based on the ability to track a specific cohort of households with shared characteristics across multiple surveys. The averages (or median) within these cohorts are treated as observations in a pseudo-panel. This grouping estimator has been widely used in the literature (Blundell, Browning, and Meghir (1994), Attanasio and Weber (1995) and Attanasio, Blow, Hamilton, and Leicester (2009)).

In order to employ a grouping estimator in the spirit of Deaton (1985) two concerns must be addressed. The first one is that households do not endogenously switch between different categories (age, housing tenure, and education) due to a monetary policy shock. Notice that if monetary policy is inducing a change in the household's tenure decision, the results of our analysis can be attributed to a compositional change. The second concern is about selection, if the

[6]For the analysis, we exclude households that are in either the top 1% or bottom 1% of either the expenditure. At the same time, we exclude households that report zero expenditure and zero food expenditure. Finally, we keep in the sample those households whose household head is above 24 and below 76 years old.

assignments into a particular group are not random, then some non/observed characteristics may be responsible for the heterogeneous responses of households.

The first grouping dimension used to classify households is the age of the head of the household. Using this dimension we classify households into young (25–34), middle (35–64), and old (65+) age groups. The rationale for these age categories is related to the fact that the 25–34 age group is when long-term asset accumulation generally begins, while people 65 and older are usually retired.

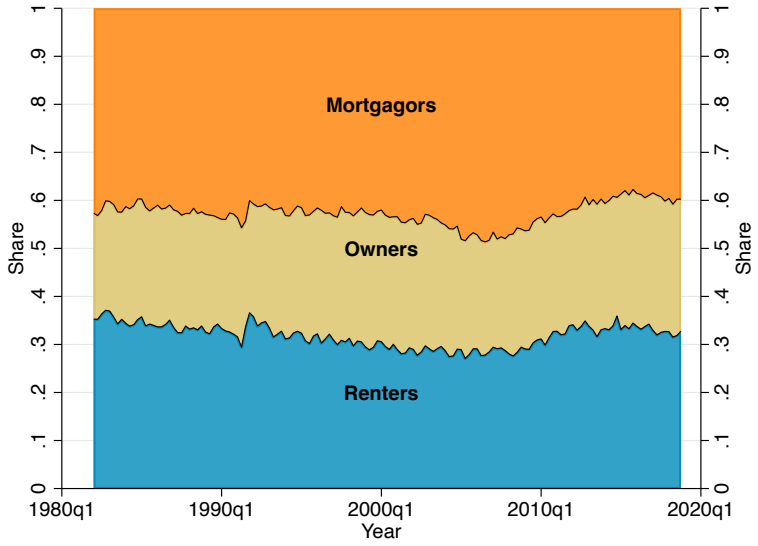
Table 2: Households - Age group

Age	Observations
24-34 years	129,342
35-64 years	321,393
65+	118,623
Total	569,358

Notes: This table shows the number of observations according to their age. Estimations are based on CEX survey.

The second dimension that we consider in our analysis is the housing tenure. As Wong (2019) and Flodén, Kilström, Sigurdsson, and Vestman (2021) emphasize that housing tenure serves as a valuable proxy for assessing the balance sheet position of households, which should indicate the household's net wealth position and its vulnerability to potential fluctuations in the credit market or interest rate. Broadly speaking, homeowners with mortgages possess substantial wealth tied to their properties, while outright homeowners exhibit significant housing and financial assets. Conversely, renters tend to have comparatively lower levels of wealth. Figure 1 exhibit the time series of tenure shares, as we can see these series tend to be relatively stable over time or "slow-moving". This is the first evidence in favor of our grouping estimation. In subsection 5.2, we provide a comprehensive analysis addressing the concern of using the grouping estimation in the household tenure context. We provide compelling empirical evidence demonstrating that our results are not driven by compositional changes.

Figure 1: Tenure share



Notes: Proportion of mortgagors, homeowners, and renters in the US (percentage). Estimations are based on CEX survey.

The last dimension considered in this work is education. Education has long been identified as one of the most important determinants of economic outcomes. Recent works have pointed out the heterogeneous effect of monetary policy over labor outcomes[7]. Particularly, Amir-Ahmadi, Matthes, and Wang (2022) finds that monetary policy has a differential effect on the unemployment rate across different levels of education. Specifically, individuals with at least a college degree experience significantly lower fluctuations in the unemployment rate compared to less educated groups or the overall aggregated unemployment rate. Based on this evidence, we categorize households, considering the educational attainment of the household head, into three groups: "No HS" for households with less than a high school education, "HS Complete" for households with a completed high school education, and "Higher Education" for households with an undergraduate college degree or higher. Table 3 shows the division of households according to their education level attained, as we can see the sample is concentrated on households with less than undergraduate education, but with high-school complete.

[7]In particular, it has been documented how less skilled workers are more likely to experience larger unemployment rates (or a reduction in their worked hours) during recessions, which further reduces skills and potential earnings (Heathcote, Perri, and Violante (2020)).

Table 3: Households - Education level

Educational Level	Observations
Non High-School complete	96,489
High-school complete and less than college	311,273
Undergraduate or more	161,596
Total	569,358

Notes: This table shows the number of observations according to their education level. Estimations are based on CEX survey.

It is important to recall that the CEX survey presents some limitations. First of all, the CEX is a survey-based data source, which introduces a certain degree of measurement error in individual responses compared to administrative data sources. Moreover, the dataset does not contain detailed information on the very upper part of the income (i.e. the top 1%), which has played an important role in income and expenditure inequalities dynamics. These limitations are considered in the analysis, but there just have only a limited implication for our analysis.

3.2 Monetary Policy Shocks

What is a monetary policy shock? According to Bernanke (1986), shocks are primitive exogenous forces that are uncorrelated with each other and they should be economically meaningful. In this sense, our goal is to estimate the impact of a Monetary Policy shock on household spending. To do so, we identify the U.S. monetary policy shock using alternative measures.

First of all, we consider the narrative approach proposed by Romer and Romer (2004). In this work, the authors derivates a series of Intended Fed Funds Rate movements around FOMC meetings, which eliminates much of the endogenous relationship between interest rates and economic conditions. Then, they regress the change in the intended interest rate on the Federal Reserve's forecasts of CPI, GDP, and unemployment. The residuals from this regression, the changes in the policy rate that could not be predicted by their forecasts, represent the monetary policy shock. Particularly, the authors run the following regression between 1969 and 1996:

$$\begin{aligned} \triangle ff_m = \alpha + \beta ffb_m + \sum_{i=-1}^{2} \gamma_i \triangle \tilde{y}_{mi} + \sum_{i=-1}^{2} \lambda_i (\triangle \tilde{y}_{mi} - \triangle \tilde{y}_{m-1,i}) \\ + \sum_{i=-1}^{2} \phi_i \triangle \tilde{\pi}_{mi} + \sum_{i=-1}^{2} \theta_i (\triangle \tilde{\pi}_{mi} - \triangle \tilde{\pi}_{m-1,i}) + \rho u_{m,0} + \epsilon_m \end{aligned} \tag{1}$$

Where $\triangle ff_m$ is the change in the intended funds rate around FOMC meeting m. $ffbm$ is the level of the target funds rate before the change in the meeting m. $\tilde{y}_{mi}$, $\tilde{\pi}_{mi}$ and $u_{m,0}$ represent the forecasts of real GDP, inflation, and unemployment rate. Notice that the authors include both the current forecast and the change since the previous meeting because both changes and levels influence Federal Reserve policy. Finally, the subscript i refers to the horizon of the forecast. We recover the data from 1969 to 1996 from Romer and Romer (2004) and the public information available in the Philadelphia Fed [8], in order to extend the sample and recover the monetary policy shocks until 2007.

At the same time, we incorporate into the analysis high-frequency identification of monetary policy shocks, developed by Gertler and Karadi (2015) and Jarociński and Karadi (2020) [9]. These methodologies use high-frequency data, particularly the movements of federal funds futures in a narrow window of 30 minutes around FOMC announcements. The identification strategy behind these papers relies on the fact that financial agents react to monetary policy news by exchanging financial positions to the extent they did not expect these policy changes because they have already discounted the information available ex-ante[10]

Broadly speaking, Central Bank announcements can contain information not just about monetary policy, but also about the Central Bank's assessment of the economic outlook. In fact, the Central Bank's outlook may differ from that of the public, and the communication can, therefore, drive private expectations independently of the monetary policy shock, affecting interest rate surprises. Jarociński and Karadi (2020) disentangle the two shocks by using stock market surprises together with interest rate surprises. The main idea behind including stock price movements is related to the fact that interest rate surprises around policy announcements only reflect monetary policy shocks if they co-move negatively with stock price surprises (stock prices would unambiguously increase after a negative interest rate surprise). According to the authors, the reason is that a policy easing (cutting rates) raises the present value of future dividends because it both lowers discount rates and increases future dividends by engineering an upswing. However, the co-movements are not always negative, thus, a positive co-movement of interest rate surprises and stock prices points out the presence of an information shock in the announcement.

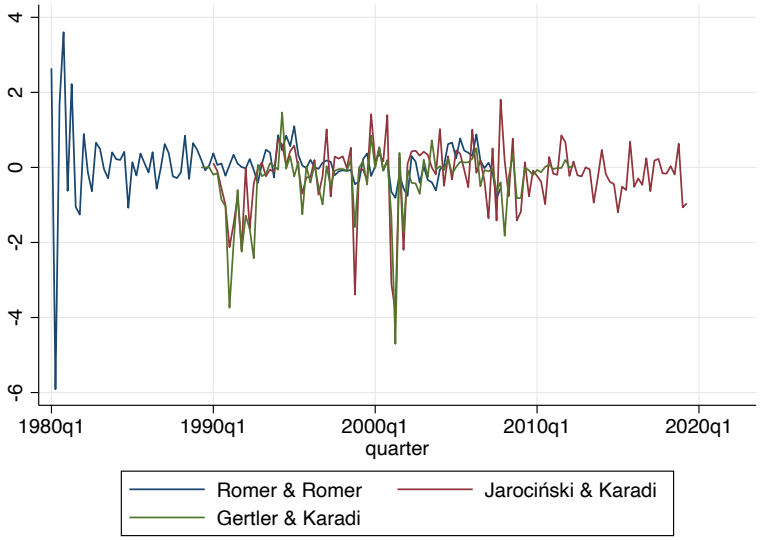
[8] See: Federal Reserve Bank of Philadelphia.

[9] There other works that have exploited the same idea such as Nakamura and Steinsson (2018) and Swanson (2021).

[10] Gertler and Karadi (2015) uses these noisy measures of monetary policy shocks as instruments for the policy rate in a proxy-SVAR framework. While Jarociński and Karadi (2020) offers a refined approach in which they are able to separate the "true" monetary policy shock from the "informational" shock of the Central Bank.

Table 4 reports some descriptive statistics of the three shocks until the last quarter of 2007. Notice that the three shocks are not statistically different from zero, but they have different degrees of variability. Particularly, we can see that R&R shock is the one with the larger variability and its mean is positive. On the other hand, the high-frequency shocks have a negative mean. In general terms, a truly exogenous monetary policy shock should be serially uncorrelated. Figure 2 show the evolution of the Monetary Policy shocks, notice that there is a strong and positive correlation between G&K and J&K, which can be attributed to the similar methodology used in their estimation, while R&R exhibits a slightly different pattern. To facilitate easier comparison of expenditure responses across different measures of monetary policy shocks, we normalize these series by adjusting their standard deviations to align with changes in the federal Fed Funds Rate. By doing so, the response to a one-standard-deviation innovation in the monetary policy shock series becomes comparable to an unanticipated one-standard-deviation change in the policy rate. This normalization allows for a more meaningful assessment of the impact of monetary policy on expenditures.

Figure 2: Monetary Policy Surprises



Notes: These series are normalized by adjusting their standard deviations to align with changes in the federal Fed Funds Rate, measured in percentage points. The starting dates for the series are 198Q1 for R&R, 1990Q1 for G&K, and J&K. The ending dates are 2007Q4 for R&R, 2012Q2 for G&K and 2018Q4 for J&K.

Table 4: Monetary Policy Surprises: Summary of Statistics

Statistics			
	R&R	J&K	G&K
Mean	0.053	-0.021	-0.039
St. Dev.	0.287	0.084	0.101

Correlation			
	R&R	J&K	G&K
R&R	1.0		
J&K	0.328	1.0	
G&K	0.3071	0.7183	1.0

Notes: The starting date for the series is 1990Q1 and the ending date is 2007Q4.

4 Empirical Strategy

4.1 Local Projections

We investigate the impact of a monetary policy shock on consumption responses across different cohorts using local projections. In general terms, Local projections (LPs) are linear regressions of a future outcome on current covariates. This method was proposed by Jordà (2005) and it has been increasingly used by empirical macroeconomists in recent years to estimate impulse response functions. Local projections have several advantages in comparison to the classical VAR estimation. First, it can be estimated by single-equation OLS regression. At the same time, provides a simple, analytic, joint inference for impulse response coefficients. In general, LPs are more robust to misspecification and do not impose a rigid structure in the estimation of the IRFs [11]. Hence, experimentation with nonlinear and flexible models is straightforward. Moreover, the estimation can easily be scaled to a panel-data framework.

By combining the Monetary Policy shock with LPs estimation, we aim to compute the effect of a Monetary Policy Shock on household expenditures using the following representation:

$$y^c_{t+h} = \alpha^c_h + \sum_{j=0}^{J} \beta^c_{j,h} \cdot \epsilon^{MPS}_{t-j} + \sum_{k=1}^{K} \gamma^c_{k,h} X_{t-k} + u^c_{h,t} \tag{2}$$

Here, h, t, and c represent the horizon, quarter, and cohort. Hence, for each h in $h = 0, ..., H$, we estimate the previous equation. y is our variable of interest (log expenditure), ϵ^{MPS} is our mon-

[11] See Li, Plagborg-Møller, and Wolf (2022) for a deeper discussion regarding the properties of Local Projections and VAR.

etary policy shock. α is a specific cohort FE and X is a vector of controls, including household characteristics, and quarter dummies. The main specification includes two lags for the control variables[12], notice that these variables are included to "mop up" the residual variance. As a benchmark, we set $J = K = 2$ and $H = 20$. The parameter of interest is $\beta^c_{0,h}$, which represents the local projection of the estimated equation. Then, the series of $\beta^c_{0,h}$ yields the impulse response at horizon h for cohort c. Interestingly, in the presence of "true" exogenous shocks, there would be no need to include any control variables in the equation (Barnichon and Brownlees (2019)).

4.2 Smooth Local Projections

One of the disadvantages of estimating equation 2 by Jorda´s LP Method is related to the fact that the dynamic multiplier β^c_h is expensively parametrized, and the ordinary least square estimation tends to suffer an excess of variability, producing "choppy" responses. Given this, Barnichon and Brownlees (2019) proposes an alternative methodology, which uses penalized B-splines in order to tackle the excess of variability. Using Barnichon and Brownless' method we can approximate equation 2 to[13]:

$$y_{t+h} \approx \sum_{i=1}^{I} a_i B_i(h) + \sum_{j=0}^{J} \sum_{i=1}^{I} b_{ji} B_i(h) \cdot \epsilon^{MPS}_{t-j} + \sum_{k=1}^{K} \sum_{i=1}^{I} d_{ki} B_i(h) X_{t-k} + u_{t+h} \tag{3}$$

where the dynamic multipliers of the monetary policy shocks are:

$$\sum_{j=0}^{J} \beta_{j,h} \cdot \epsilon^{MPS}_{t-j} \approx \sum_{j=0}^{J} \sum_{i=1}^{I} b_{ji} B_i(h) \cdot \epsilon^{MPS}_{t-j} \tag{4}$$

Here B_i for $i = 1, ..., I$ is the B-spline basis function, while b_i for $i = 1, ..., I$ is a set of scalar parameters. We estimate equation 3 by generalized Ridge estimation. While the standard errors of the impulse responses is computed using the Newey-West estimator [14].

5 Empirical Results

This section describes our main findings using the Smooth Local Projections for different household cohorts. We begin our discussion by focusing on the impact of monetary policy shocks on

[12] Based on information criteria statistical tests such as AIC and BIC, we find for most cohorts, an optimal lag length of between 2 and 4 yields the best fit.

[13] For simplicity we drop the supra index c, but in equation 3 we are estimating the model for each cohort.

[14] For more details of the generic estimation, please see the appendix section.

household expenditure considering the age dimension. In subsection 5.2, we incorporate the household tenure condition and provide a comprehensive discussion on endogenous switching (between tenure conditions) and compositional changes. In subsection 5.3, we comment the results for the education cohorts. Following this section, we report several additional exercises that have been conducted as robustness checks.

Is important to mention that we have normalized the monetary policy shocks by adjusting their standard deviations to align with changes in the federal Fed Funds Rate. By doing so, the response to a one-standard-deviation innovation in the monetary policy shock series becomes comparable to an unanticipated one-standard-deviation change in the policy rate. The reported coefficients are the expenditure responses to an expansionary monetary policy shock (i.e., a decline in fed fund rates).

5.1 Age Cohort Estimation

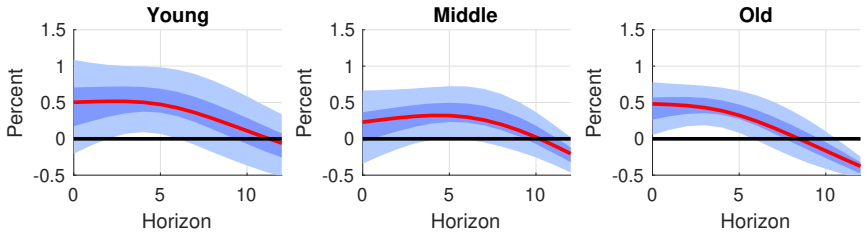
We start our analysis by estimating our main specification for 3-age cohorts: Young (24-34 years), Middle (35-64 years), and Old (65+ years). Figures 3 and 4 show the smooth local projection of mean total household expenditure to an unanticipated one-standard-deviation change in the policy rate for each age group under R&R and J&K shocks, respectively. In this case, the sample for the R&R shock spans from 1982Q1 to 2007Q4 period, while the J&K shock covers the period from 1990Q1 to 2018Q4[15]. In all cases, the dark and light blue shaded areas indicate 1 and 1.65 standard deviation confidence intervals, respectively.

The results show a heterogeneous response for the three groups to an unanticipated monetary policy shock. Notice that older households adjust their consumption relatively more than younger households in both cases. The impulse response for older households is positive and statistically significant, while the response of middle and young households do not. However, it is worth noting that the timing and persistence of the consumption response differ between the two shocks. The R&R shocks exhibit an instantaneous positive response, which starts falling immediately after one quarter, but the J&K response shows an inverted-U shape. In the latter case, expenditure reaches its peak over the ensuing two years after the shock. Interestingly, the monetary policy easing induces a statistically significant and relatively large increase of 0.6% in aggregate expenditure for the elderly. In Figure 5, we directly compare responses between age

[15] As a robustness check we estimate the model using the same samples and the results are similar.

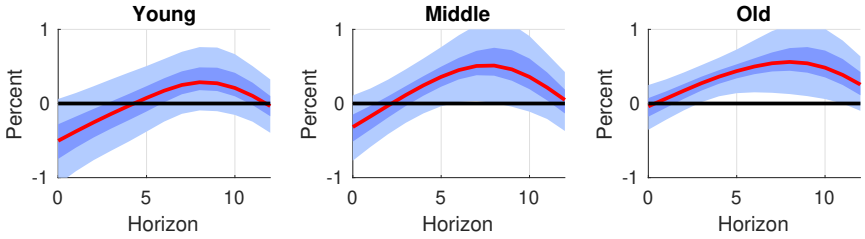
groups. We can notice that the young cohort responses are half of the older cohort, while the old minus middle is always positive.

Figure 3: Impulse responses by Age Group - Romer & Romer



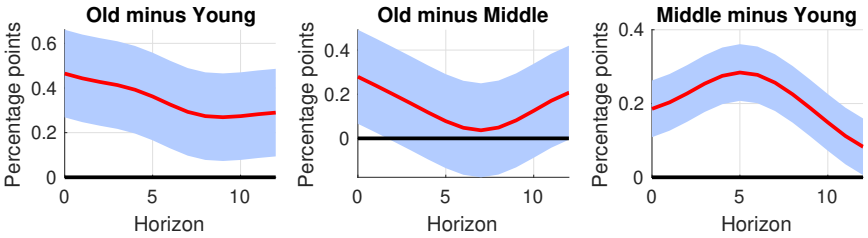
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure 4: Impulse responses by Age Group - Romer & Romer



Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure 5: Jarocinski & Karadi SLP: Old-Young, Old-Middle, and Middle-Young.

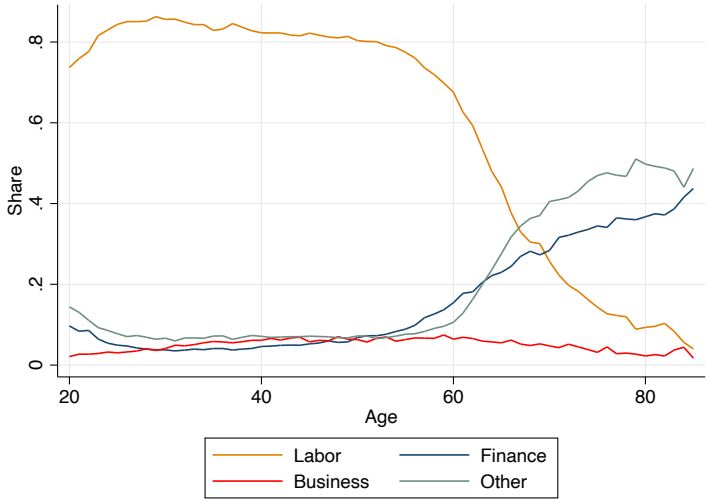


Notes: Shaded area is one standard error confidence bands. The horizontal axis indicates the number of quarters for up to 12 quarters after the shock.

These results are indeed in line with the empirical literature. As Coibion et al. (2017) points out, expenditures in older cohorts are expected to react more in comparison to young cohorts to a monetary policy shock. In principle, a life-cycle wealth effect should be driving the results because older households tend to have a portfolio (income) composition, which is tilted to more interest-sensitive assets. As we can see in Figure 6, older cohorts exhibit a higher reliance on income derived from financial sources, which indicates at the same time, a larger financial integration in this group of the population. Moreover, using data from the Survey of Consumer

Finances (SCF), Berg, Curtis, Lugauer, and Mark (2021) shows that older households have much higher net wealth than younger households, and also they hold more interest-rate-sensitive assets, such as property equities, stock, mutual funds, and bonds. As older cohorts tend to be wealthier than younger households, a given interest rate decline should induce a larger capital gain for this group of the population.

Figure 6: Shares of income sources



Notes: Labor is defined as earning from wages. Business income is earnings derived from both farming and non-farming business. Financial income is earnings from dividends, royalties, estates, or trusts, and the amount of interest on savings accounts or bonds. Other is defined as income coming from transfers, benefits, pensions, and social security.

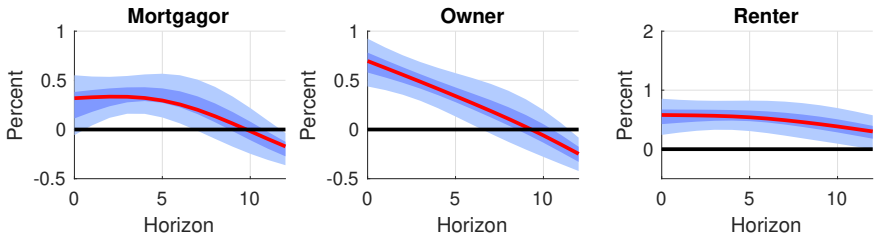
5.2 Tenure Cohort Estimation

Now we turn to the second dimension of household heterogeneity, housing tenure (mortgagor, owner, and renter). According to Cloyne et al. (2020), we should expect that mortgagors show a larger response to a monetary policy easing because they face larger liquidity constraints in comparison to outright homeowners and renters. In this regard, households with a mortgage tend to have limited liquid wealth, which often results in hand-to-mouth behavior despite owning significant illiquid assets. In contrast, outright owners typically possess enough liquid assets and thus may not experience significant changes in their consumption patterns.

Figures 11 and 12 report the smooth impulse responses of mean total household expenditure to an unanticipated one-standard-deviation change in the policy rate. Interestingly, we have found evidence of a differential effect of monetary policy on consumption for different house tenure conditions, in line with Cloyne et al. (2020) and Wong (2019). Nonetheless, between

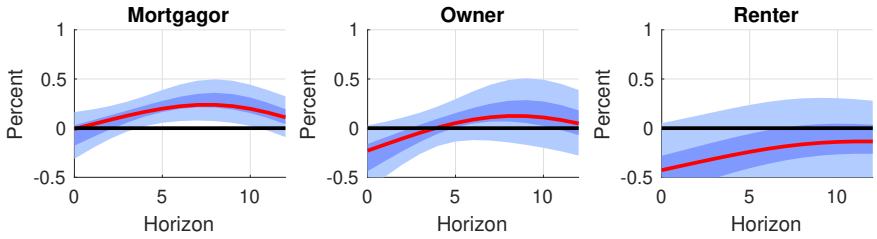
the R&R and J&K shocks, it seems to be a different history. While the response for outright homeowners shows a large and statistically significant impact in the case of narrative shocks, the pattern is different for high-frequency shocks. In the former, we observe an immediate and substantial response in consumption, which gradually diminishes over a 10-quarter period. In the latter, there is a small (and not significant) decrease in expenditure, which is compensated by an increase in consumption after the first year. On the other hand, we observe a positive response from mortgagors in both scenarios, with consumption increasing by approximately 0.5%, in line with the hypothesis that liquidity-constrained households should increase their consumption after a negative monetary policy shock.

Figure 7: Impulse responses by Tenure Group - Romer & Romer



Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure 8: Impulse responses by Tenure Group - Jarocinski & Karadi



Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

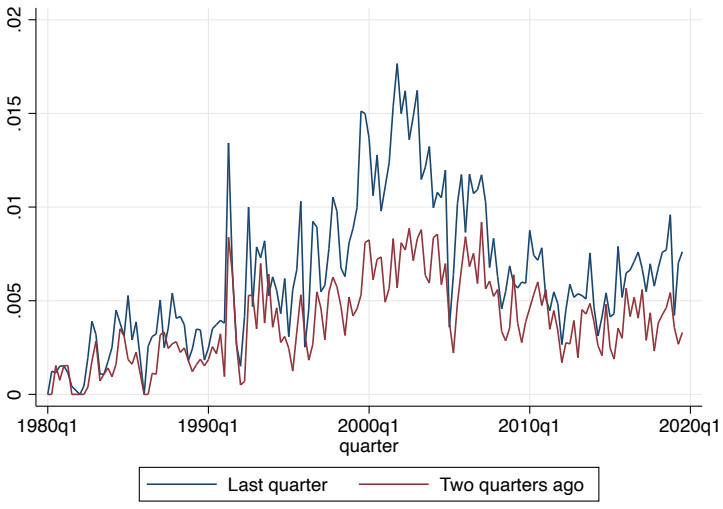
In this context, the main assumption behind the group estimator (Deaton (1985) is that households do not endogenously switch between different categories due to monetary policy shocks. If monetary policy is inducing a change in the household's tenure decision, the results of our analysis can be attributed to a compositional change. At the same time, if the assignments into a particular group are not random, then some non/observed characteristics may be responsible for the heterogeneous responses of households.

As we mentioned in section 3, the time series of tenure shares tend to be relatively stable over

time or "slow-moving". This evidence suggests that there are no significant inflows or outflows between categories during the observed time period. At the same time, Figure 9 shows the share of households that switch their tenure status. As we can see, there is a small proportion of households that change their status between the current and previous quarter (blue line) as well as between the current quarter and two quarters before (red line). The number of households that change their housing tenure status goes from 0 to 80 for the sample period, representing, on average, 0.5% of the sample.

Regarding endogenous switching, we need to be sure that monetary policy shocks are not inducing changes in housing tenure, this is, mortgagors becoming homeowners, renters becoming outright homeowners, renters becoming mortgagors, and outright homeowners becoming mortgagors. To test the endogenous switching, we estimate the main specification with the dependent variable being the total number of switchers for each category in the current quarter. Figure 10 shows the impulse response function for each switching category. Consequently, the responses are close to zero and not statistically significant in each case. Hence, we can conclude that the decrease in the Fed Funds Rate has a minimal and statistically insignificant impact on the number of switchers. This validates the use of our grouping estimator in this particular context.

Figure 9: Share of households that switch status



Notes: Share of households that change their status between the current and previous quarters.

Figure 10: Impulse response of the number of switchers

Notes: Impulse response of number of switchers using Jarocinski & Karadi shocks. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

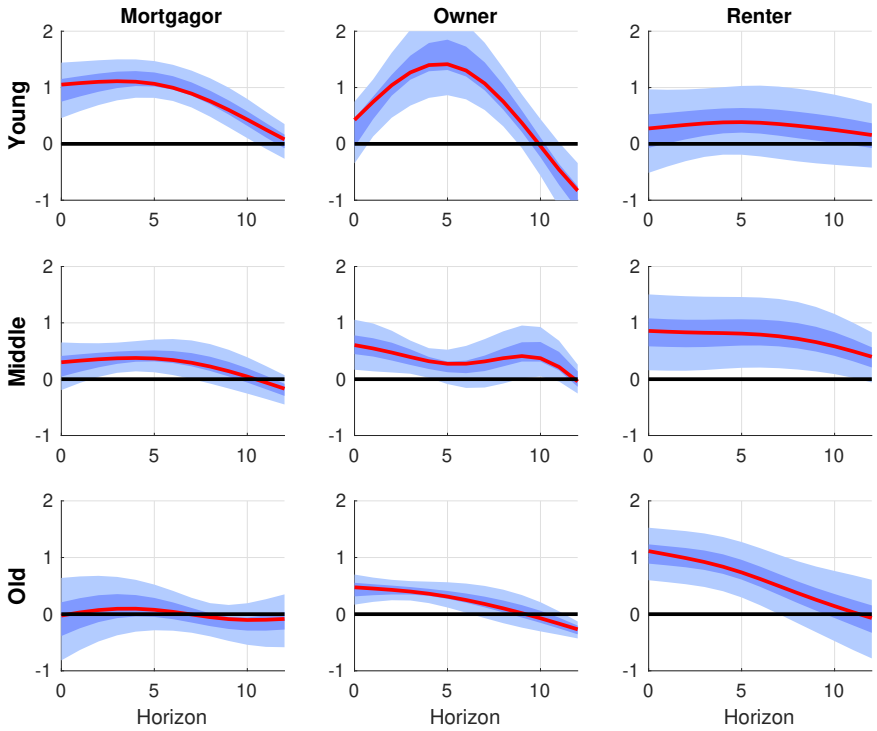
Now we continue our analysis by including a life-cycle dimension in our estimation. Particularly, we estimate our model considering age and housing tenure, keeping in the sample only households that do not change their housing tenure status between interviews. First and foremost, it is worth noting that when we incorporate the age of the household head into the analysis, the effects of the R&R and J&K shocks are reconciled. The magnitude of the responses is quantitatively similar for mortgagors and homeowners. Focusing on middle-aged households, the response of mortgagors tends to be larger in comparison to the outright owners, in line with Cloyne et al. (2020). The positive response in expenditure for mortgagors reaches its peak (0.5%) over the ensuing two years after the shock. Moreover, old homeowners have higher expenditure responses than non-homeowners, the results are similar for young homeowners. These outcomes may be driven by a positive wealth effect if old and young homeowners have a larger net wealth in comparison to mortgagors, since the unexpected decrease in the interest rate may induce an increase in the value of their home.

Furthermore, our findings confirm a greater response among young mortgagors compared to the older and middle-aged groups. This discrepancy may be attributed to the financial circumstances of young mortgagors who are in the early stages of homeownership. It is common for them to have relatively low net wealth, as the size of their mortgage is often comparable to

the value of their home. Consequently, our results could be driven by a positive wealth effect, which can be traced back to two different factors. First, there is an increase in the value of their home due to the decrease in the interest rate, while they observe a reduction in the present value of their mortgage payments. Wong (2019) raised this issue and our findings support her hypothesis. However, it is important to note that our analysis focuses on examining the distinct effects of mortgagors and outright homeowners. Berg et al. (2021) conducted a similar analysis, but they aggregate both mortgagors and outright homeowners into a single category of homeowners. Interestingly, their findings do not provide support for Wong's hypothesis. Notice that the response observed among older homeowners aligns closely with the aggregate case, which confirms the proportion of older households with mortgages or rental payments is relatively small.

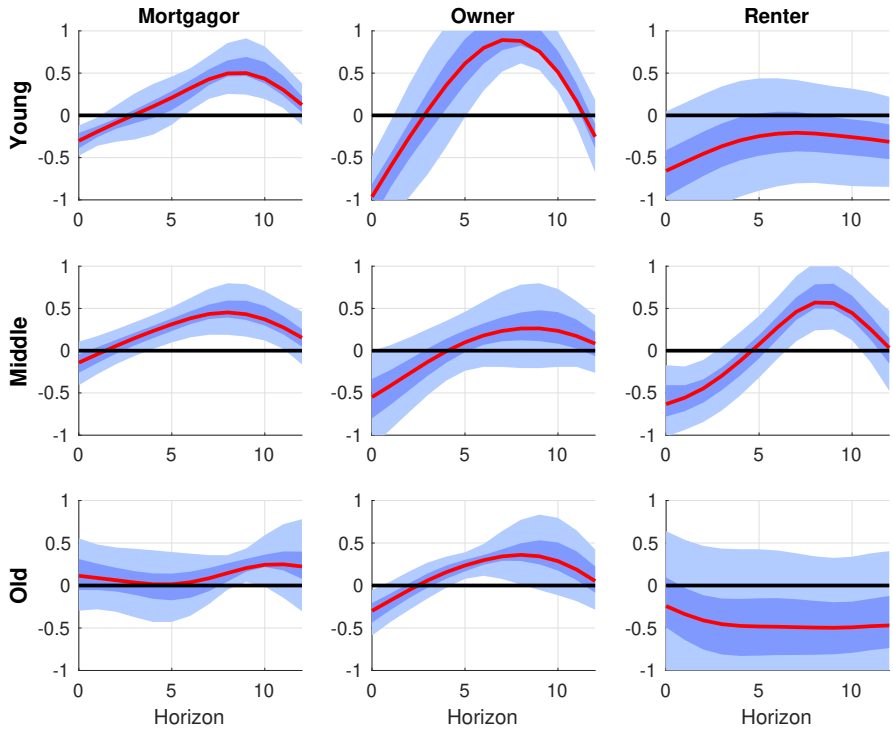
Lastly, when examining the renter cohorts, we find mixed evidence. In the case of R&R shocks, there is a positive and relatively persistent response across all groups. However, the response to high-frequency shocks varies among the groups. Young and old renters exhibit a negative, persistent, and statistically insignificant response. On the other hand, middle-aged renters initially experience a decrease in consumption, but this is offset by an increase after the fifth quarter. Notably, the responses for this cohort tend to be larger and more volatile compared to outright homeowners and mortgagors. These findings could be driven by the fact that renters are often concentrated bottom part of the income distribution, indicating a higher sensitivity to changes in monetary policy. In this sense, the evidence in the literature is mixed as well, Wong (2019) did not find any statistically significant response for renters, while Cloyne et al. (2020) shows a large response by renters, comparable to the mortgagors' response.

Figure 11: Impulse responses by Age-Tenure Group - Romer & Romer



Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure 12: Impulse responses by Age-Tenure Group - Jarocinski & Karadi



Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

5.3 Educational Cohort Estimation

The final dimension we consider in our grouping estimation, before moving on to the robustness checks, is education. This variable has long been identified as a major determinant of economic outcomes, but the evidence regarding the heterogeneous effect of monetary policy considering this dimension is relatively scarce. Recent papers have focused on the impact of monetary policy on labor market outcomes across these different groups, but they do not investigate the direct implications for consumption. Amir-Ahmadi et al. (2022) find a differential response of the unemployment rate across different groups of the population. Particularly, less educated individuals exhibit a larger increase in the unemployment rate after an increase in the interest rate. This leads us to focus on estimating the diverse responses of consumption among households with different educational levels. We categorize the households into three distinct groups based on the highest level of education attained by the household head. Households with less than a high school education are defined as "No HS", "HS Complete" for households with a completed high school education, and "Higher Education" for households with an undergraduate college degree or higher.

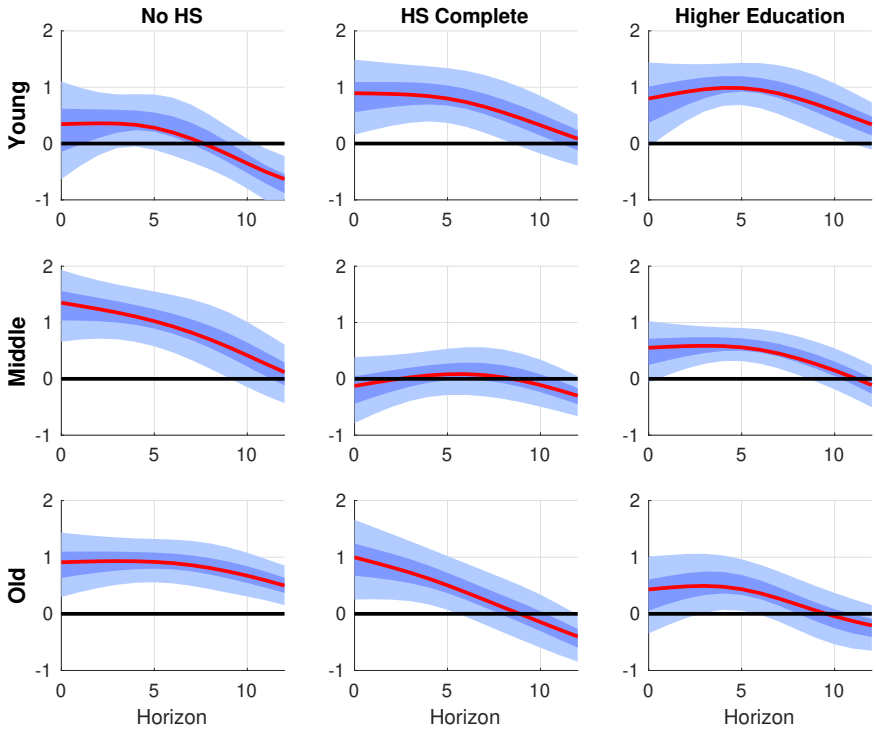
Figure 13 presents the results of our main estimation using our R&R shocks. Here we are taking into account both dimensions, age and education. Each cohort exhibits a positive response in consumption following a decline in the interest rate. Notably, households with lower levels of education tend to exhibit a more pronounced increase in consumption in response to a monetary policy shock. Specifically, middle-aged households without complete high-school experience an immediate surge of 1.5% in consumption immediately after the shock, which vanishes after 3 years. For old and low-skilled households, the immediate response is a bit smaller in comparison to middle-aged households, but their response is persistent over time. Interestingly, Amir-Ahmadi et al. (2022) finds that the impact of a monetary policy shock over unemployment rates for this particular cohort returns to its original level after almost 5 years. In our case, we display the response over a horizon of 3 years [16].

As Heathcote et al. (2020) points out, less skilled workers are disproportionately likely to experience larger changes in unemployment, which further induce higher changes in skills and potential earnings via a scarring effect. Table A2 shows the number of observations according to their educational level and annual household income, it is clear that less educated households

[16] Several studies have found persistent effects of monetary policy shocks, such as Romer and Romer (2004), Coibion et al. (2017), Paul (2020) and Berg et al. (2021)

have a lower level of income. Thus, changes in earnings induced by the monetary policy should have a larger impact on consumption, particularly for this group, through the earnings heterogeneity and income composition channel. For both the "HS Complete" and "Higher Education" cohorts, the responses in consumption tend to be quite similar and, overall, smaller compared to the "No HS" cohort. Nonetheless, the response for HS Complete" and "Higher Education" groups in the young-aged category are larger than the "No HS" group.

Figure 13: Impulse responses by Age-Education Group - Romer & Romer



Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

6 Robustness Checks

In this section, we provide supplementary exercises to assess the robustness of the previous results. Detailed documentation of all figures and tables can be found in the appendix section.

6.1 "Normal" Local Projections

Here we present the results obtained from estimating Equation 2 using regular local projections instead of smooth local projections. In general terms, the impulse response functions exhibit an excess of variability in comparison to the smooth impulse responses. As Barnichon and Brownlees (2019) points out, this is due to the fact that the dynamic multipliers in the equation are

expensively parametrized. This has been highlighted by Ramey (2016). Clearly, the sharp fluctuation from quarter to quarter makes the interpretation of the impulse responses more difficult, since it is not completely clear whether these movements are real features of the impulse response or noisy measurements.

Despite the last issue, we observe a similar response to an unanticipated one-standard-deviation change in the policy rate, thus, our interpretations do not change using this method. Nonetheless, it is worth noting that Jorda's estimation method tends to exhibit a larger absolute response in comparison to the smooth estimation. This effect comes directly from the estimation method. By using B-splines to smooth responses, we are reducing the variance of the estimated local projection coefficients. Then, outliers or extreme values tend to disappear. Figures A1, A2, A3 and A4 show the results of the "Normal" Local Projection for each grouping estimator.

6.2 Gertler & Karadi Shocks

The second robustness check included in this section is the introduction of a different monetary policy shock. Using Gertler & Karadi high-frequency shocks and smooth local projections, we estimate our main model for each cohort. As we mentioned in section 3, there is a strong correlation between J&K and G&K shocks, because the estimation methodology is very similar. The main distinction is that the latter does not account for the covariance between stock markets and futures of the fed fund rates. As a result, the authors do not distinguish between a conventional monetary policy shock and an informative monetary policy shock. Hence, G&K represents an "average" of the conventional and informative monetary policy shocks by J&K.

Figures A5, A6, A7 and A8 show the consumption responses to an unanticipated one-standard-deviation change in the policy rate. In general, we do not observe significant differences compared to the J&K estimations. The responses in G&K estimation show similar differences in comparison to R&R, just like the responses in the J&K case. It is important to note that the estimation period is slightly shorter compared to the estimations using J&K, spanning from 1990Q1 to 2012Q2. In the next section, we narrow down the estimation period to 1990Q1-2007Q4 to align with the R&R estimation period. Interestingly, our results remain unchanged.

6.3 Sample selection

One important consideration in impulse response estimation, particularly for local projections, is the sensitivity of the estimated parameters to the choice of the sample period. As noted by Ramey (2016), the effects of monetary shocks can vary depending on the specific period under consideration. This is due to the changing nature of monetary policy conduction and the evolving economic conditions over time. In this sense, it is essential for our estimations to be consistent across different sample periods to ensure the stability of our interpretations. Without this consistency, our understanding and conclusions would be subject to change depending on the specific time period chosen for analysis.

To do so, we estimate our model considering different periods of time. Here we present the estimation from 1990Q1 until 2007Q1 for the J&K case. Figures A11 and A12 show the responses for the age and age-tenure cohorts. As we can see, the smooth impulse responses do not exhibit any substantial change, and the statistical significance remains intact.

6.4 Lag structure

We conclude the robustness checks section by exploring the impact of changing the lag structure in our main specification. The baseline estimations utilize two lags of total expenditure and two lags of the control variables. However, by considering alternative lag lengths, we assess the robustness of our results. Based on information criteria statistical tests such as AIC and BIC, we find for most cohorts, an optimal lag length of between 2 and 4 yields the best fit. Hence, we estimate the smooth local projection including four lags of the dependent and control variables.

In figures A11 and A12 we present the estimation for age and age-tenure cohorts. The inclusion of these additional variables in the specification does not yield important differences, thus, does not fundamentally alter our findings. In this sense, is important to mention that in the presence of a true exogenous monetary policy shock, it would be not necessary to include any control variable in the specification, since the parameters recovered from the estimation would be the ”true” response to a monetary policy shock (Barnichon and Brownlees (2019)).

7 Conclusion

How monetary policy impacts the real economy is one of the fundamental questions in macroeconomics. In this sense, there is a widespread agreement that changes in interest rates or the implementation of unconventional monetary policies could have a significant impact on aggregate variables. Nonetheless, the distributional effect of monetary policy and particularly the heterogeneous responses of households have been less studied and there is not a clear consensus of its effects. The primary objective of this work is to contribute to the growing body of empirical research on the heterogeneous effects of monetary policy. Our focus is specifically on examining the diverse expenditure responses among different groups of households. To achieve this, we conduct an analysis using disaggregated household-level data, where households are categorized based on three key dimensions: age, housing tenure, and educational attainment.

To estimate the dynamic effects of expansionary monetary policy shocks in the United States, we employ both narrative identification methods (Romer and Romer (2004)) and high-frequency identification methods (Gertler and Karadi (2015) and Jarociński and Karadi (2020)). Specifically, we employ smooth and normal local projections techniques (Barnichon and Brownlees (2019) and Jordà (2005)) to capture the dynamic effects of these policy shocks. By combining these identification approaches with our categorization of households, we aim to provide a comprehensive understanding of how different groups of households respond to expansionary monetary policy in terms of their expenditure patterns.

Our results provide robust evidence of a heterogeneous response for US households. The presented evidence reveals that monetary policy shocks have a more pronounced (and delayed) impact on the aggregate consumption of older households compared to middle-aged and young households. We hypothesize that the observed patterns in the expenditure response can be attributed to key aspects of life-cycle heterogeneity such as portfolio composition, discounting horizons, income composition, labor earnings, and wealth accumulation. Moreover, the results suggest that households with a mortgage exhibit hand-to-mouth behavior, which explains the larger response at the aggregate level in comparison to middle-aged outright homeowners, in line with previous literature (Cloyne et al. (2020)). At the same time, we find a larger response for young mortgagors and outright homeowners supporting the evidence presented by Wong (2019). When considering the educational dimension, households with lower skill levels tend to exhibit a more pronounced increase in consumption. This finding aligns with the notion

that individuals with fewer skills are disproportionately susceptible to experiencing greater fluctuations in unemployment rates. Consequently, these fluctuations can have a scarring effect, leading to substantial changes in skills and potential earnings. (Amir-Ahmadi et al. (2022) and Heathcote et al. (2020)). In general, our findings suggest the relevant influence of the income composition channel, earnings heterogeneity, and balance sheet composition channel in the transmission of monetary policy.

These results have important implications for the design of monetary policy by Central Banks, which helps to make progress in understanding the key features of the transmission mechanism of monetary policy. However, further research is needed to address some interesting questions within our framework. For instance, it would be valuable to differentiate between positive and negative monetary policy shocks to understand non-linearities in the implementation of monetary policy. Some studies suggest that contractionary shocks may have larger impacts compared to expansionary shocks. Additionally, it would be informative to examine the differential effects of monetary policy across different states of the economy (recessions vs expansions). In this paper, the estimations consider the full sample without distinguishing between conventional monetary policy periods and those affected by the zero lower bound or unconventional monetary policy. Furthermore, integrating other shrinkage estimation methods, such as Bayesian Local Projections, could enhance the analysis (Miranda-Agrippino, Ricco, et al. (2021)).

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8 Appendix

8.1 Smooth Local Projection

A generic approximation of equation 3 will be:

$$y_{t+h} \approx \sum_{i=1}^{I} a_i B_i(h) + \sum_{i=1}^{I} b_i B_i(h) x_t + \sum_{k=1}^{K} \sum_{i=1}^{I} d_{ki} B_i(h) z_{kt} + u_{t+h} \tag{5}$$

An appealing feature of the approximating model is that it retains linearity with respect to the parameters and can be represented as a linear regression. From here, we can let Y_t for $t = 1, ..., T - H_{min}$ be the vector $(y_{t+H_{min}}, ..., y_{min}(T, t + H_{max}))'$ and d_t its size. Denoting $X_{\beta t}$ as $d_t \times I$ matrix the (h, i)-th element of which is $B_i(h)x_t$. Doing the same for X_α and $X_{\gamma_k t}$ for $k = 1, ..., K$ we can stack horizontally the matrices, such that $X_t = (X_{\alpha t} X_{\beta t} X_{\gamma_1 t} ... X_{\gamma_K t})$. On the other, we define θ the vector of B-splines parameters $(a_1, ., a_K, b1, ., b_I, d_{11}, ., d_{1I}, ., d_{K1}, ., d_{KI})'$. Then, we can represent equation 5 as a linear regression:

$$Y_t = X_t \theta + U_t \tag{6}$$

where U_t denotes the $d_t \times 1$ prediction error vector term of the regression. Finally, we denote by Y, X and U the vertically stacked versions of, respectively,Y_t, X_t and U_t. Then, we can estimate equation (5) by generalized ridge estimation:

$$\hat{\theta} = \arg\min_{\theta} \{\|Y - X\theta\|^2 + \lambda \theta' P \theta\} \tag{7}$$

$$\hat{\theta} = (X'X + \lambda P)^{-1} X'Y \tag{8}$$

where λ is a positive shrinkage parameter determining the amount of shrinkage and P is a symmetric positive semi-definite penalty matrix.5 The shrinkage coefficient $lamda$ determines the bias/variance trade-off of the estimator. For λ = 0 we get the OLS estimator, while λ large induces a bias estimator with small variance. We can select λ using k-fold cross validation.

8.2 Tables

Table A1: Housing Tenure by Household Income

Annual Income	Housing Tenure			
Before Taxes	Mortgagor	Owner	Renter	Total
Less than $5,000	10,279	16,470	28,373	55,122
$5,000 to $9,999	11,651	21,234	28,319	61,204
$10,000 to $14,999	15,260	18,914	23,832	58,006
$15,000 to $19,999	17,940	14,461	19,061	51,462
$20,000 to $29,999	38,485	20,478	25,430	84,393
$30,000 to $39,999	35,262	12,737	13,864	61,863
$40,000 to $49,999	27,158	8,146	7,573	42,877
$50,000 to $69,999	32,275	9,662	7,645	49,582
$70,000 and over	36,386	11,328	7,469	55,183
Incomplete	18,881	12,928	17,812	49,621
Total	243,577	146,358	179,378	569,313

Notes: This table shows the number of observations according to their housing tenure and annual income before taxes. Estimations are based on CEX survey.

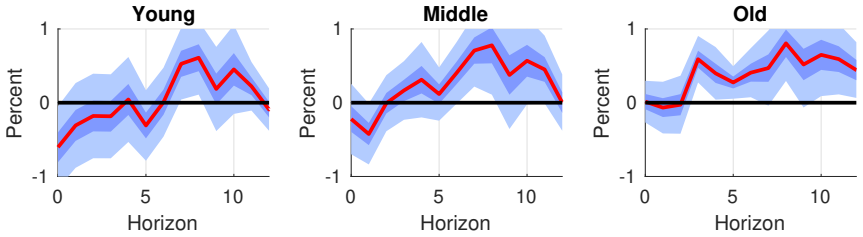
Table A2: Educational Level by Household Income

Annual Income	Educational Groups			
Before Taxes	Non HS	Complete	Higher Ed	Total
Less than $5,000	18,482	28,983	7,657	55,122
$5,000 to $9,999	20,224	33,780	7,200	61,204
$10,000 to $14,999	14,237	34,933	8,836	58,006
$15,000 to $19,999	9,659	31,298	10,505	51,462
$20,000 to $29,999	11,916	50,991	21,486	84,393
$30,000 to $39,999	6,351	36,017	19,495	61,863
$40,000 to $49,999	3,274	23,267	16,336	42,877
$50,000 to $69,999	3,264	23,981	22,337	49,582
$70,000 and over	2,742	21,194	31,247	55,183
Incomplete	6,332	26,798	16,491	49,621
Total	96,481	311,242	161,590	569,313

Notes: This table shows the number of observations according to their educational level and annual household income before taxes. Estimations are based on CEX survey.

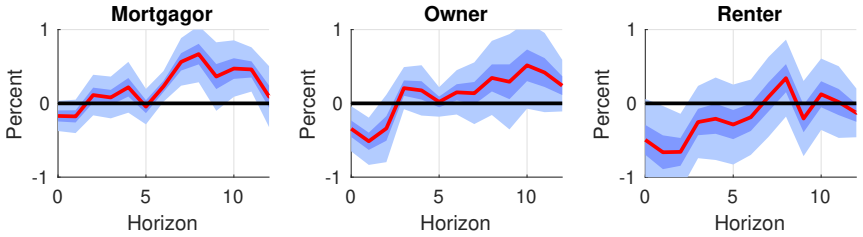
8.3 Figures

Figure A1: Local Projection by Age - J&K



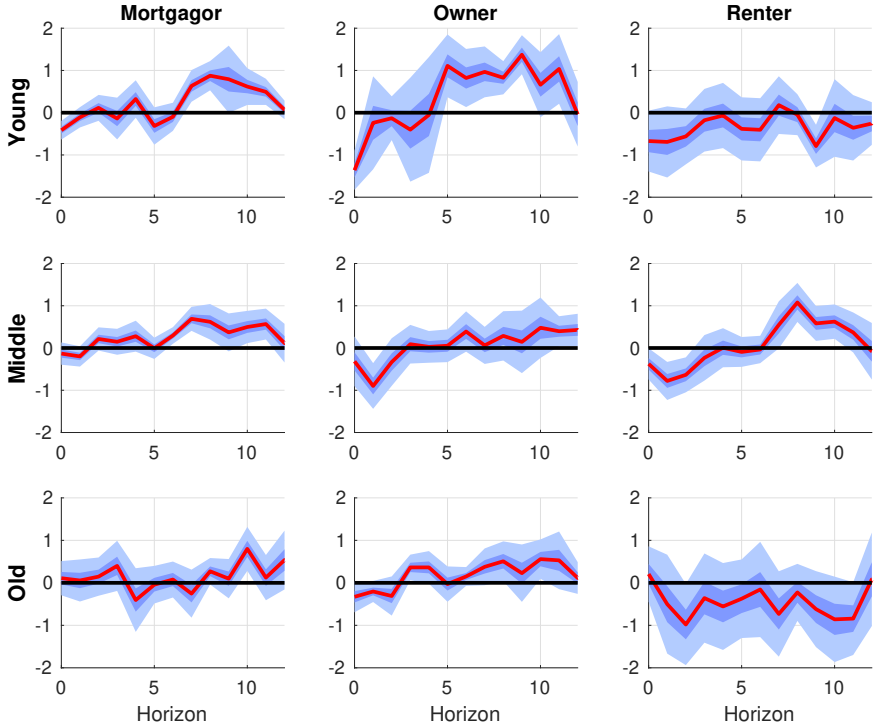
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A2: Local Projection by Tenure - J&K



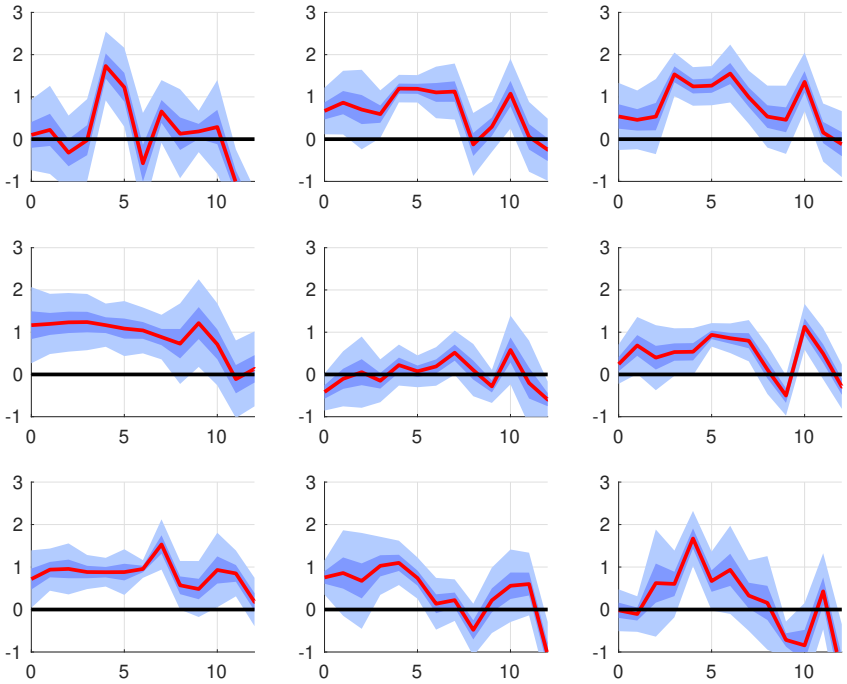
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A3: Local Projection by Age and Tenure - J&K



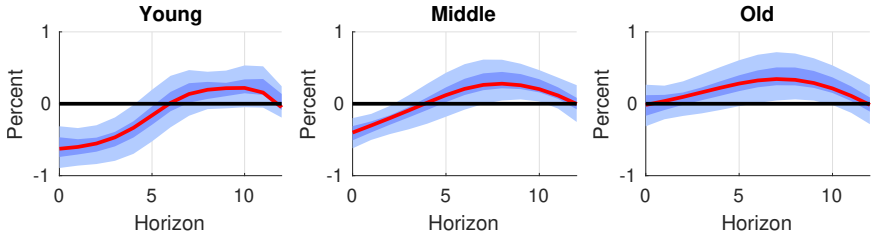
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A4: Local Projection by Age and Education - R&R



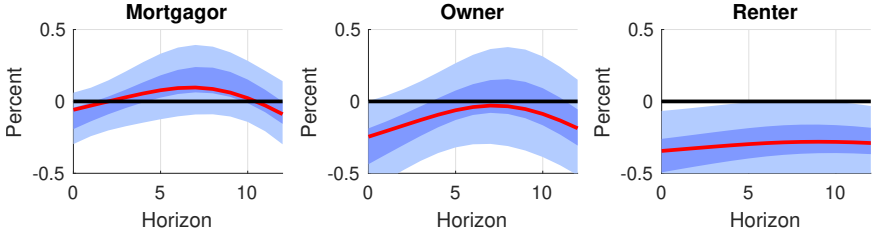
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A5: Local Projection by Age - G&K



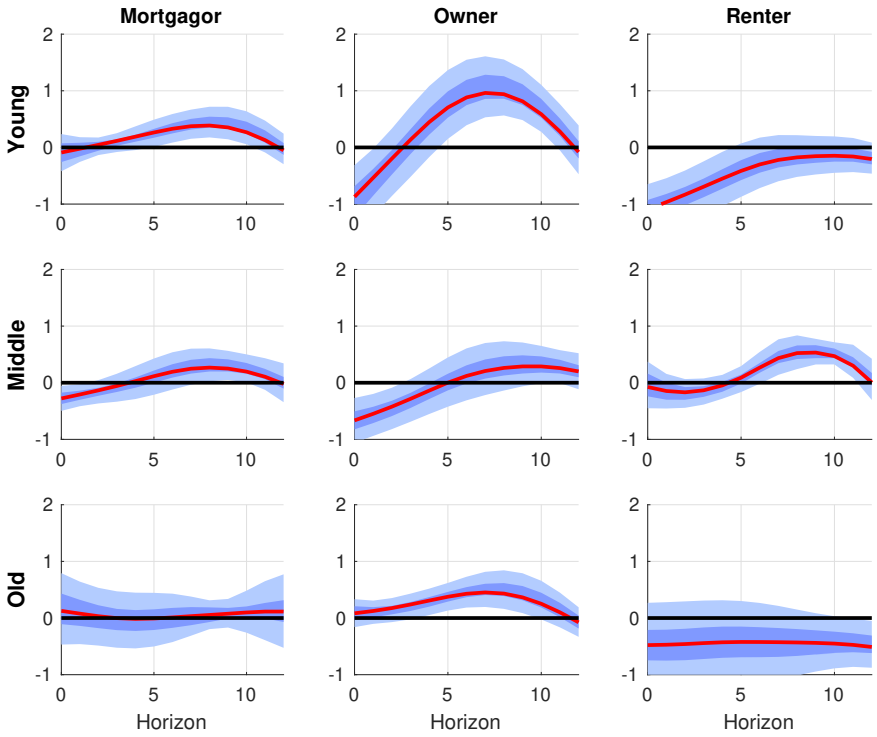
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A6: Local Projection by Tenure - G&K



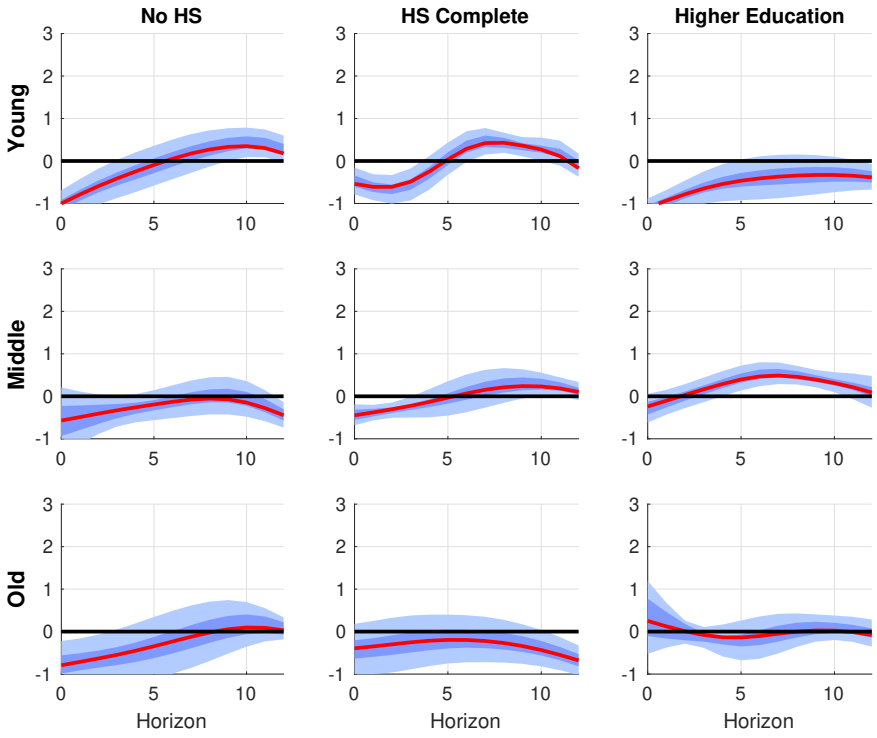
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A7: Local Projection by Age and Tenure - G&K



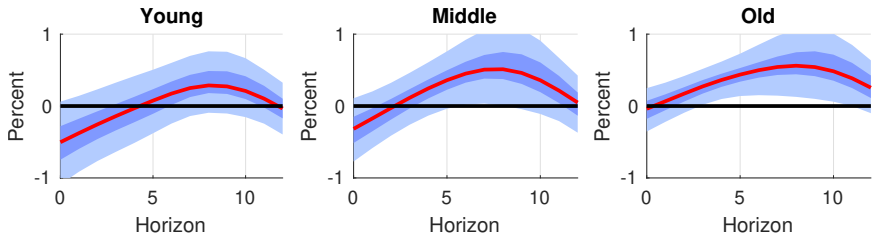
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A8: Local Projection by Age and Education - G&K



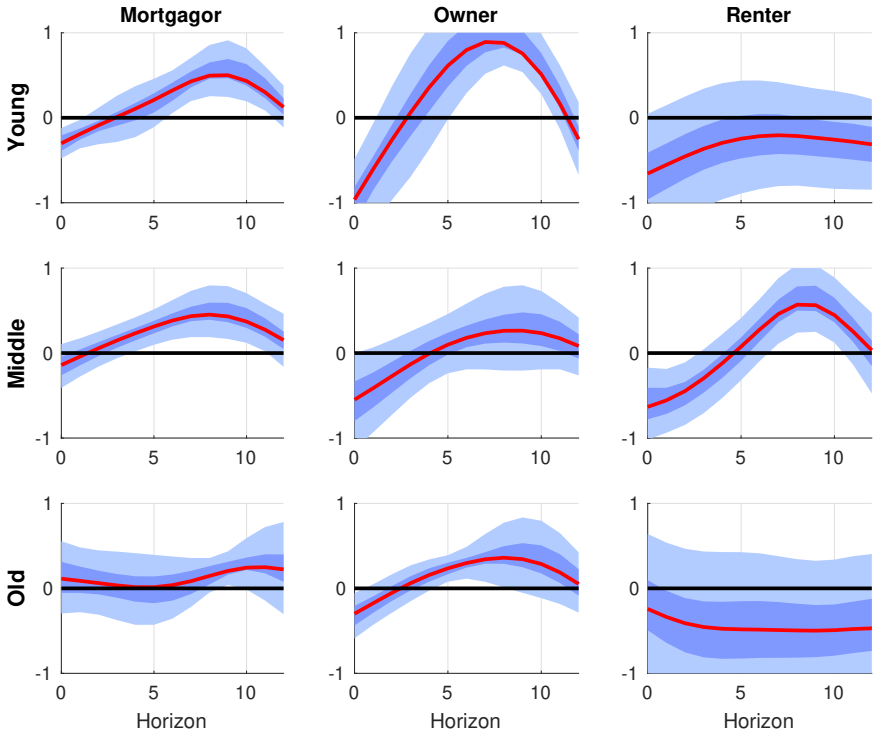
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A9: Local Projection by Age (1990-2007) - J&K



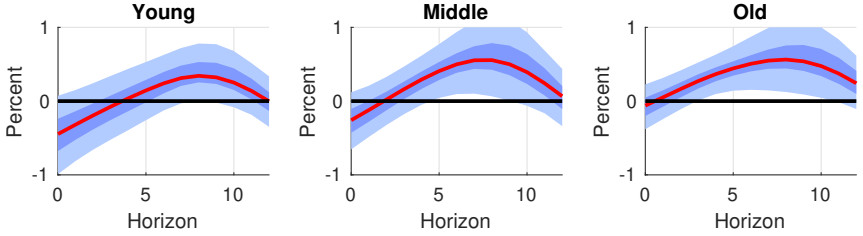
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A10: Local Projection by Age and Tenure (1990-2007) - J&K



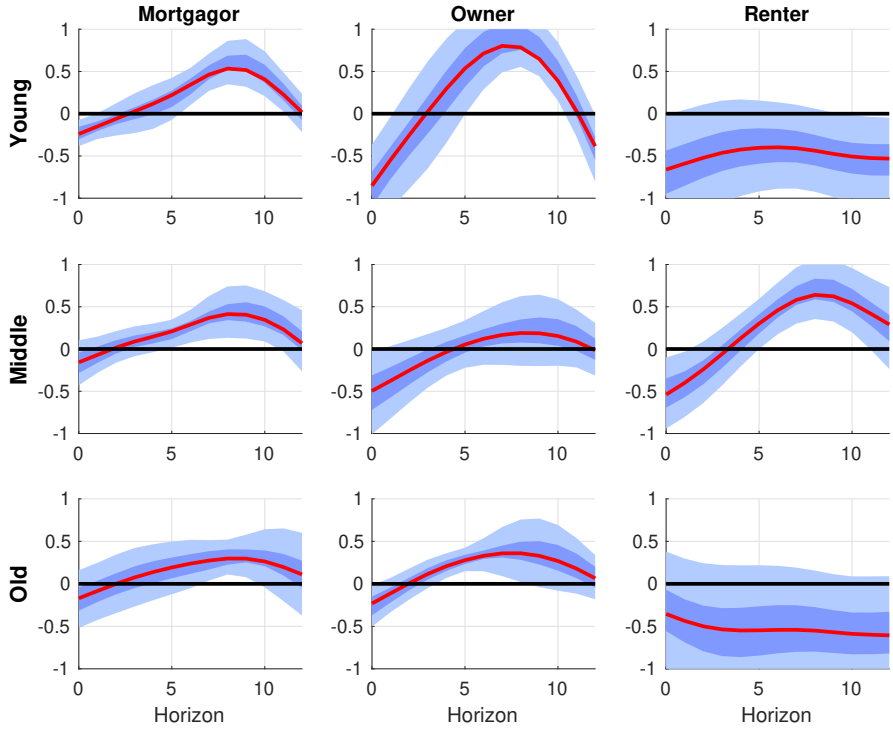
Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A11: Local Projection by Age (4-lags) - J&K



Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

Figure A12: Local Projection by Age and Tenure (4-lags) - J&K



Notes: The figure reports the IRFs to a 1-sd expansionary monetary policy shock. The dark and light blue shaded areas indicate 1 standard deviation and 1.65 sd confidence intervals, respectively.

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