Revisiting the Effect of Monetary Policy on Household Consumption: A Functional Approach *

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Abstract

Using the functional local projection (FLP) approach developed by Inoue and Rossi (2021), we revisit the effect of monetary policy shocks on household consumption. Measuring shocks as shifts in the entire term structure of interest rates reveals a heterogeneous response of households to conventional and unconventional policies. We find that consumption by outright owners is more sensitive to unconventional shocks than that of mortgagors and renters. In addition, we show that younger households' consumption is more responsive to shocks that affect medium and long-term interest rates than that of middle-age and older households. Two transmission mechanisms appear to play a key role in explaining heterogeneity in the transmission of unconventional monetary policy: differences in wealth and in the planning horizon of households.

Keywords: Monetary Policy, Interest Rates, Consumption, EIS

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1 Introduction

How do monetary policy shocks affect households' consumption expenditure? Do they affect households with different levels of debt or at different points in the life cycle in a heterogeneous manner? These questions have long been at the core of economic research and policy discussions. Yet, our understanding of how monetary policy shocks affect consumption is largely based on studies that focus on changes in short-term interest rates during conventional times. For instance, earlier empirical studies have found that differences in households' balance sheets and differences in life-cycle stages play a key role in the transmission of conventional monetary policy shocks (see e.g., Cloyne et al. (2020) and Berg et al. (2020) among others).

Unconventional monetary policy actions have been commonly employed by central banks since the Great Recession. Some features of these actions –such as forward guidance– may have heterogeneous effects on consumption expenditure, as their impact may depend on how households' perceptions of future monetary policy actions affect their wealth, future income or risk premia.[1] Yet, compared to our knowledge regarding the transmission of conventional monetary policy, less is known about the effect of unconventional measures on consumption expenditure.

The objective of this paper is to investigate the effect of unconventional monetary policy shocks on consumption expenditure and to inquire whether household characteristics found to play a key role in the transmission in conventional times are important when unconventional tools are used. To do so we use a novel method to estimate the effect of monetary policy shocks developed by Inoue and Rossi (2021): the *functional* local projections (FLP) approach. Their methodology identifies shocks as exogenous shifts in the term structure of interest rates. More specifically, following Nelson and Sigel (1987) and Diebold and Li (2006) it models yields as a function of their maturity and defines *functional* monetary

[1] Evidence that the latter type of shocks have significant effects on the term structure of interest rates is found by Gürkaynak et al. (2005)

policy shocks as movements in the term structure on monetary policy announcement days. As Inoue and Rossi (2021) demonstrate, an advantage of this approach is that it provides a unified framework to study the effect of conventional and unconventional monetary policy shocks. Furthermore, employing *functional* shocks is key for our study as traditional procedures may miss important aspects of the transmission of monetary policy shocks to aggregate output and inflation (see Inoue and Rossi (2021)), and hence might fail to capture particular features of the effect on household income. A second advantage of this approach is that it allows us to simultaneously evaluate how different dimensions of monetary policy shock affect households that face diverse financial constraints or are at different points of the life cycle. This aspect is crucial for our analysis. Because earlier empirical work identified *scalar* shocks as exogenous changes in short-term interest rates, it may have underplayed a source of heterogeneity in the consumption response to monetary policy: the diverse nature of monetary policy shocks over time. Lastly, by using the FLP methodology we are able to estimate the effect of monetary policy shocks on consumption during conventional and unconventional times using a unified framework and re-evaluate the importance of different transmission channels.

Building on the work by Cloyne et al. (2020) and Berg et al. (2020), we use household expenditure and income data from the U.S. Consumer Expenditure survey to estimate the dynamic response of consumption expenditure to monetary policy shocks. Following these studies, we construct pseudo cohorts based either on housing tenure (outright owners –hereafter owners–, mortgagors, and renters) or on age (old, middle-aged and young). By splitting the survey into pseudo-cohorts, we are able to investigate the heterogeneous response of consumption to unconventional shocks, and revisit the response to conventional shocks, along two key dimensions: differences in balance-sheet positions and differences in the stage of the life-cycle. As noted by other researchers, an advantage of these data is that they span a long period of time and contain information on household expenditure, income, assets, liabilities and age. Hence, it allows us to study how consumption dynamics have

changed as the monetary policy behavior has evolved.

We find three important differences in the transmission of monetary policy shocks during conventional and unconventional times. First, reductions in consumption expenditure are clearly an important transmission channel of contractionary monetary policy during conventional times; declines in consumption are born both by the poor (via reductions in nondurable consumption) and the wealthy (via contractions in the purchase of durables). Second, the changing behavior of monetary policy during unconventional times, shifted the burden to the wealthy households (outright owners), especially through curtailed expenditure in durable goods. Lastly, we uncover an important degree of heterogeneity in the response to unconventional shocks across age groups: shocks that simultaneously reduce short-term interest rates and increase long-term interest rates lead young households to reduce consumption while they have insignificant or slightly positive effects for middle-age and old households.

What transmission channels account for the heterogeneity in the transmission of monetary policy to consumption? While the vast majority of theoretical literature treats short-term nominal interest rates as the primary monetary policy instrument (Kaplan et al., 2018), and do not model changes in the whole structure of interest rates, it provides a solid theoretical guide for our investigation. A recent survey of heterogeneous agent incomplete market models by Kaplan and Violante (2022) notes that heterogeneity in the marginal propensity to consume (MPC) of households could stem from the presence hand-to-mouth households, precautionary savings or ex-ante heterogeneity. Clearly, ex-ante heterogeneity such as a household's stage in the life cycle, whether they mostly hold liquid or illiquid assets, among others, would result in heterogeneous MPCs and, thus, diverse responses to monetary policy shocks.

Regarding the importance of hand-to-mouth households, the literature shows that poor hand-to-mouth households –with zero or low wealth–, borrowers who face binding credit constraints, and wealthy households who hold most of their wealth in illiquid assets respond similarly to changes in short-term interest rates. However, expansionary monetary policy

actions that target long-term interest rates when short-term interest rates are stuck at the zero lower bound, could distinctly impact poor and wealthy households. We further inquire into the importance of this channel by estimating the effect of monetary policy shocks on disposable income, rental and mortgage payments –which directly affect the cash-flow of renters and wealthy-hand-to-mouth mortgagors–, and total household assets. Because housing is the largest asset in household balance sheets, we complement our analysis by inquiring into the response of housing prices to monetary policy shocks.[2] We find that, both in conventional and unconventional times, heterogeneity in the income response cannot fully explain the heterogeneity in the response of consumption expenditure. Instead, differences in balance sheet positions appear to play a key role in understanding the transmission of unconventional monetary policy. In particular, we show that the expenditure response of owners –who hold a large portion of illiquid assets– is key in understanding the transmission of unconventional monetary policy shocks.

As for precautionary saving –the idea that households save to insure against future income uncertainty because they want to smooth consumption–, Kaplan and Violante (2022) argue that the marginal propensity to consume can be large for low levels of wealth even when households do not face a binding constraint. Carroll and Kimball (2021) show that households not currently liquidity constrained may engage in precautionary saving when they believe there is a risk to face a binding constraint in the future. Therefore, even in the absence of current liquidity constraints, monetary policy announcements and unconventional monetary policy that alter household's expectations about risk premia (e.g., forward guidance) could affect consumption expenditure via this precautionary savings motive. Moreover, given a longer planning horizon, changes in the expected path of future interest rates or risk premia, stemming from unconventional monetary policy actions, might have a different effect on the young. Indeed, our estimation results speak to this issue; we find that unconventional monetary policy actions that increased short-term interest rates and reduced long-term in-

[2]Work by Mian et al. (2013), Mian et al. (2017), and Kaplan et al. (2018), among others, suggests heterogeneity in household debt plays a key role in the transmission of macroeconomic shocks.

terest rates led young consumers to increase their consumption expenditure, while it had the opposite effect on the old.

Several key insights regarding the transmission of unconventional monetary policy emerge when using the functional approach. Heterogeneity in the response of consumption expenditures across household tenure and age indicate that conventional and unconventional monetary policy have diverse effects for different population groups. While the former has a larger impact on older households and groups that face stricter liquidity constraints, unconventional policies place a larger burden on wealthier and younger households. Regarding the transmission channels that might account for differences in the response to conventional and unconventional shocks, we find two mechanisms play crucial roles. First, the contractionary wealth effect (both through housing and other assets) that stems from unconventional policies - via upward pressure on medium- and long-term interest rates- accounts for the greater sensitivity of durable consumption expenditure by outright owners. Second., our estimation results suggest the interaction between liquidity constraints and longer planning horizons is a driving factor of the heterogeneity across age groups.

Our work is related to several strands of literature. First, our paper is related to the existing literature that investigates the effects of monetary policy shocks, especially that of unconventional monetary policy actions –such as forward guidance and quantitative easing– using high frequency identification (see, e.g., Swanson (2021), Gürkaynak et al. (2005)). Our study is also related to papers that investigate the effects of monetary policy shocks during conventional and unconventional times such as Lakdawala (2019), and Jarociński and Karadi (2020), among others. Yet, we depart from the approach used in these investigations where the shock is measured as a scalar. Instead, we follow Inoue and Rossi (2021) and Inoue and Rossi (2019) who measure shocks as shifts in the entire structure of interest rates to study the effect of monetary policy on economic activity, inflation, and exchange rates.

Second, this paper is closely related to investigations that employ aggregate consumption data to inquire into the mechanisms that account for heterogeneity in the dynamic response of

aggregate consumption to monetary policy shocks across household groups. In particular, we build on the work of Cloyne et al. (2020) and Berg et al. (2020) who investigate whether the transmission of conventional monetary policy shock is influenced by differences in household balance sheets and age, respectively. Leahy and Thapar (2022) find that the share of the population under 35 (between 40 and 65) attenuates (exacerbates) the effect of interest rate increase on private employment and personal income. However, a key difference is that our paper revisits their analysis using a framework that allows us to study the effects of *conventional* and *unconventional* monetary policy in a unified manner while also digging deeper into aspects of the latter that shed some light on its transmission mechanisms.

Third, our paper relates to a large body of theoretical and empirical literature that investigates the role of household characteristics such as age, credit constraints, balance sheet positions, and wealth on the transmission of macroeconomic shocks. For instance, Kaplan et al. (2018), Kaplan and Violante (2022), McKay and Wieland (2022), Bilbiie (2020), Mian et al. (2013), Mian and Sufi (2014) and Mian et al. (2017) amongst many others highlight the importance of household balance sheets in the transmission of shocks. On the empirical front, Di Maggio et al. (2020) explore the effect of large-scale asset purchases on the real economy and consumption, while Flodén et al. (2020) and Di Maggio et al. (2017) exploit adjustable-rate mortgages (ARMs) in different contexts to illustrate the importance of balance sheets regarding the cash-flow channel. Our study provides empirical support in favor of theories that underline the importance of wealth and life-cycle effects on the responsiveness of consumption to unconventional monetary policy.

Finally, our investigation is connected to an extensive body of empirical research that investigates the effect of income changes on consumption expenditure. (See Jappelli and Pistaferri (2010) for an excellent survey.) While the earlier investigations focused on aggregate data, the vast majority of studies rely on empirical strategies that employ micro-level data. In contrast, we build our aggregated data from the household survey and are interested in estimating the dynamic response of consumption to unconventional (and conventional)

monetary policy shocks.

The paper is structured as follows. Section 2 reviews the *functional local projection* approach developed by Inoue and Rossi (2021) and discusses why considering functional monetary policy shocks is important for understanding the response of consumption. Then, we describe the data in Section 3 and discuss the empirical specification in section 4. Sections 5 and 6 discuss the results by housing tenure and age, respectively. We then explore the relevance of alternative transmission channels in section 7 and describe the results of a battery of robustness checks in section 8. Section 9 concludes.

2 Measuring Monetary Policy Shocks

We use a novel method proposed by Inoue and Rossi (2021) - the *functional local projection (FLP)* approach- to study the effect of conventional and unconventional monetary policy on household consumption. Given the novelty of the methodology, and to gain some intuition as to how the functional approach differs from the conventional approach, section 2.1 compares the functional and scalar approaches. Then, in section 2.2, we discuss why the distinction matters for estimating the effects of monetary policy on consumption.[3]

2.1 High-frequency Identification, Functional and Scalar Monetary Policy Shocks

The novelty of the functional shock approach lies not in the identification of the shock, rather in how a monetary policy shocks are measured. Consider the case, as in this paper, where a high-frequency identification (HFI) scheme is used to study the effect of monetary policy. In the HFI framework, a monetary policy shock is defined as the change in a yield at a given maturity within a short window around the FOMC announcement. (See the top left panel of Figure 1 for a hypothetical illustration). The FLP method fundamentally differs in that it

[3]Section 4 explains how the functional shocks are computed.

simultaneously captures the change at each maturity in the yield curve, as illustrated on the top right panel of Figure 1. Note that the functional shock captures the shift in the whole function (yield curve) around the time of the FOMC announcement. Hence, it comprises movements in the shorter and longer maturities around FOMC meetings simultaneously.

HFI of monetary policy shocks assumes that changes in high-frequency interest rates around FOMC announcement are only due to the monetary policy and not the endogenous contemporaneous response of monetary policy to changes in economic conditions. This high-frequency approach has been implemented using different measures of interest rates and short window lengths. For example, Gertler and Karadi (2015) measure a monetary policy shock as the change in the 3-month ahead federal funds future prices within a 30-minute window of Federal Open Market Committee (FOMC) announcements; Gorodnichenko and Weber (2016) use changes in the current month federal funds futures within a 60-minute window; Jayawickrema and Swanson (2021) uses intradaily interest rate changes using a window that starts 10 minutes before each FOMC announcement and ends 20 minutes after it. Others have applied factor models to capture changes in several contracts (Barakchian and Crowe, 2013). These methods have the advantage of estimating a well-identified average effect of changes in short-term rates; yet they ignore useful information regarding the impact of such announcement on longer-term interest rates during the same window of time. Ignoring the movement in longer maturities can lead to biased estimates of the response of economic aggregates to monetary policy shocks, even when Central Banks target short-term interest rates (Jarociński and Karadi, 2020) (Miranda-Agrippino and Ricco, 2021). The use of a functional shock approach can address this shortcoming.

The difference between scalar and functional shocks is further illustrated in the bottom panel of Figure 1. The figure plots two different simulated functional shocks. Both shocks represent examples of monetary policy tightening. The traditional approach would only take into account changes at a short-term maturity when defining the monetary policy shock. From this perspective, the shocks depicted in the left and right panels of the figure should

imply a similar response in consumption. However, as the figure shows, changes in the longer-term yields around the two FOMC announcements are quite different. The shock in the left panel, proportionally increased rates across the entire curve, whereas the shock in the bottom right panel comprised larger increases at the medium/long-term maturities. A monetary policy shock identified by changes only in the short-term maturities could miss this important difference.

The change in the entire term structure matters; roughly a third of the monetary policy shocks in the 1990s caused asset prices to appreciate (depreciate) when the short-term shock contractionary (expansionary), despite the Federal Reserve targeting a short-term rate (the federal funds rate).(Jarociński and Karadi, 2020) Since the onset of the zero-lower bound, central banks have intentionally targeted other parts of the yield curve via quantitative easing and forward guidance. Indeed, as we will see in the following sections, these actions sometimes led short- and long-term interest rates to move in the opposite direction.

The functional shock approach has several key advantages over the traditional scalar shock approach. This method provides a simple way to evaluate the impact of unconventional monetary policy on the real economy.[4] Moreover, it allows for a unified estimation of the response of the variables of interest to different types of monetary policy. For instance, it can simultaneously capture forward guidance and conventional monetary policy. In brief, it enables us to revisit the impact of monetary policy on household consumption using a unified framework over conventional and unconventional times.

2.2 Why Does the Distinction Between Scalar and Functional Shocks Matter for Consumption

The functional shock approach is well-suited to investigate the effect of monetary policy on aggregate consumption for several reasons. First, while the effect of wealth changes

[4]Gürkaynak et al. (2005) and Rogers et al. (2014) show that unconventional policy affects the term structure of the yield curve.

induced by monetary policy shocks has been long understood as a transmission channel of monetary policy (Modigliani and Brumberg (1954), Modigliani and Brumberg (1980), Ando and Modigliani (1963)), less is known about how unconventional policies affect wealth and, thus, aggregate consumption expenditure. Investigating such question is particularly important during periods such as the zero lower bound (ZLB) when unconventional monetary policy tools are heavily utilized.

Second, many empirical investigations into the transmission of monetary policy shocks identify the direct effect of the policy via changes in a single short-run interest rate (i.e., a scalar shock); the effect of the policy on long-term interest rates is captured via their response to this shock. Instead, the functional approach measures the shift in the whole yield curve around the time to the FOMC announcement and, thus, simultaneously incorporates information about future expected interest rates in the estimation of the impulse responses of interest. This is key when exploring whether the response to monetary policy shocks differs across households with different characteristics such as the composition of their assets or the stage in their life cycle. For instance, households who are wealthy hand-to-mouth (mortgagors) may have a different response to shocks that decrease the slope of the yield curve (thus reflecting lower long-term interest rates and possible gains of refinancing) than households who do not have a mortgage (outright owners). Furthermore, younger households have a longer planning horizon and could therefore be more sensitive to expected changes in long-term interest rates.

In brief, using of a scalar monetary policy shock might lead the researcher to miss heterogeneity in the response of consumption expenditure across households, especially during ZLB periods. Given that consumption is the largest component of GDP, and that previous work has found traditional identification methods might miss important monetary policy effects on output and inflation (see Inoue and Rossi (2019)), we believe is important to revisit its impact on consumption.

3 Household Consumption Expenditure Data

To investigate the effect of monetary policy shocks on consumption we use data from the Consumption Expenditure Survey (CEX) spanning the period between the first week of January 1984 and the last week of December 2019.[5] To measure household average consumer expenditure by housing tenure and age, we follow Cloyne, Ferreira and Surico (2020) and Berg, Curtis, Lugauer and Mark (2020), respectively. Consumption by housing tenure is calculated based on the code that identifies the household as outright owner, mortgagor or renter. Consumption expenditure by age group is computed based on the age of the household's head. We divide households into young (25–34), middle (35–64), and old (65+).[6]. We divide real household expenditure by the number of household members to create a per capita measure of consumption expenditure. Because the timing of the interviews may not align with calendar quarters, we weight a given household's consumption by the number of months their interviews overlap with each calendar quarter (Berg, Curtis, Lugauer and Mark (2020)). These weighted consumption measures are deflated by the Consumer Price Index.

One advantage of the CEX is that it contains detailed expenditure data on durable and non-durable goods, as well as household income at a weekly frequency. Hence, the data allows us to investigate the dynamic response of durable and nondurable consumption to monetary policy shocks. This distinction is important as recent theoretical models and empirical evidence suggest demand for durable goods is more sensitive to current changes in interest rates than to forward guidance (McKay and Wieland, 2022). An additional advantage of the survey is that it provides information on household characteristics such as the household size, demographics, mortgage, and rent payments, which allows us to investigate heterogeneity in

[5]The survey comprises five interviews conducted three months apart and the expenditure data –collected in the last four interviews– covers a twelve-month period. The motivation to use the CEX data instead of the Panel Survey of Income Dynamics (PSID) is twofold. Regular data collection for the CEX started in 1980 making it the most widely used data set to study consumption dynamics in the U.S. Data collection on expenditures other than food and housing did not start until 1999 for the PSID. Second, even for the modern PSID, data collection takes place at a bi-annual frequency, which is not an ideal frequency given our interest in identifying the dynamic response to monetary policy shocks.

[6]Cloyne, Ferreira and Surico (2020) and Berg, Curtis, Lugauer and Mark (2020) employ samples that end in 2007 and focus on the impact of conventional monetary policy.

the transmission of monetary policy across different household characteristics.

In addition, data on housing tenure status may be used a proxy for a household's balance sheet position (Cloyne, Ferreira and Surico (2020)). In particular, mortgagors are characterized by the fact that their wealth is largely composed by equity in housing. In addition, they have a large level of debt. In contrast, homeowners' wealth is composed by both housing and other financial assets. While there may be concerns regarding endogenous changes in tenure status due to a monetary policy shock, Cloyne, Ferreira and Surico (2020) provide descriptive and formal evidence that the composition changes are slow moving, while monetary policy decisions take place at a significantly higher frequency. Figure A.1 shows the composition changes between 1983 and 2019 in the CEX. As the figure illustrates, the composition remains slow moving in the extended sample.

Another concern is how well the survey data match national estimates of consumption expenditure. Figure A.2 compares total, durable and non-durable expenditure per capita across tenures with data obtained from the National Income and Product Accounts (NIPA). Each figure shows corresponding trends in the CEX and the NIPA. Table A.0 shows that the CEX series and the NIPA series are highly correlated. Note that the evolution of the CEX time series for mortgagors and owners closely follows that of the NIPA; the correlations for all variables but non-durable consumption exceed 0.95 and equals 0.87 and 0.80 for mortgagors and owners, respectively. On the other hand, renter total expenditure is highly correlated with its NIPA counterpart, but is weakly correlated for the other categories[7].

4 Empirical Specification and Estimation Strategy

Following Inoue and Rossi (2021) we identify monetary policy shocks as shifts in the yield curve, on the day of a Federal Open Market Committee (FOMC) meeting, using a parametric approach. That is, we first employ the widely-used Nelson and Siegel (1987) / Diebold and

[7]The main specification includes quarterly dummies to deseasonalize the data. Following Cloyne, Ferreira and Surico (2020), the data is also smoothed using a 4 quarter backwards-looking moving average.

Li (2006) framework to fit the yield curve using the three factor model,

$$y_t(M) = \beta_{l,t} + \beta_{s,t}\left(\frac{1-e^{-\lambda M}}{\lambda M}\right) + \beta_{c,t}\left(\frac{1-e^{-\lambda M}}{\lambda M} - e^{-\lambda M}\right) \tag{1}$$

where $y_t(M)$ denotes the yield to maturity for maturity M at time t, λ is a tuning parameter that governs the exponential decay rate (e.g., small values result in slow decay and better fit at longer maturities whereas large values result in fast decay and better fit at shorter maturities), and $\beta_{l,t}$, $\beta_{s,t}$, and $\beta_{c,t}$ represent three latent dynamic factors that govern the level, slope and curvature of the yield curve, respectively. To estimate the yield before and after the FOMC announcement, we employ the U.S. Zero Coupon yields from Gürkaynak, Sack and Swanson (2007),[8] and following Diebold and Li (2006) we fix the value of λ to 0.0609, which maximizes the loading on the medium-term factor at 30 months.

Then, the functional monetary policy shock is computed as:

$$\epsilon_{f,t}(M) \equiv \Delta y_t(M) \cdot d_t \tag{2}$$

where d_t is an indicator variable that takes the value of one when an FOMC announcement takes place at time t. Therefore, from equations (1) and (2), we may rewrite the functional monetary policy shock as

$$\epsilon_{f,t}(M) \equiv \Delta\beta^d_{l,t} + \Delta\beta^d_{s,t}\left(\frac{1-e^{-\lambda M}}{\lambda M}\right) + \Delta\beta^d_{c,t}\left(\frac{1-e^{-\lambda M}}{\lambda M} - e^{-\lambda M}\right). \tag{3}$$

where $\Delta\beta^d_{j,t} \equiv d_t \cdot \Delta\beta_{j,t}$ for $j = l, s, c$ capture the changes in the level, slope and curvature of the yield curve around the FOMC announcement. This equation makes it evident that each β embodies a different aspect of monetary policy. For instance, $\Delta\beta_{s,t}$ may be interpreted as a conventional monetary policy shock as it reflects changes in the short-term maturities. In contrast, $\Delta\beta_{c,t}$ captures changes in monetary policy that affect the medium-term yields.

[8] As in Inoue and Rossi (2021) we employ yields at 3, 6, 12, 24, 36, 48, 60, 72, 84, 96 and 120 months to fit the yield curve at any time t.

For example, unconventional monetary policy may target medium and long-term interest rates without having a significant impact on the short-term rate Inoue and Rossi (2021). This can be the case with forward guidance. In addition, $\Delta\beta_{l,t}$ corresponds to a policy that simultaneously shifts all interest rates.

As noted by Inoue and Rossi (2021), linear combinations of the three terms provide a useful way to compare differences across shocks. The combination $\Delta\beta_{l,t} + \Delta\beta_{s,t}$ yields the instantaneous change in yields whereas $\Delta\beta_{c,t} - \Delta\beta_{l,t}$ expresses changes in the long run after accounting for any simultaneous shifts. Table 2 illustrates how these parameters vary across shocks during conventional and unconventional times, respectively. For example, for the 1997:Q1 episode reported Table 2, $\Delta\beta_{l,t} + \Delta\beta_{s,t} = -0.001$ indicates that the change in the instantaneous yield was small, while $\Delta\beta_{c,t} - \Delta\beta_{l,t} = 0.228$ reveals a considerably larger increase at longer maturities. This example depicts how monetary policy may cause little to no change in the instantaneous rate, yet affect longer term interest rates though changes in the longer term yield. Henceforth, we will refer to $\Delta\beta_{l,t} + \Delta\beta_{s,t}$ as the *instantaneous yield* and $\Delta\beta_{c,t} - \Delta\beta_{l,t}$ as the *long-run yield*. Furthermore, the functional shock approach allows us to decompose the effect of a historical shock into these three components and, thus, evaluate on how much of the effect is driven by changes in each of the latent factors.[9]

Because the data used to fit the yield curve are daily, whereas consumption is measured at a quarterly frequency, once we have computed the functional monetary policy shocks around each FOMC announcements, we need to attribute the daily shift to a given quarter. To do so we aggregate the shocks that take place in a quarter.[10] We denote these quarterly structural shocks at time t by $\epsilon^q_{f,t}$ and the corresponding changes in the three factors by $\Delta\beta^q_{j,t}$, $j = l, s, c$. We then estimate the effect of these functional monetary policy shocks on household consumption via the FLP. The benchmark specification is given by:

[9] To economizes space, decomposition of the contribution of each β to the impulse response functions are not report within the paper. These are available from the authors upon request.

[10] Each quarter contains at least one announcement and most quarters contain two announcements. Estimation results reported in the appendix reveal our results are robust to aggregating the daily shocks in three different ways (i) weighting each shock by the number of days left in the month after the shock, (ii) using a simple average, and (iii) summing all the shocks in the quarter.

$$C_{t+h} - C_t = \alpha_h + \Gamma_{1,h}(L)\Delta\beta^q_{l,t} + \Gamma_{2,h}(L)\Delta\beta^q_{s,t} + \Gamma_{3,h}(L)\Delta\beta^q_{c,t} + A(L)C_{t-1} + u_{t+h} \quad (4)$$

where $C_{t+h} - C_t$ denotes the cumulative change in log expenditure for each household tenure between time t and $t+h$, the horizons of the response are given by $h = 1, 2, ...12$, the vector α_h contains quarterly dummies, a constant, and a time trend polynomial.[11] We use Newey and West (1987) standard errors to account for serial correlation.

The effect of the functional shock on consumption growth between t and $t+h$ is then computed as $\sum_{j=1}^{3} \Gamma_{j,h}(L)\Delta\beta^q_{j,t}$. Note that, for a given functional shock, the effect can be decomposed into the contribution of each $\Delta\beta^q_{j,t}$. Equation (4) implies that each monetary policy shock, $\epsilon^q_{f,t}$, has a different impulse response function, allowing us to study the effect of each policy announcement.

5 Revisiting the effects of monetary policy when households have debt

This section reports the estimation results by housing tenure, which we interpret as a proxy for debt (Cloyne, Ferreira and Surico (2020)). For ease of exposition, and to gain some intuition as to how the responses differ across housing tenure, we first present estimation results for the conventional monetary policy period in section 5.1. Then, in section 5.2, we discuss the results for the period of unconventional monetary policy. For the sake of brevity, and because each functional shock at a point in time results in an individual impulse response function, we report estimates for three selected events in each period (i.e., conventional and unconventional). Additional summary statistics are reported for other episodes.[12]

[11] For ease of comparison with earlier studies, we include a time trend polynomial as in Cloyne et al. (2020); we select the lag length by minimizing the AICC.

[12] Impulse response functions for the remaining shocks are available upon request.

5.1 Conventional monetary policy

Given that durable consumption is a key component of the transmission of monetary policy (McKay and Wieland, 2021), we dis-aggregate consumption into durables and non-durables. To economize space, we relegate the plots of the impulse response functions for total consumption to the online appendix and report summary statistics in the Tables.

To take a first glance at how functional monetary policy shocks differ across events, we follow Inoue and Rossi (2021) in reporting changes in the three yield curve factors (level, $\Delta\beta_l^q$, slope, $\Delta\beta_s^q$, and curvature, $\Delta\beta_c^q$) as well as changes in the instantaneous yield ($\Delta\beta_l^q$+$\Delta\beta_s^q$) and the long run yield ($\Delta\beta_c^q$-$\Delta\beta_l^q$).[13] As Table 2 illustrates, all episodes represent distinct changes in the yield curve. For instance, 1987Q1 corresponds to a decline in the instantaneous yield and an increase in the long run yield with the decline in the former mostly driven by a decrease in β_l^q. In contrast, in 1997Q3, the long-run yield increases while there is nearly no change in the instantaneous yield as the increase in β_s^q (typically associated with conventional monetary policy) is offset by an increase in β_l^q (due to the ability of the central bank to simultaneously shift short- and long-term expectations).

As a first summary of the results, Table 3 reports the peak response of consumption for five monetary policy episodes. The table provides evidence of heterogeneity in the magnitude of the peak consumption response to conventional monetary policy shocks. Mortgagors and renters exhibit a stronger, albeit sometimes slower, response than owners for all the monetary policy events. For instance, in response to the 1987:Q1 shock, which resulted in a 0.259% decline in the instantaneous yield and a 0.656% increase in the long-run yield, mortgagors and renters cut their non-durable consumption by more than two percent, while owners reduced it by less than one percent. In turn, durable consumption dropped by -0.805%, -0.532%, and -0.906%, respectively, for mortgagors, owners, and renters. The larger decline in mortgagors' and renters' consumption is consistent with the cash-flow channel having a

[13] Recall that while the frequency of their data is monthly, we aggregate the shocks to a quarterly frequency to match the frequency of the expenditure data.

greater impact on households that face more stringent liquidity constraints (Cloyne et al., 2020).

A key difference in the response to *scalar* and *functional* monetary policy shocks across housing tenure is our finding of a statistically significant effect on durable consumption for outright owners. To better illustrate this point, Figure 2 plots the impulse responses for three episodes along with the 68% and 90% confidence intervals denoted by light and dark blue shaded areas, respectively. The last column in the figure depicts the shift in the yield curve (i.e., the functional shock).

Consider first the response of durable consumption to the 1987Q1 shock (top panel) where the level and slope of the yield curve decline, but the curvature increases leading to a slight rise in the long run yield and a somewhat larger increase in the short run rates. In this case, the drop in durable consumption expenditure is greater for mortgagors and renters than for owners. The latter cut durable consumption, but the response is smaller and only marginally significant. In contrast, for the 1997:Q3 shock (middle panel), when the yield curve tilts downwards, owners exhibit the largest increase in durable consumption. This suggest that owners' expenditure is more sensitive to monetary policy actions that target long-term interest rates. As a last example of a functional shock during the conventional monetary policy period, consider 1998:Q4 (bottom panel) where the level and, especially, the curvature increase, but the slope declines. Notably, owners exhibit a significant decline in durable consumption that is similar (slightly larger) at the trough than the decline for mortgagors (renters) but recovers a bit faster.

Our estimation results for expenditure in durable goods stand in contrast with Cloyne, Ferreira and Surico (2020) who find no significant response of owners' consumption to an *scalar* unanticipated cut in interest rates. The difference in responses to scalar and functional shocks suggests that the former may not fully capture consumption responses that stem from changes in the slope and curvature of the yield curve and, thus, underestimate the responsiveness of wealthy households to changes in monetary policy that alter long-term

interest rates. While we will further investigate the transmission mechanism in Section 7, we posit here that an important transmission channel of monetary polices that lower long-term interests rates is that they stimulate purchases of durable goods by wealthy households. Such stimulus may act via increases in wealth that result from appreciation of the assets held by owners.

As for the effect of the functional monetary policy shocks on non-durable consumption, the heterogeneity found across housing tenure is consistent with the recent estimates for scalar shocks (see, e.g. Cloyne, Ferreira and Surico (2020)). Nondurable expenditure by households with a higher level of debt (mortgagors) and, especially, by those more likely to live hand-to-mouth (renters) is more sensitive to changes in interest rates (see Figure 3). That the response for functional and scalar shocks are similar, is perhaps not surprising as non-durables goods are well known to be less interest rate sensitive whereas durable goods are often financed (Mankiw (1985), Lerner (1959), Rampini (2019)).

To summarize, the effects of conventional *functional* monetary policy shocks on non-durables are consistent with those found in the earlier literature using *scalar* shocks. In contrast, our estimates underscore the importance of considering changes in the slope and curvature of the yield curve when estimating the response of durable consumption, especially for households with lower debt.[14]

5.2 Unconventional monetary policy

In the prior section, we showed that taking into account changes in the entire term structure is important for estimating the consumption response of owners to conventional monetary policy. Less is known about the transmission mechanisms of unconventional monetary policy on the average household's consumption expenditure. Previous studies have found that quantitative easing shifts the term structure towards the origin implying decreases in the short- and medium-term rates with larger changes in the long-term rates (Inoue and Rossi,

[14]Responses for total consumption expenditure are reported in Figure A.1 of the Online Appendix.

2021). Furthermore, some investigations suggest that forward guidance may have an expansionary effect on output (see, e.g. Lakdawala (2019), Jarociński and Karadi (2020). Such results highlight the importance of taking a comprehensive approach to modeling the effect of unconventional monetary policy on household expenditure.

Table 2 reports the values of the factors and key linear combinations for the selected episodes of unconventional monetary policy. For most episodes, the change in the long-run yield exceeds that in the instantaneous yield. The only exception being 2014Q2 where the magnitudes match. That unconventional monetary episodes exhibit larger changes in the long-term yield is to be expected as longer maturities where the targeted instrument when the short-term interest rates hit the zero lower bound. Yet, it is important to note that for the majority of events, monetary policy actions did not result in a parallel shift of the yield curve.

Table 3 reports the peak/trough response of durable, non-durable, and total consumption expenditures across housing tenures for the selected shocks. Interestingly, 2009Q1 saw increases in the short-term interest rate but decreases in the long-run. In a conventional method where a shock is a scalar, this shock would be interpreted as monetary tightening; however, the functional shock method reveals a more nuanced picture. Also to be noted are the opposite signs of the changes in the instantaneous and long run yields for 2012Q3 and 2012Q2.

Three patterns emerge from Table 3. First, owners' purchases of durable goods are more sensitive to unconventional monetary policy shocks than renters and mortgagors. Second, purchases of durables by wealthy hand-to-mouth households (mortgagors) respond in the same direction but to a lesser degree than owners. Third, owners' purchases of non-durable goods are less sensitive than those of renters and mortgagors.

To better grasp the variation in dynamic responses to unconventional monetary policy shocks, Figure 4 plots the responses of durable consumption expenditure for three episodes: 2009Q1, 2013Q2, and 2014Q2. The last column illustrates the shift in the yield curve

associated with the corresponding monetary policy shock. Figure 5 depicts the responses of non-durable consumption expenditure for the same episodes.

The impulse responses clearly illustrate how shocks that tilted the yield curve downwards (2009Q1 and 2014Q2) resulted in significant increase in durable consumption for owners, a smaller and marginally significant increase for mortgagors, and a statistically insignificant increase for renters. In contrast, the 2013Q2 shock, which resulted in a considerably steeper yield curve, led to a large and significant decline in purchases of durable goods for owners, marginally significant decline in durables' expenditure for mortgagors, and no significant response for renters.

The response of non-durable expenditure stands in contrast with that of durables. For the three episodes highlighted in the paper where unconventional monetary policy mainly alters medium and long-term interest rates, the direction of the response is consistent with that found for the conventional monetary policy episodes, albeit estimated with a low degree of precision.

5.3 Unifying threads

As mentioned earlier, the functional approach provides a unifying framework to analyse the response of consumption expenditure to conventional and unconventional shocks. Yet, for ease of exposition, we followed Inoue and Rossi (2019) and focused on a few monetary policy shocks to illustrate the impact of these policies. However, the reader may wonder if our results would change were we to pick a different set of events. Figure 6 illustrates the consumption responses across housing tenure for all events in the sample. The two top panels depict the impulse response functions and the two bottom panels show a slice of the surfaces depicting the peak/trough response for each episode.

Two unifying threads connect the responses across different monetary policy events: the greater sensitivity of durable consumption by wealthier households (especially the less-liquidity-constrained outright owners) and the greater responsiveness of nondurable con-

sumption by poorer, liquidity constrained households.

There are three potentially important takeaways from our estimation results. The first is that heterogeneity in the consumption response to monetary policy may stem not only from the micro-level characteristics of the households (e.g., the liquidity of their assets), but also from the the type of policy implemented. In fact, Figure 6 reveals an important degree of variation across different shocks. Another key takeaway is that contractionary monetary policies –whether conventional or unconventional– exert a large burden on liquidity constrained households who, when faced with lower cash-flows, are forced to curtail their nondurable consumption. Hence, such policies may exacerbate consumption inequality during inflationary times. Lastly, because contractionary monetary policies that target long-term interest rates have a greater impact on wealthier less-liquidity constrained households, the consequences of such policies on consumption inequality might be less detrimental.[15]

6 Revisiting the effects of monetary policy shocks across demographic groups

Berg, Curtis, Lugauer and Mark (2020) find that consumption expenditure by older households is more sensitive to conventional monetary policy shocks than that of young and middle age households. They conjecture that "life-cycle heterogeneity in wealth, portfolio composition, discounting and planning horizons, and labor supply" accounts for the heterogeneous response across age groups. This section investigates whether more nuanced effects of monetary policy on the consumption across different age groups is found when using a *functional* approach.

[15]Responses for total consumption expenditure are reported in Figure A.2 of the Online Appendix.

6.1 Monetary policy and consumption over the life cycle

Figures 7 and 8, respectively, plot the response of durable and non durable expenditure to conventional monetary policy shocks for the three age groups. The solid line denotes the impulse response, while 68% and 90% confidence bands are denoted by the light and dark blue areas, respectively. The corresponding figures for unconventional times are reported in Figures 9 and 10. The magnitude of the peak/trough response, along with the horizon at which they occur, are summarized in Table 4.[16]

Three takeaways are gleaned from the estimation results. First, durable consumption expenditures by middle age and older households are rather unresponsive to monetary policy shocks during unconventional times. Second, monetary policy shocks that comprise larger drops in long-term than in short-term interest rates (e.g., 1997Q3, 2012Q3, 2013Q1) have a greater impact on durable purchases made by the young. Finally, unconventional monetary policy had heterogeneous effects on the nondurable consumption by old and young households. More specifically, shocks that tilted the yield curve upwards led the young to cut their purchases of non durable goods, whereas older households slightly increased their spending.

It is interesting to contrast our results with those of Berg, Curtis, Lugauer and Mark (2020) who study the effects of *scalar* monetary policy across these demographics during conventional times. They find older households to be more responsive to monetary policy shocks identified as changes in short-term interest rates. Using Inoue and Rossi (2021)'s functional approach we uncover an additional layer of heterogeneity: policy actions that affect the slope and curvature of the yield curve cause younger households to curtail their spending in non-durable goods while older households slightly increase their purchases. This response is consistent with young households facing more stringent liquidity constraints than the middle-aged or the old. Durable consumption of young households is also more responsive to these monetary policy shocks, which suggest differences in wealth and portfolio

[16]For the sake of brevity, we focus on select episodes. Estimates for other dates are available from the authors upon request.

composition could give rise to heterogeneous responses to shocks that tilt the yield curve.

To further inquire what mechanism drives the response of young households, we split the young into mortgagors, owners and renters. The motivation for splitting the sample in this manner is threefold. First, recent literature has found heterogeneity in the response of consumption to conventional monetary policy across household tenure, even after controlling for demographics (Campbell and Cocco (2007), Cloyne et al. (2020)). Thus, differences in balance sheets might account for the response of the young. Second, for households that expect to work many years before retiring, monetary policy shocks that largely affect expected long-term interest might have a very heterogeneous effect depending on their debt profile.

6.2 Heterogeneity among the young

Our results for the conventional monetary episodes are consistent with Berg et al. (2020) who, using a sample that ends in 2007Q4, find that old households are more responsive to monetary policy shocks. Yet, for the unconventional period, our results stand in stark contrast with their findings. This begs the question of what drives the sensitivity of the young. Is it driven by households that are more liquidity constrained or by the rich young household that hold less debt? This brings us to our third motive for splitting the sample. As Figure A.3 illustrates, there is a large degree of heterogeneity in household tenure across demographics. Specifically, the majority of young households are renters or mortgagors (see Figure A.3 in the appendix), but there is a non-negligible percentage of young households that are outright owners.

Thus, we zero in on the young and focus on four monetary policy shocks: 1997Q3, 1998Q4, 2009Q1, and 2012Q3. The first two shocks fall on conventional times, whereas the last two correspond to unconventional episodes. Interestingly, the 1997Q3 shock resembles the shocks during unconventional times in that it did not shift the yield curve in a parallel fashion, but tilted it. As Figure 7 illustrates, the response of durable consumption to mon-

etary policy shocks differs across housing tenure. During conventional and unconventional times, young owners increase their purchases temporarily while young renters and mortgagors cut theirs. For instance, at the trough, durable consumption of young owners drops one percentage point in response to the 2012Q2 shock. In contrast, that of young renters and young mortgagors exhibits a statistically significant change. Regarding purchases of non-durables, young mortgagors and renters curtail their purchase when short-term interest rates increase, but do not when the monetary policy mainly implies an increase in long-term interest rates.

6.3 Unifying threads

As we did when revisiting the response to monetary policy when household have debt, we will end this section by taking a comprehensive look the responses by household age. Figure 11 illustrates the consumption responses across age for all events in the sample. The two top panels depict the impulse response functions and the two bottom panels show a slice of the surfaces depicting the peak/trough response for each episode.

Two unifying threads across monetary policy events are the greater sensitivity of durable consumption expenditure by older households and the greater responsiveness of nondurable consumption by younger households. As previous studies, we find an significant degree of heterogeneity in the response of consumption expenditure over the life cycle. In addition, our results reveal an important degree of heterogeneity across different monetary policy events. In particular, we find a higher responsiveness of nondurable consumption expenditure to unconventional monetary policy for young households than for other age groups.

7 Revisiting the monetary transmission mechanisms

The previous sections revisited the effect of monetary policy shocks when households have debt and across demographics using a functional LP approach. We uncovered a significant

degree of heterogeneity in responses across housing tenure and demographic groups. Two novel results are the finding of an economic and statistically significant response of owners to unconventional monetary policy shocks, and a significant response of young households to monetary policy shocks that mostly affect expectations of future interest rates. Differences in the response of consumption spending to diverse functional shocks are in line with Inoue and Rossi (2021)'s results that illustrate how specific features of the shape of the terms structure of interests rate may have different effects on output. Our results suggest that an important component of the transmission mechanism works through the effect monetary policy has on expected long-term interest rates and, in turn, on durable consumption. In this section, we dig deeper into the possible transmission mechanisms by estimating the impact of particular functional shocks on income, mortgage and rental payments, housing prices and assets holdings.

7.1 The Effect on Mortgage and Rental Payments

Previous studies (see e.g., Cloyne et al. (2020)) find that U.S. rental (mortgage) payments increase (decrease) in response to a conventional expansionary monetary policy shock. Yet, scalar shocks may mask variations in historical responses that stem from changes in expectations about future interest rates.

To investigate this transmission channel, we compute the average real per capita mortgage/rental payment by summing the payments and dividing by the number of adults in a household. Then, we estimate the impulse response functions using FLP. Figure 12 depicts the response of mortgage and rental payments to selected monetary policy shocks. Two results stand out. Parallel shifts in the yield curve (1987Q1, 1998Q4) appear to have little impact on mortgage payments. In contrast, unconventional monetary policies that result in larger drops in long-term than short-term interest rates lead to significant declines in mortgage payments in the medium and long run. This suggest that unconventional monetary policies that target long-term interest rates may stimulate expenditure by having a direct

impact on mortgage payments.

Regarding rental payments, we find a statistically significant response for almost all selected episodes (see Figure 12). In general, we find that monetary policy that exerts downward pressure on long-term interest rates lowers the user cost of housing and, by providing households with an incentive to purchase over renting, puts additional downward pressure on rental payments. An important take-away is that monetary policy that results in lower interest rates in the short- and the long-run relaxes the liquidity constraints of renters. Resources that result from lower rental payments can then be used to purchase durable and non-durable goods.

In brief, this section provides evidence in support of the household cash flow channel of monetary policy during conventional and unconventional times.

7.2 Wealth Effects

Changes in wealth have been long considered to have important effects on consumption. For instance, Chodorow-Reich et al. (2021) find "that for every dollar of increased stock market wealth, consumer spending rises by 2.8 cents per year", whereas Mian et al. (2013) and Kaplan et al. (2018) find significant effects of house pricing changes on consumption.

To inquire whether the heterogeneity we uncover in the response of consumption to functional monetary policy shocks could be driven by differences in the response of assets to diverse shocks we take a two-pronged approach. First, we investigate the effect of the shocks on household asset holdings by using data obtained from the Board of Governors of the Federal Reserve System Flow of Funds. We deflate the total household asset holdings by the CPI and compute logged growth rates. Second, to complement the analysis of section 7.1 and to gather additional insights into the housing wealth channel, we estimate the effect of select monetary policy shocks on housing prices. We measure housing prices as the purchase-only house price index for the U.S. computed by the U.S. Federal Housing Finance Agency and retrieved from FRED as in Mishkin (2007). We deflate this housing price by the CPI.

Figure 13 reports the response of total households assets. As the figure illustrates, for all the depicted episodes we find monetary policy actions that result in lower (higher) long-term interest rates lead to increases (decreases) in real asset holdings. Our results are broadly consistent with the seminal work of Bernanke and Kuttner (2005) who find the monetary tightening in the US leads to negative stock returns, and recent work by Bekaert et al. (2021) who find evidence of a negative effect of such policy on bond returns. An important takeaway from the functional framework is that the negative relationship between total asset holdings and interest rates is driven by changes in the long-term component of the yield curve. For instance, real asset holdings declined in 2013Q2 when short-term interest rates remained almost unchanged while the yield curve tilted upwards. These results suggest wealth effects play a key role in accounting for the consumption response of owners during unconventional times.[17]

Figure 13 provides additional evidence in favor of a wealth channel that operates through housing wealth and partially accounts for the heterogeneity found across housing tenure and age. More specifically, monetary policy shocks that exert downward pressure on long-term interest rates lead to increases in the average price of houses sold. Housing wealth for outright owners and older households, who hold more housing assets, thus increases allowing them expand consumption expenditure.

7.3 The Effect on Income

As demonstrated by Inoue and Rossi (2021) monetary policy shocks that result in a rise (drop) in short-term interest rates while exerting upward (downward) pressure on expectations of future interest rates have different effects on GDP than scalar shocks. This suggests that general equilibrium effects of monetary policy on household income may differ across diverse functional shocks and could further account for the heterogeneity in the response across housing tenure or age. We thus investigate how total income net of taxes responds to

[17] Gürkaynak, Sack and Swanson (2005) find that unconventional monetary policy actions and statements have a significant effect on asset prices.

selected functional monetary policy shocks across housing tenure and age. Two results stand out from Figures 14 to 17. First, there is some evidence of heterogeneity in the response of disposable income across housing tenure and age during conventional times. In particular, shocks that cause short- and long-term interest rates to increase (1987Q1, 1998Q4) result in lower income for mortgagors and renters, but have a slightly positive effect on owners' income in the long run. Moreover, young households are somewhat more responsive than middle-age and old households to shocks that comprise larger movements at longer maturities (e.g., 1997Q3). Second, we find no evidence of heterogeneity in the response of income during unconventional times.

Contrasting the response of income with that of expenditure suggests heterogeneity in the response of the latter, is not generally driven by heterogeneity in the effect of monetary policy on income across groups. In fact, for most shocks, the response of income is statistically insignificant. The only exception appears to be the 1987Q1 episode where a typical conventional monetary policy shock comprised by larger increases in the short than the long-run interest rates results in a significant decline in income for mortgagors and renters, but no immediate resource windfall for owners.

8 Robustness Checks

This section summarizes the results of a battery of robustness checks. As in the earlier sections, we restrict the discussion to select functional shocks and for the sake of brevity, we relegate the figures to the Appendix.[18]

Alternative Measures of Consumption Figures A.5 and A.6 depict the response of consumption expenditure when alternative measures of expenditure are used. For reference we also plot the baseline response along with 68% and 90% confidence intervals.

As mentioned earlier, we do not use the probability weights provided by the CEX to

[18]Estimation results for all monetary policy events and alternative specifications are available form the authors upon request.

group households. Instead, we follow Berg et al. (2020) and Dynan et al. (2009) to compute expenditure by groups. Yet, the reader may wonder whether our results are robust to using the CEX weights or if differences between our results and thus from Cloyne et al. (2020) stem from using different weights. As the blue x dashed line in Figures A.5 and A.6in the Appendix illustrate, the response by housing tenure is almost identical to the baseline estimates.

Given that housing constitutes a large expenditure for households, we also check whether our estimates are robust to computing average consumption spending after excluding housing expenses. The yellow "+" line in Figures A.5 and A.6 in the Appendix show that the responses retain their shape and significance; yet, a decline in the magnitude of the consumption response at the peak/trough is evident. This indicates that contractionary monetary policy -whether conventional or unconventional- has a negative effect on households' expenditure that is not completely accounted for by changes in rental and mortgage payments.

Alternative Estimation Strategies and Model Specification The estimation results presented in the previous sections were obtained using a fourth-order polynomial (Inoue and Rossi (2021)) in order to avoid excess variation that is common in local projection estimates of impulse responses. Such strategy can be interpreted as a generalization of Barnichon and Brownlees (2019) smooth local projections approach to the case of multidimensional shocks. To alleviate any concerns that the use of the polynomial smoothing may provide a different story regarding the impact of monetary policy shocks, the red circle line in Figures A.5 and A.6 report the responses computed using the common local projections in the dashed circle marker red line. As expected, there is more variation in the local projection estimates; yet, the qualitative results remain unchanged.

We also evaluate whether the results are robust to estimating the model in levels including a linear and time trend. Figures A.7 and A.8 plot the estimated impulse response functions. As can be seen, the level responses are very similar to the cumulative responses corresponding to the main specification.

Alternative time aggregation The last set of robustness checks explore alternative computations of the quarterly *functional* monetary policy shocks. Specifically, we explore whether using a simple average of the shocks in the quarter or the sum of all the shocks alters our results. We confirm that our results are robust to computing the shocks in these alternative ways. The dashed circle marker red line and the diamond blue line in Figures A.9 and A.10 report the mean and sum aggregation respectively and reveal no significant changes.

9 Conclusions

Using FLP approach, this paper revisited the effect of monetary policy shocks on households' consumption expenditure and inquired into the sources of heterogeneity across two key dimensions: housing tenure and age. We found that heterogeneity across functional shocks constitutes an additional layer of heterogeneity whereby conventional and unconventional policies might have diverse effects on different population groups.

Our work provided new insights regarding the effects of monetary policy when households have debt. In particular, while prior work found outright owners to be rather insensitive to (scalar) conventional contractionary monetary policy, we showed they are more responsive than renters and mortgagors to unconventional policies. In addition, we provided evidence suggesting the wealth-channel constitutes an important transmission channel for monetary policy.

We also found new empirical evidence of heterogeneity in the response of households across different age profiles. More specifically, we showed that unconventional monetary policy affects young households and old/middle-aged households in a different manner. Shocks that simultaneously reduce short-term interest rates and increase long-term interest rates, typical of unconventional times, led young households to reduce consumption while they had insignificant or slightly positive effects for middle-age and old households. We posited that

differences in the planning horizons could account for these differences.

Building on the work of Inoue and Rossi (2019), we found that although monetary policy events that comprise unambiguous increases (decreases) in the whole term structure of interest rates have contractionary (expansionary) effects on consumption expenditure, the largest component of GDP. Yet, even these events have heterogeneous effects across households with different levels or debt or who are at different points of the life cycle.

Two potentially important implications for the conduct of monetary policy stem from our analysis. First, the greater sensitivity of durable consumption by outright owners and older household to unconventional monetary policies suggest that, as the fraction of the population aged 65 years and older who have less need to borrow increases, monetary policies that target medium and long-term interest rates might become increasingly useful in stimulating consumption, and thus economic activity, during recessionary times. A second important implication is that conventional contractionary policies may place a higher burden on young liquidity constrained households and, thus, exacerbate consumption inequality during inflationary times.

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Table 1: Quarterly Expenditure by Tenure

	Durable		**Non-Durable**		**Income**	
	Mean	Std	Mean	Std	Mean	Std
Housing Tenure						
Mortgage	4492.42	542.21	7471.83	619.71	42321.41	6488.73
Own	3608.40	535.10	7634.76	791.39	30909.07	5584.09
Rent	2823.20	347.61	5720.75	222.12	27048.46	2516.91

Table 1 above presents the average quarterly expenditure from January 1984 to December 2019 for each housing tenure in the Consumer Expenditure Survey in 2010 US Dollars. Each category of consumption follows the definitions detailed in Cloyne, Ferreira and Surico (2020) .

Table 2: Monetary Policy shocks in Selected Episodes

Date	Level $\Delta\beta_l^q$	Slope $\Delta\beta_s^q$	Curvature $\Delta\beta_c^q$	Instantaneous Yield $\Delta\beta_l^q + \Delta\beta_s^q$	Long Run Yield $\Delta\beta_c^q - \Delta\beta_l^q$
Conventional					
1987 Q1	-0.243	-0.016	0.413	-0.259	0.656
1991 Q2	-0.068	-0.115	0.067	-0.183	0.135
1997 Q3	-0.216	0.215	0.012	-0.001	0.228
1998 Q4	0.022	-0.492	0.496	-0.47	0.474
2002 Q3	-0.161	0.064	0.752	-0.096	0.913
Unconventional					
2009 Q1	-0.326	0.348	0.268	0.022	0.594
2012 Q3	0.140	-0.137	-0.188	0.003	-0.329
2013 Q2	0.262	-0.31	-0.045	-0.048	-0.307
2014 Q2	-0.128	0.156	-0.101	0.028	0.028

Table 2 presents the factors that summarize each of the select conventional and unconventional monetary policy shock episodes. Instantaneous yield and long run yield help describe changes in the latent factors of the yield curve.

Table 3: Peak/Trough Responses to Monetary Policy Shocks By Tenure

	Mortgagors		**Owners**		**Renters**	
	Magnitude (%)	Horizon	Magnitude (%)	Horizon	Magnitude (%)	Horizon
Durable						
1987 Q1	-0.805	8	-0.532	4	-0.906	12
1991 Q2	-0.68	8	-0.617	5	-0.643	9
1997 Q3	0.281	12	0.584	8	-0.213	12
1998 Q4	-1.951	8	-2.044	6	-1.702	9
2002 Q3	-0.226	8	0.158	10	-0.406	12
2009 Q1	0.492	12	0.97	7	-0.26	12
2012 Q3	-0.175	12	-0.37	8	0.146	12
2013 Q2	-0.484	12	-0.9	7	-0.247	8
2014 Q2	0.254	7	0.46	7	0.138	8
NonDurable						
1987 Q1	-2.033	6	-0.858	8	-2.917	5
1991 Q2	-1.429	6	-0.419	4	-1.868	5
1997 Q3	-1.498	12	-1.061	10	-1.569	12
1998 Q4	3.679	12	-1.023	4	-4.42	5
2002 Q3	-0.802	7	-0.662	10	-1.348	12
2009 Q1	-2.438	12	-1.634	10	-2.323	12
2012 Q3	0.953	12	0.686	10	1.025	12
2013 Q2	2.189	12	1.356	10	1.815	12
2014 Q2	-1.107	12	-0.67	10	-0.879	12
Total						
1987 Q1	-0.863	8	-0.332	5	-1.046	12
1991 Q2	-0.458	7	-0.342	4	-0.423	6
1997 Q3	-0.415	11	0.247	4	-0.887	12
1998 Q4	-0.911	7	-1.103	4	-0.758	5
2002 Q3	-0.432	9	-0.105	9	-0.679	12
2009 Q1	-0.631	12	0.427	4	-1.334	12
2012 Q3	0.271	11	-0.154	4	0.577	12
2013 Q2	0.519	12	-0.412	4	1.069	12
2014 Q2	-0.256	12	0.213	4	-0.522	12

Table 3 reports the peak/trough magnitude and horizon of the consumption response to a select functional monetary policy shock. Each column corresponds to the percentage change and timing of the consumption response for a given group. Each row represents a given monetary policy shock episode. Durable and Non-Durable Consumption are as defined in Cloyne et al. (2020)

Table 4: Peak/Trough Responses to Monetary Policy Shocks by Age Group

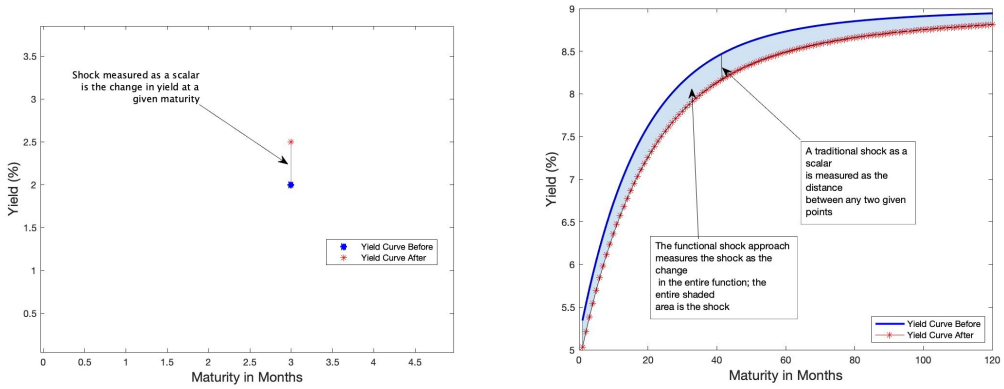
	Middle		**Older**		**Younger**	
Date	Magnitude(%)	Horizon	Magnitude(%)	Horizon	Magnitude(%)	Horizon
Durables						
1987 Q1	-0.956	6	-1.271	5	-0.805	8
1991 Q2	-1.180	7	-1.359	5	-1.371	7
1997 Q3	0.115	8	0.096	5	0.211	6
1998 Q4	0.088	3	0.083	6	-0.279	6
2002 Q3	-0.480	8	-0.438	5	-0.389	7
2009 Q1	-0.493	12	-0.862	12	1.339	6
2012 Q3	-0.038	7	-0.037	8	-0.135	6
2013 Q2	-0.171	7	0.320	12	-0.540	6
NonDurables						
1987 Q1	-2.603	7	-3.652	5	-1.587	3
1991 Q2	-2.149	7	-2.41	4	-2.897	4
1997 Q3	-0.252	12	-0.248	10	0.489	4
1998 Q4	0.690	5	1.088	5	-0.999	5
2002 Q3	-1.218	6	-1.565	4	0.94	12
2009 Q1	-2.981	5	-5.471	10	5.860	5
2012 Q3	0.209	12	0.312	10	-0.395	5
2013 Q2	0.758	5	1.764	10	-2.099	5
2014 Q2	-0.634	5	-1.315	10	1.505	5
Total						
1987 Q1	-0.695	7	-1.000	5	0.342	5
1991 Q2	-0.739	7	-0.720	5	-0.478	7
1997 Q3	0.051	7	-0.081	12	0.148	5
1998 Q4	0.194	5	0.252	6	-0.331	5
2002 Q3	-0.473	7	-0.410	5	-0.141	1
2009 Q1	-1.112	8	-1.424	11	1.280	6
2012 Q3	0.040	4	0.069	11	-0.120	5
2013 Q2	0.306	8	0.474	11	-0.429	6
2014 Q2	-0.237	8	-0.345	11	0.327	6

Table 4 depicts the peak expenditure responses to select monetary policy shocks. Each column corresponds to the percent deviation and timing of the consumption response for a given group. Each row represents a given monetary policy shock episode. The table is divided into three measures of expenditure: Durable, Non-Durable and Total Consumption. Durable and Non-Durable Consumption are as defined in Cloyne et al. (2020)

Figure 1: Functional Shock Example

(a) Traditional Shock

(b) Functional Shock



(c) Comparing Functional Shocks

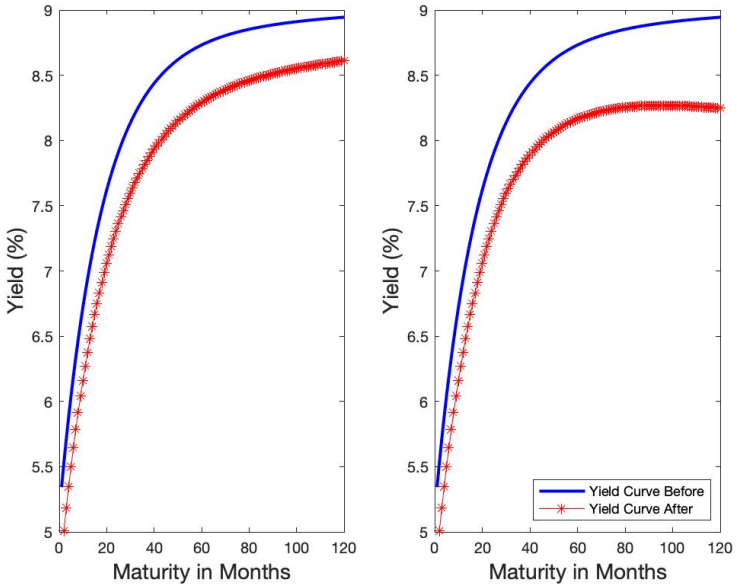


Figure 1 illustates an example of a functional shock in three parts. In the upper-left, the figure depicts how a traditional shock is measured in a given point in time. The figure in the upper right describes how a functional shock captures the change in an entire function, not just a single point. The bottom figure shows how to functional shock can have similar differences at some maturities, but greatly different at others.

Figure 2: Durable Consumption Response by Housing Tenure, Conventional Times

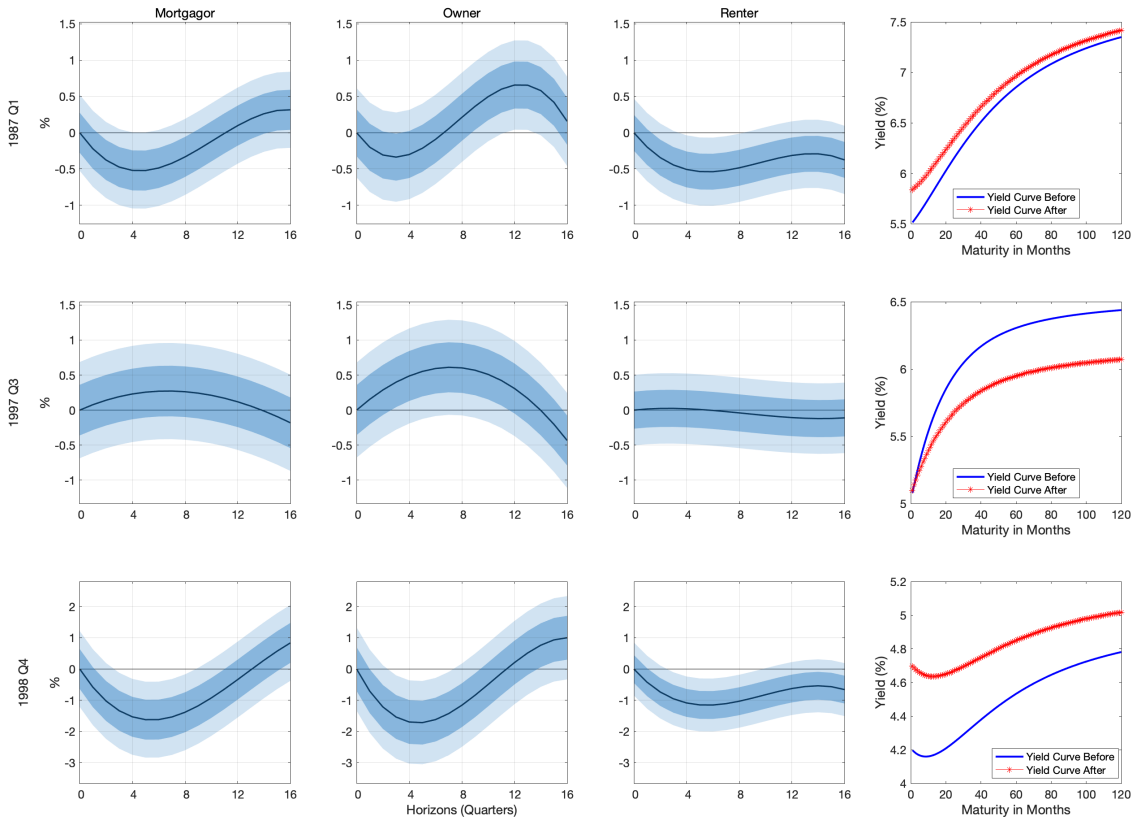


Figure 2 plots the response of durable consumption by housing tenure for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively. The right panels depict the functional monetary policy shock at each date.

Figure 3: Non-Durable Consumption Response by Housing Tenure, Conventional Times

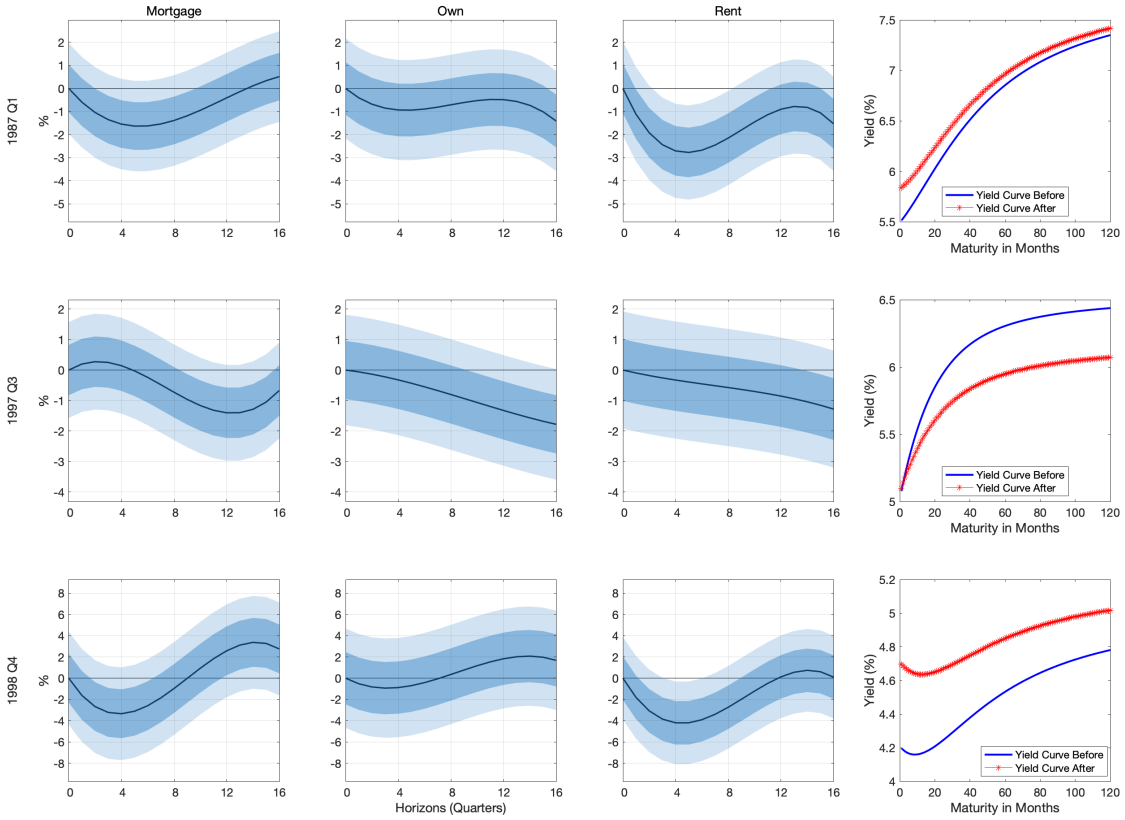


Figure 3 plots the response of non-durable consumption by housing tenure for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 4: Durable Consumption Response by Housing Tenure, Unconventional Times

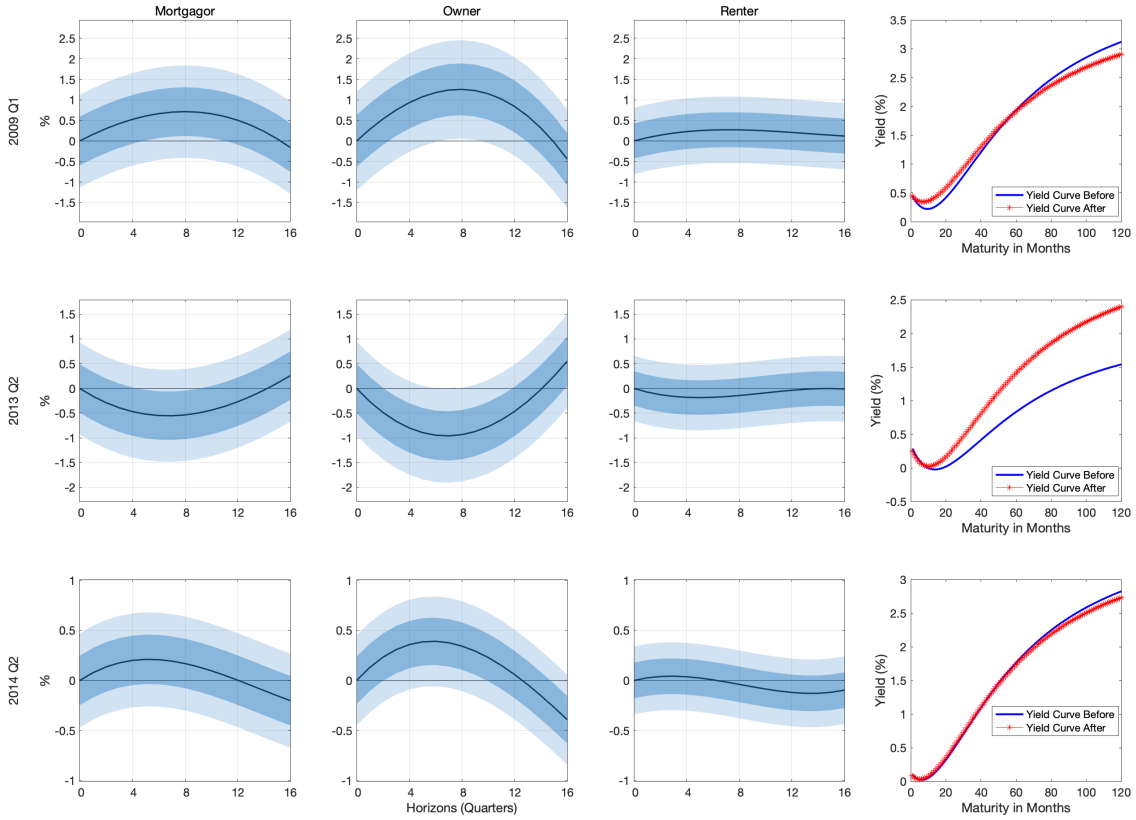


Figure 4 plots the response of durable consumption by housing tenure for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 5: Non-Durable Consumption Response by Housing Tenure, Unconventional Times

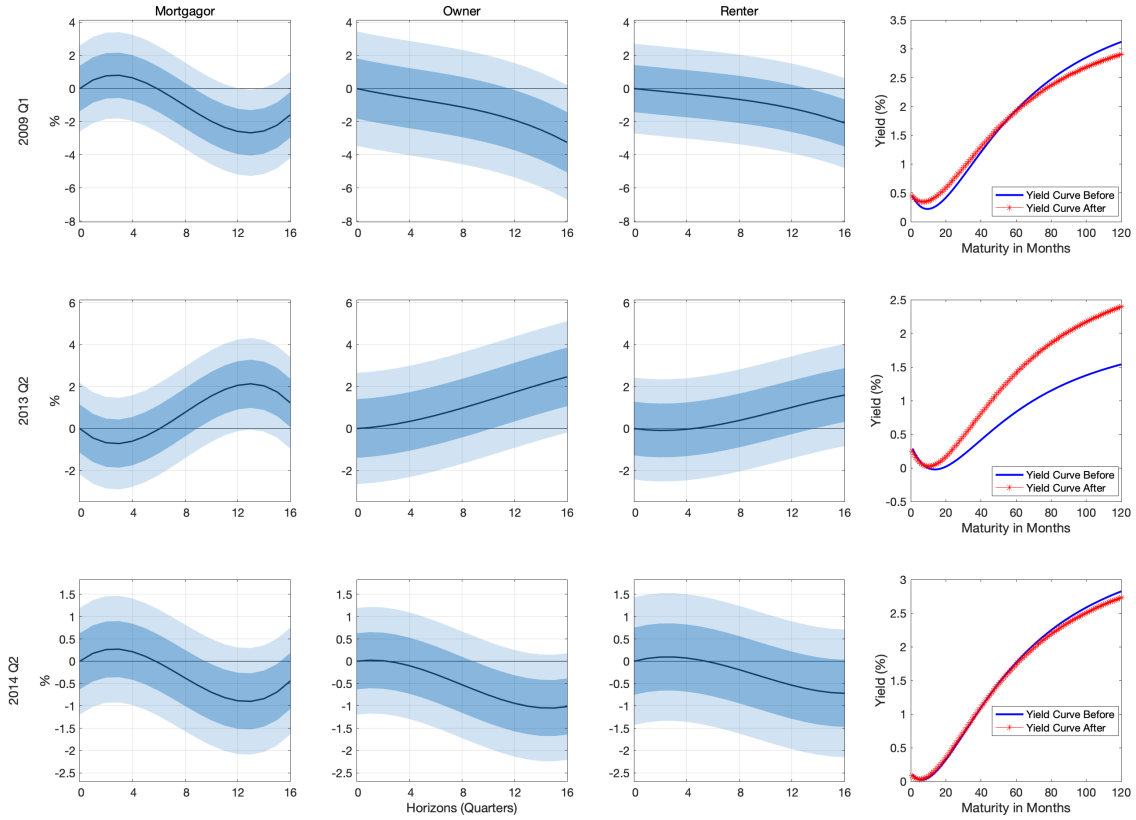


Figure 5 plots the response of non-durable consumption by housing tenure for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 6: Response to Functional Shocks, All Episodes - Housing Tenure

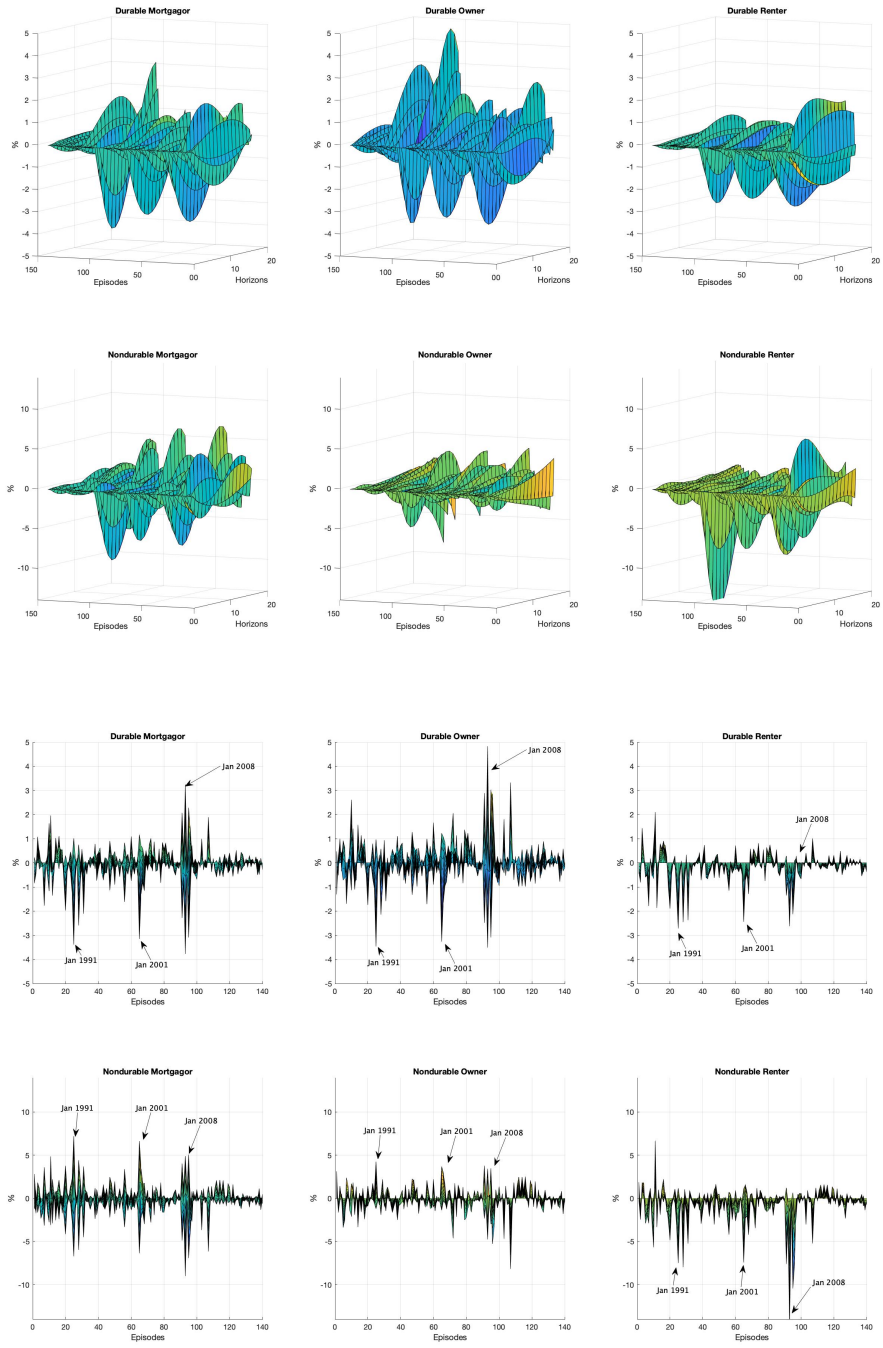


Figure 6 plots the response of consumption by housing tenure for each *functional* monetary policy shock. The first two rows plot a view of the responses where the magnitude of the impulse response is measured in the z-axis, horizons are denoted in the y-axis, and the x-axis denotes the events. The two bottom rows show a slice of the above surfaces with the peak and trough responses for each event. The first and third row present the response to durable consumption whereas the second and fourth rows report the response of non-durable consumption.

Figure 7: Durable Consumption Response by Age, Conventional Times

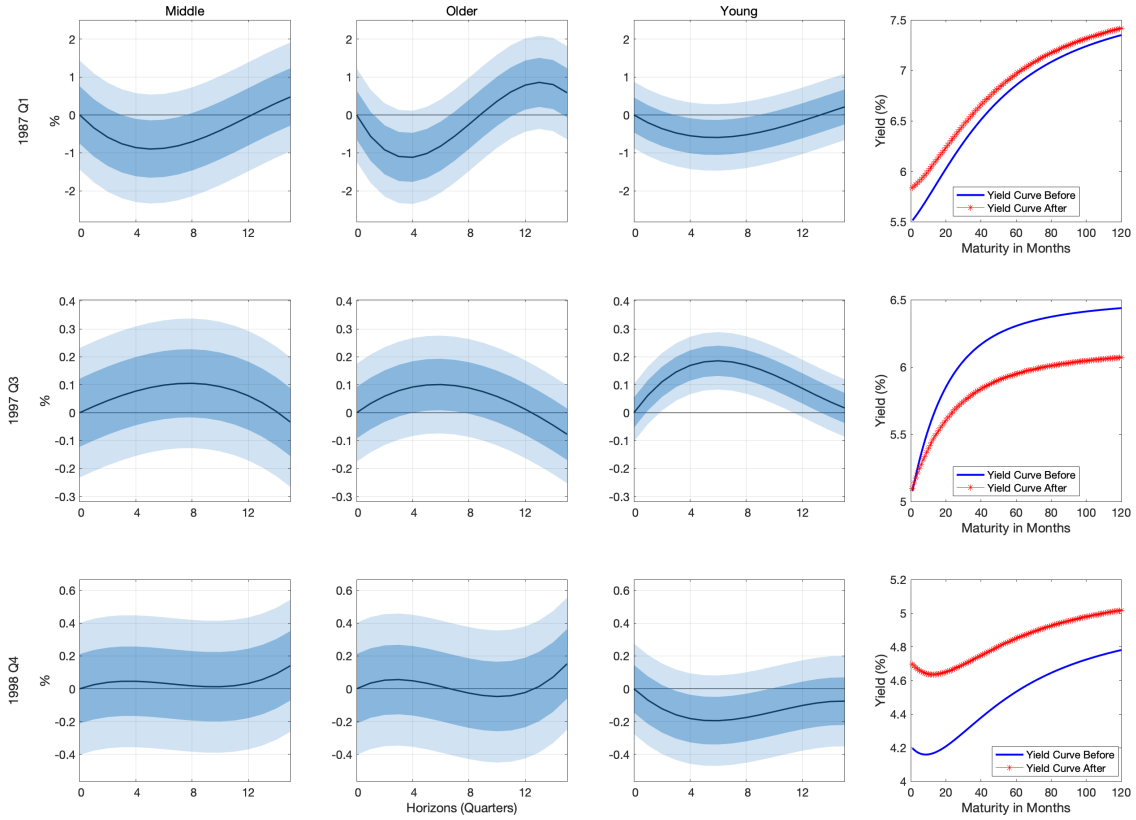


Figure 7 plots the response of durable consumption by age groups for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 8: Non-Durable Consumption Response by Age, Conventional Times

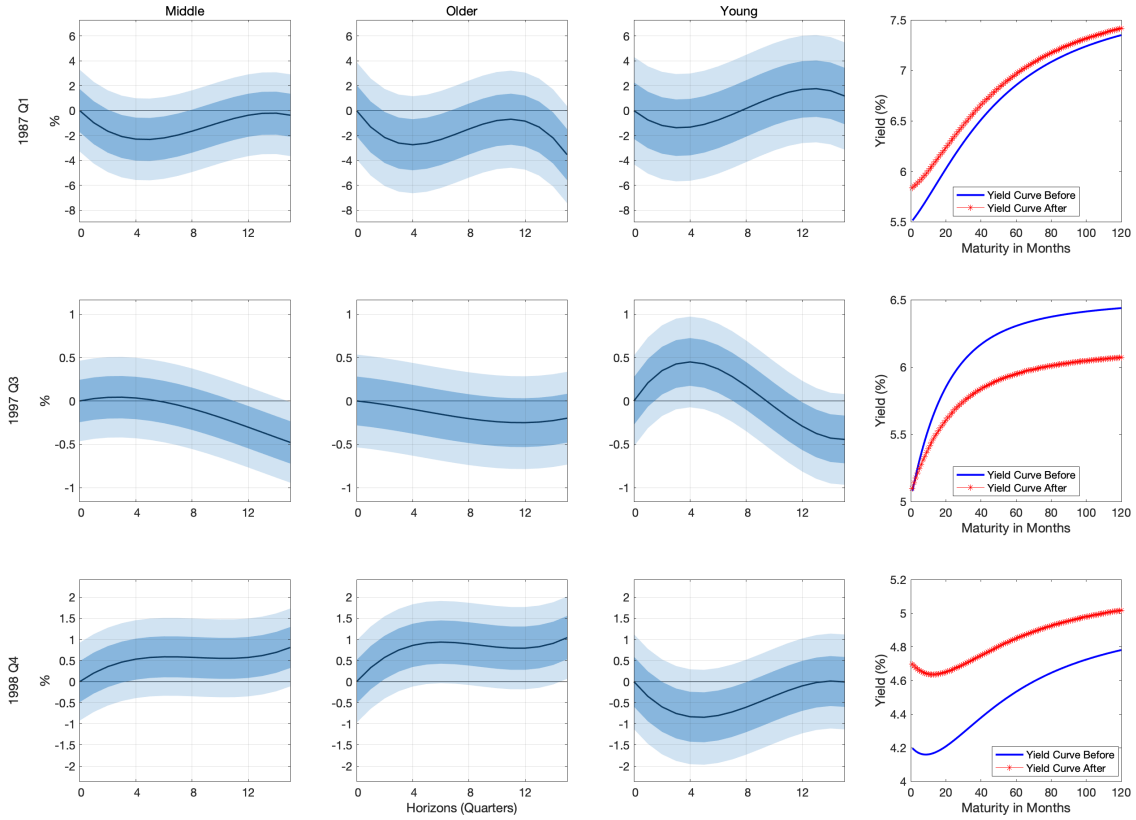


Figure 8 plots the response of non-durable consumption by age groups for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 9: Durable Consumption Response by Age, Unconventional Times

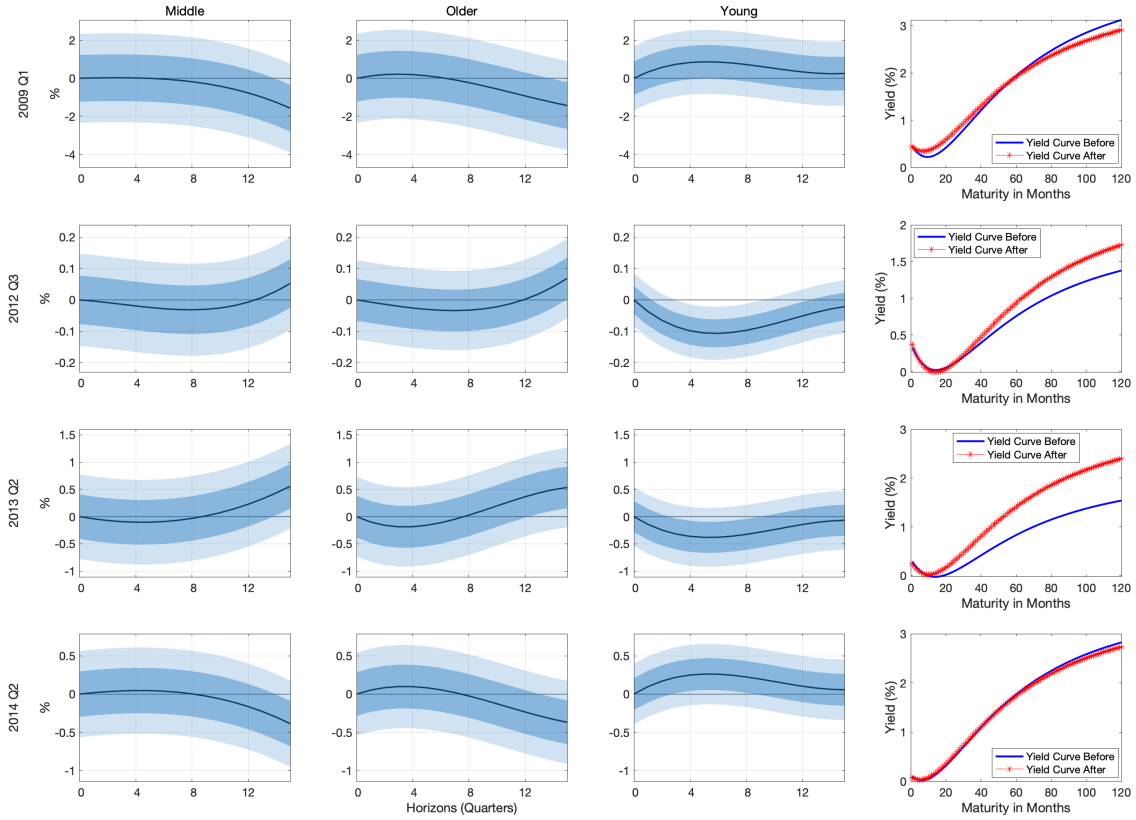


Figure 9 plots the response of durable consumption by age groups for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 10: Non-Durable Consumption Response by Age, Unconventional Times

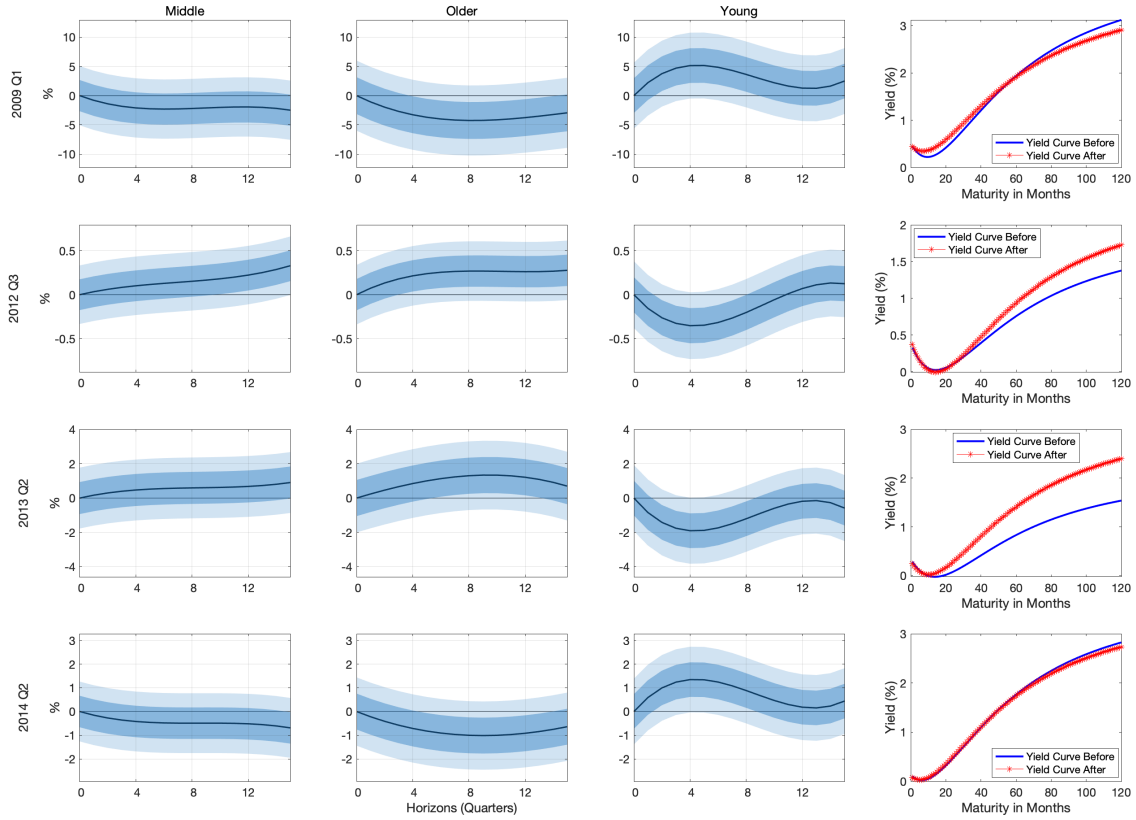


Figure 10 plots the response of non-durable consumption by age groups for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 11: Response to Functional Shocks, All Episodes - Age

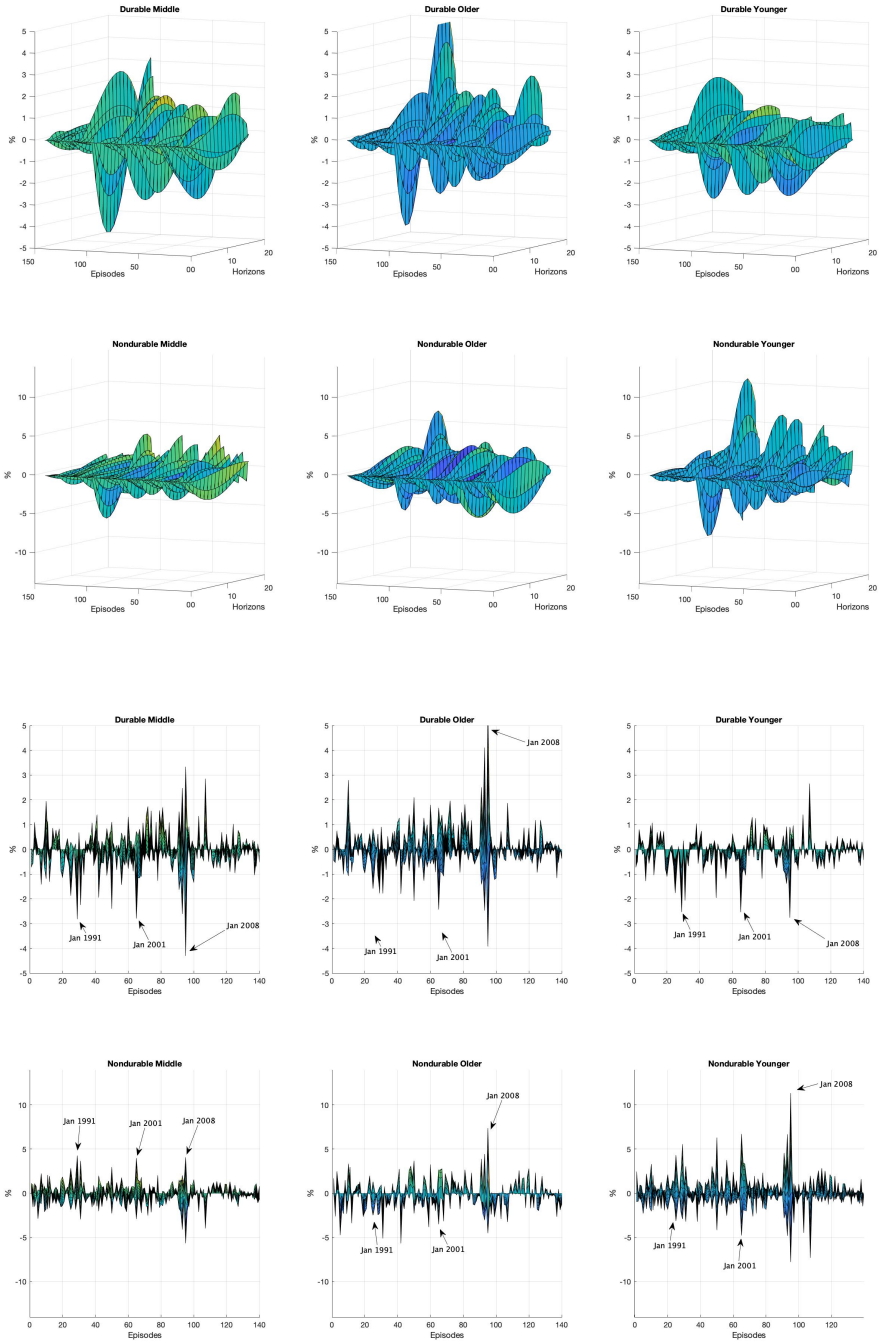


Figure 6 plots the response of consumption by housing tenure for each *functional* monetary policy shock. The first two rows plot a view of the responses where the magnitude of the impulse response is measured in the z-axis, horizons are denoted in the y-axis, and the x-axis denotes the events. The two bottom rows show a slice of the above surfaces with the peak and trough responses for each event. The first and third row present the response to durable consumption whereas the second and fourth rows report the response of non-durable consumption.

Figure 12: Response of Mortgage and Rental Payments

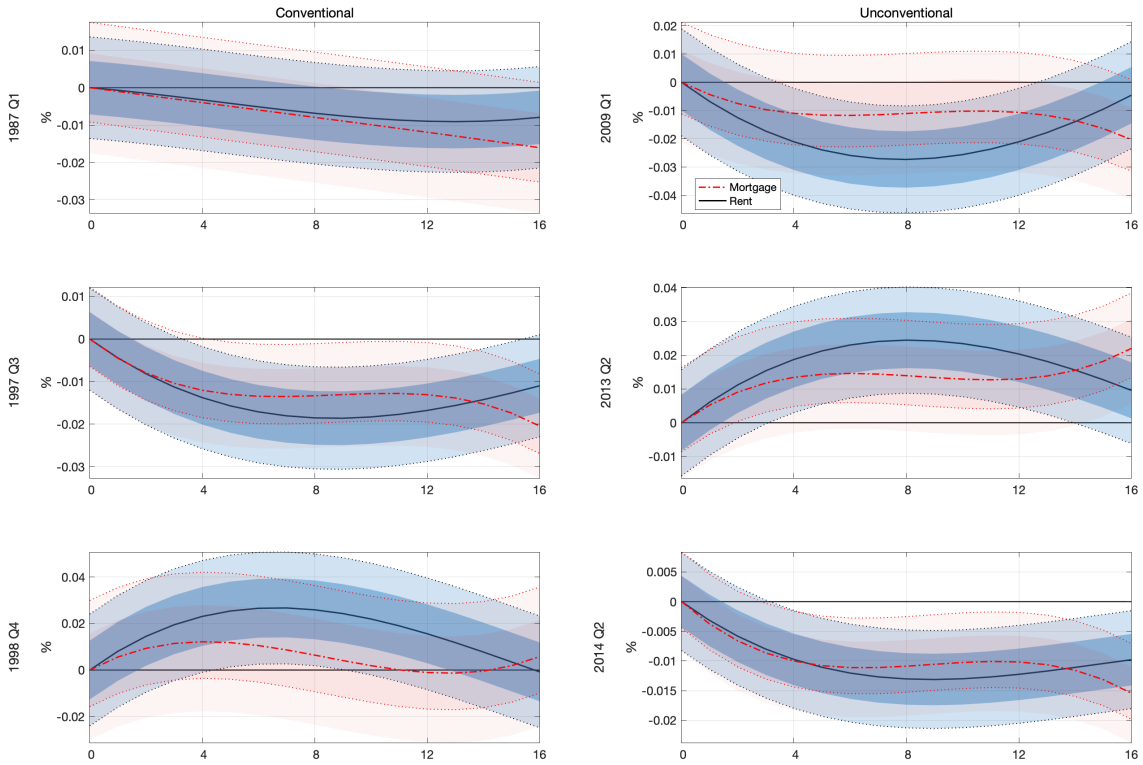


Figure 12 plots the response of rental payments for selected monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 13: Response of House Price and Household Assets

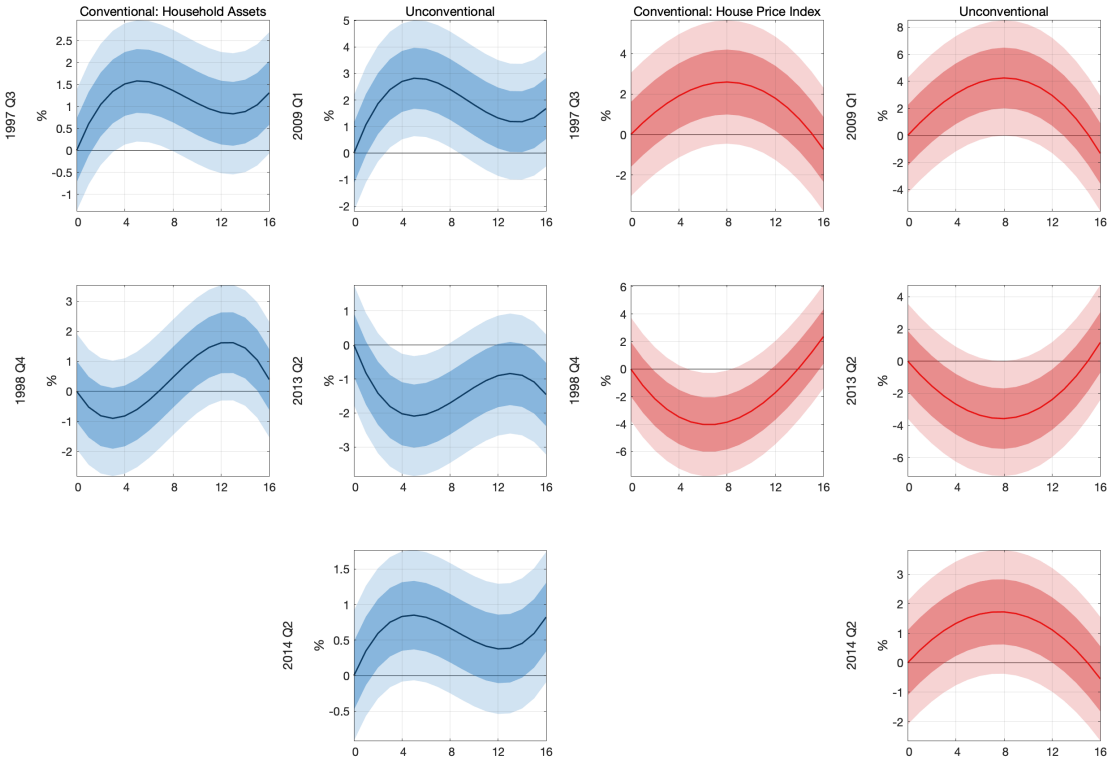


Figure 13 plots the response of Logged Real Purchase-only House Price index (red) and Logged Returns of Household Total Assets (blue) for selected monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 14: Response of Income, Conventional Times

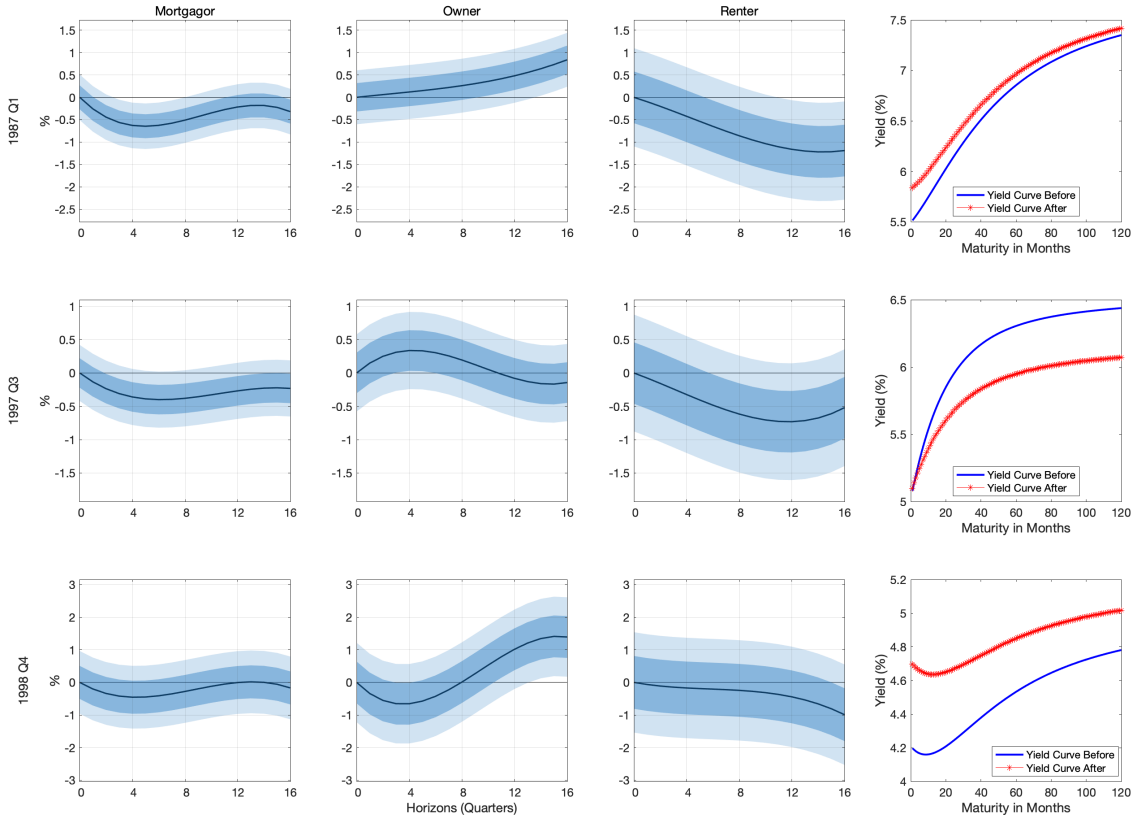


Figure 14 plots the response of income by housing tenure for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 15: Response of Income, Unconventional Times

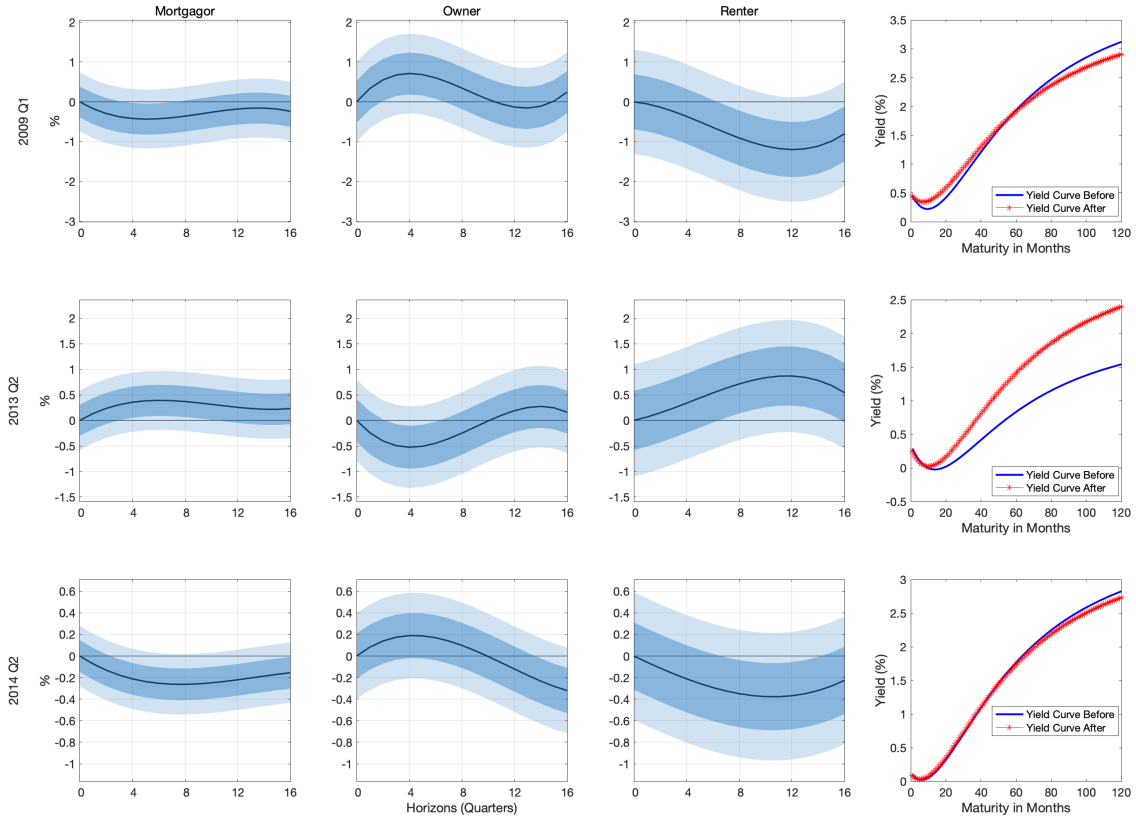


Figure 15 plots the response of income by housing tenure for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 16: Income Response, Conventional Times

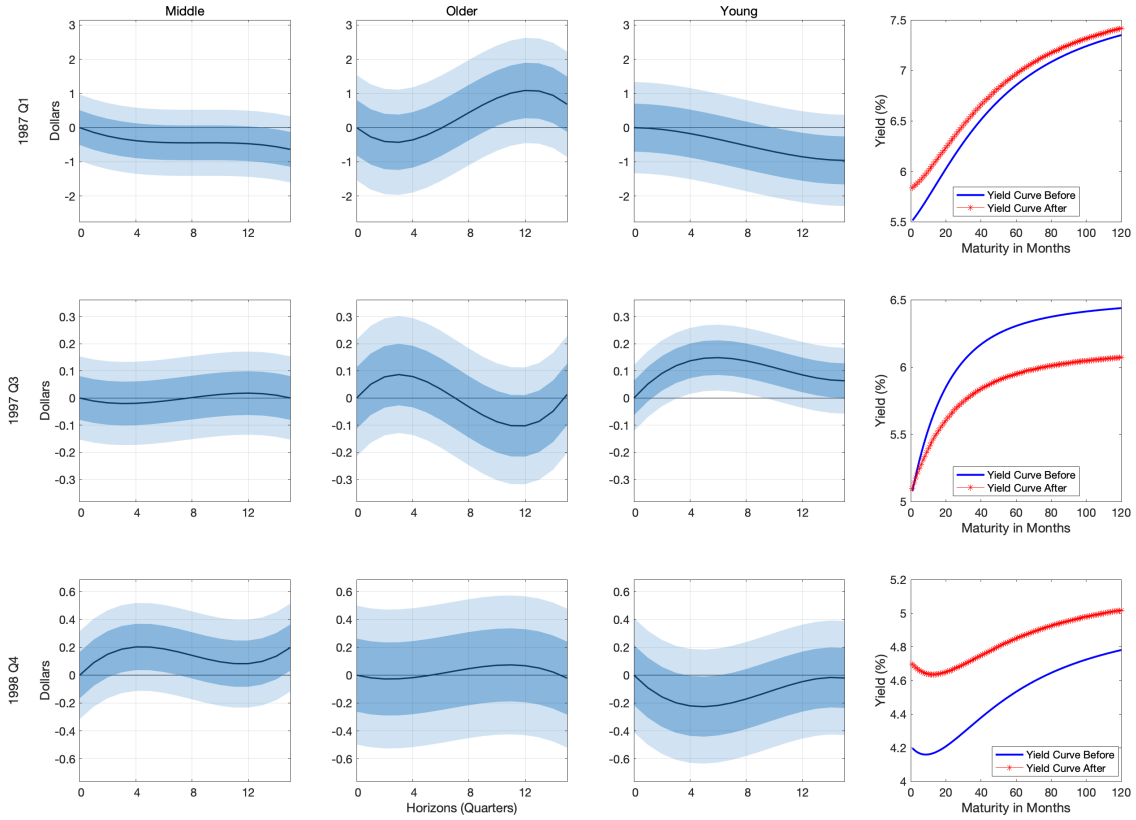


Figure 16 plots the response of income by age groups for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure 17: Income Response, Unconventional Times

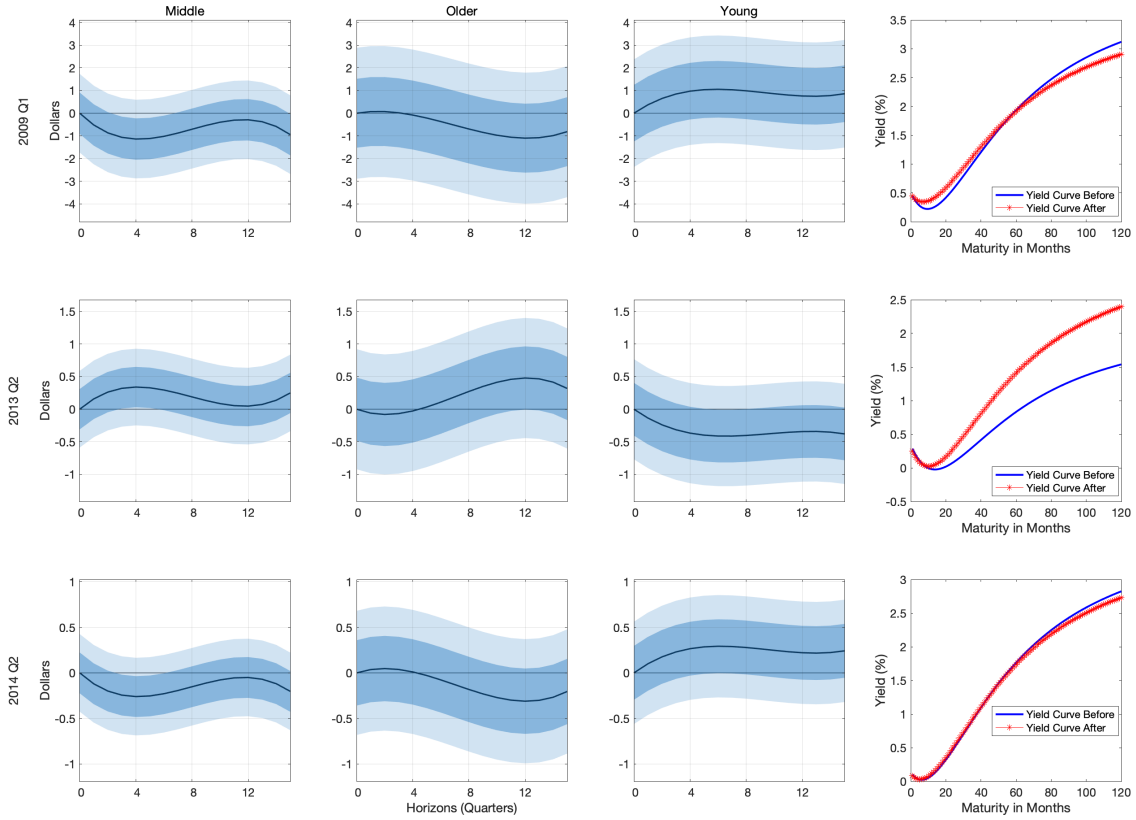


Figure 17 plots the response of income by age groups for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Appendix A:

A.0 Yield Curve Parametric Model

As discussed in Section **??**

A.1 The Response of Total Consumption to Functional Shocks - Alternative Measures of Consumption

As noted in Section 8, our results generalize across several alternative measures and estimation strategies. Notably, Figures A.5 and A.6 depicts similar results to the response of total expenditure as compared to using probability weights or removing housing expenses from total consumption by housing tenure. Both alternatives measure fall within the confidence intervals of the baseline and follow the same shape.

The results by age group similarly retain the shape and magnitude for these alternative measures. Figures A.11 and A.12 presents the response of total expenditure by age group as compared to weighting and removing housing costs. The figures show no distinguishable differences across each measure.

A.2 The Response of Total Consumption - Alternative Estimation Strategies and Model Specification

In the baseline results, we fit a fourth-order polynomial (Inoue and Rossi, 2021) to avoid excess variation common to local projections. One may wonder if the normal local projection could alter the results. Figures A.5 and A.6 highlight that that responses are qualitative no different than that on the LP; rather there is less variation but follow the same trend.

A similar concern could be whether the housing tenure results are robust to alternative model specification. Figures A.7 and A.8 plot the baseline results estimated in level including both a linear and time trend. The results in levels follow a similar shape to the cumulative responses in the main specification.

We repeat the above robustness exercises for the response of total consumption by age group. Figures A.11 and A.12 reports the local projection as compared to our baseline, showing no unexpected differences. The same can be seen for age group results in levels. Figures A.13 and A.14 differ little from the baseline shape.

A.3 The Response of Total Consumption - Alternative Shock Time Aggregation

Often times monetary policy shocks occur at a higher frequency than the variable of interest. As a result, researchers must aggregate the shocks to match the frequency of said variable, or used some mixed frequency model. In the section we explore alternative computation for aggregation quarterly *functional* monetary policy shocks. Figures A.9 and A.10 depict no notable differences across aggregation approach for the housing tenure results, all results fall within the confidence intervals. We find the results similarly hold across age groups. Figures A.15 and A.14 report this result.

Each shock series presents similar results. Renters have the largest responses by increasing their non-durable consumption when shocks are measured as changes in short run maturities. The fact that renters respond largely is not surprising. Given that these shocks do not capture co-movements along the yield curve or movements in the long-run, short-term interest rate shocks should cause debt-constrained households to temporarily alter their consumption instead of increasing their debt balance. As expected, these consumption responses follow closely to the cash-flow channel

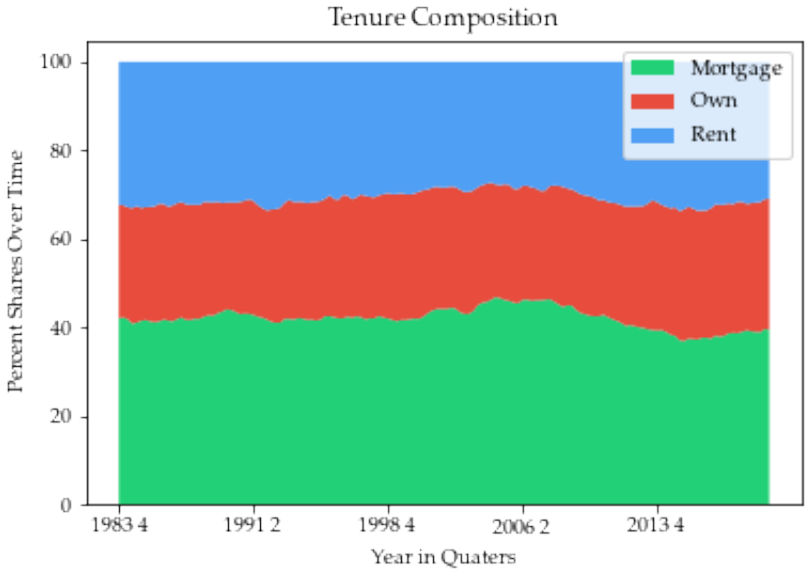
Similarly, owners initially have larger durable consumption, which they quickly curtail and mortgagors modestly respond by increasing their non-durable consumption. While this provides additional support for owners altering consumption due to a larger EIS, without using the functional approach, there is less evidence of an asset pricing or an information effect. Given these differences between the short run shocks and select episodes from the prior sections, the functional approach is crucial to identifying the entirety of monetary policy's impact on household consumption.

Table A.0: CEX compared to NIPA

Tenure	Durable	NonDurable	Income	Total Consumption
Mortgagors	0.98	0.87	0.99	0.99
Owners	0.98	0.80	0.98	0.99
Renters	0.68	0.65	0.91	0.97

Table A.0 shows the correlation between the CEX data and NIPA data for each real per capita measure. Given researchers use the NIPA data as a consumption measures.

Figure A.1: Tenure Shares Across Time



This figure presents the share of each housing tenure from the Consumer Consumption Survey over time. Each tenure share is relatively slow moving overtime.

Figure A.2: CEX Compared to NIPA

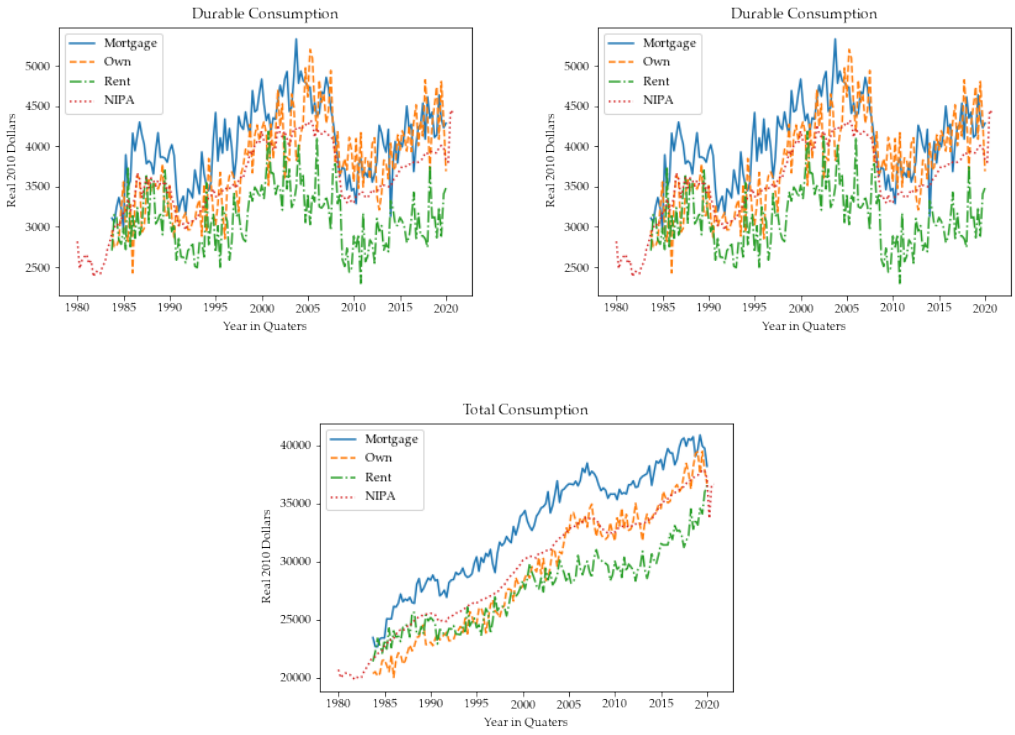


Figure A.2 shows the consumption trends of the CEX data as compared to the NIPA values. The top figures show duable (left) and non-durable (right) consumption, and the bottom figure total consumption. Values are reported in 2010 dollars.

Figure A.3: Tenure Shares Across Age Demographics

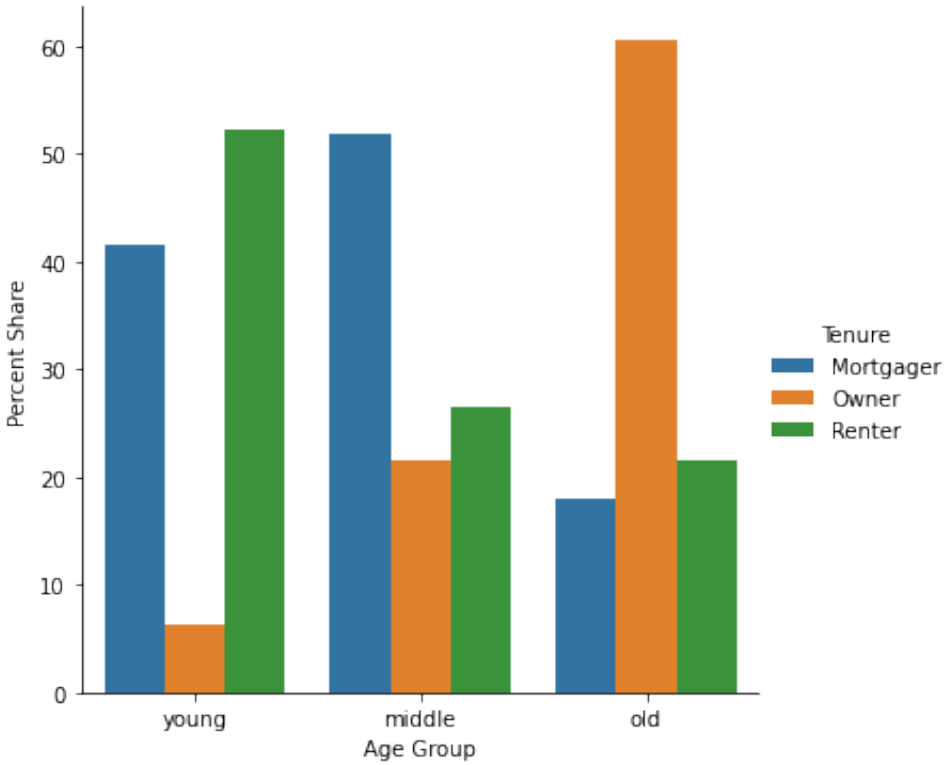


Figure A.3 presents the share of each housing tenure from the Consumer Consumption Survey across age groups.

Figure A.4: Wealth Across Tenures

(a) Net Worth

(b) Liquid Wealth

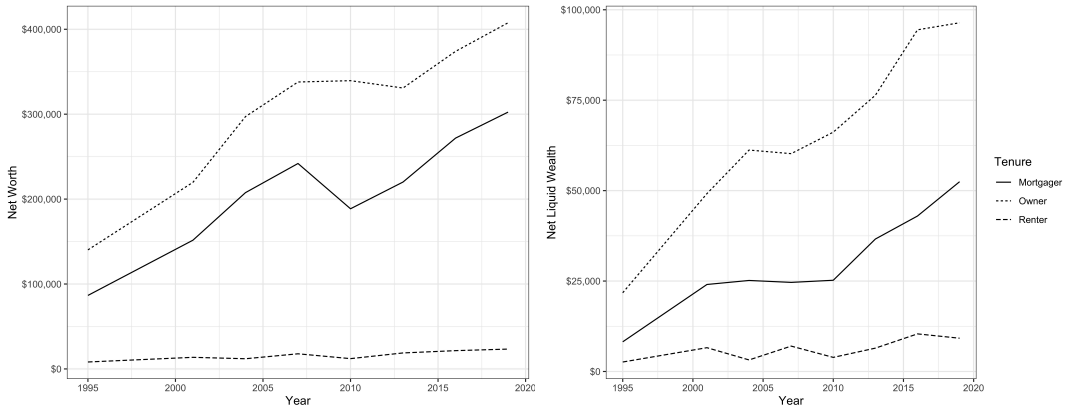


Figure A.4 illustrates two different measures of wealth from the Survey of Consumer Finance across different housing tenures. The figure on the right hand side shows liquid wealth, while the figure on the left depicts overall net worth measured in 2010 US dollars. The definitions of total and liquid wealth are as defined in Kaplan et al. (2018)

Figure A.5: Total Consumption Response by Housing Tenure, Conventional Times- Alternative Measures

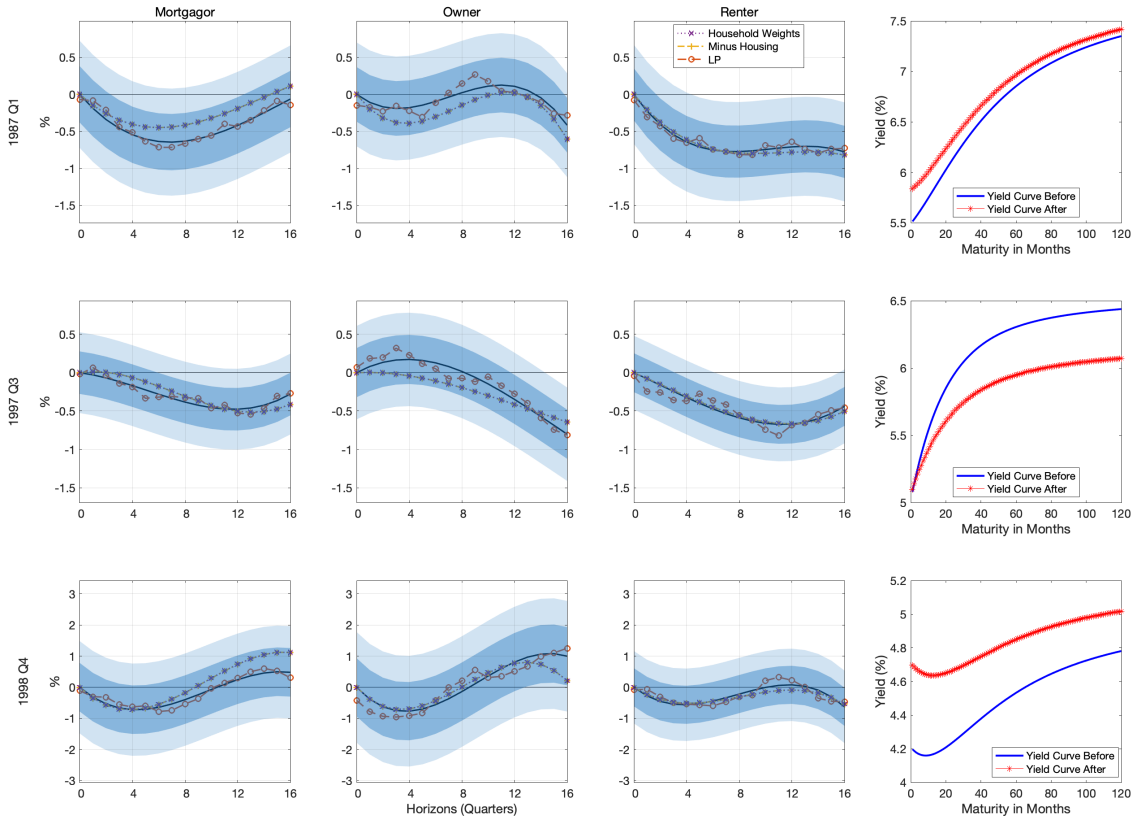


Figure A.5 plots the response of total consumption by housing tenure for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively. Each line represents a different measure of total consumption. The blue line with an x marker represents using the CEX probability weights, whereas the red circle line represents using a traditional local projection and yellow line with a + marker total consumption excluding housing costs.

Figure A.6: Total Consumption Response by Housing Tenure, Unconventional Times- Alternative Measures

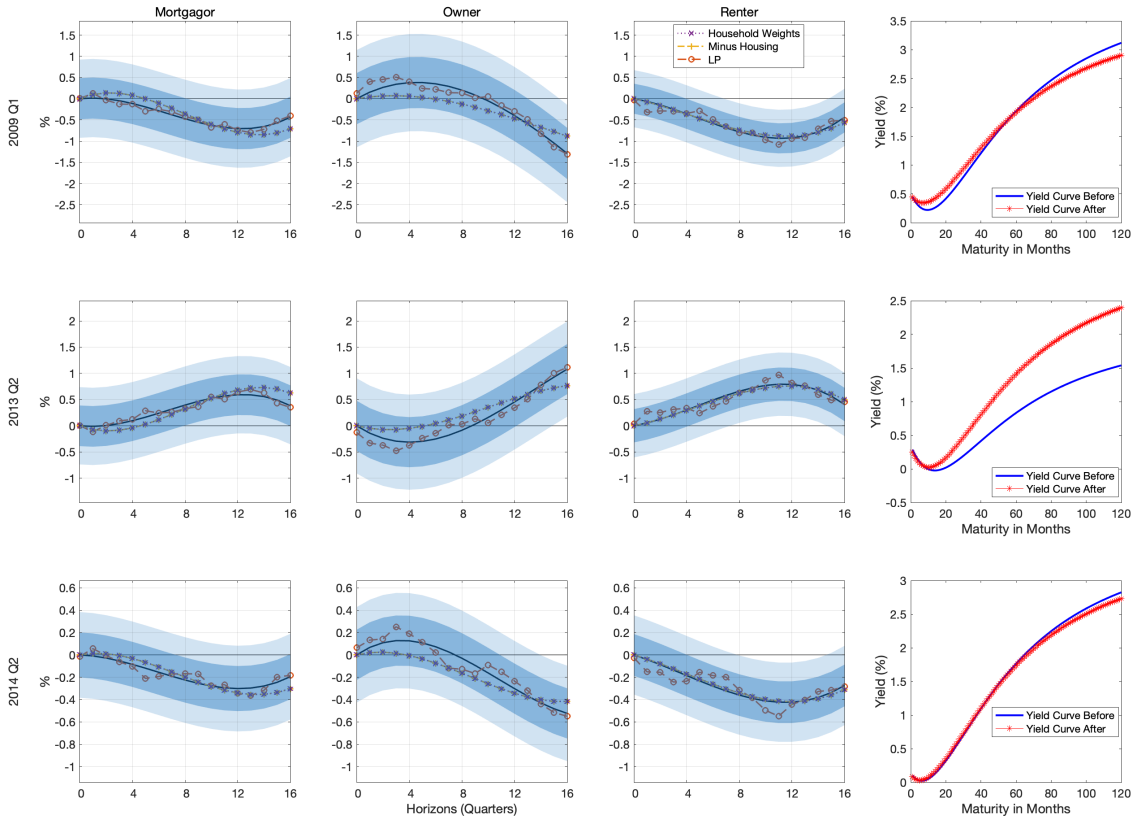


Figure A.6 plots the response of total consumption by housing tenure for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively. Each line represents a different measure of total consumption. The blue line with an x marker represents using the CEX probability weights, whereas the red circle line represents using a traditional local projection and yellow line with a + marker represents total consumption excluding housing costs.

Figure A.7: Total Consumption Response by Housing Tenure, Conventional Times- Levels

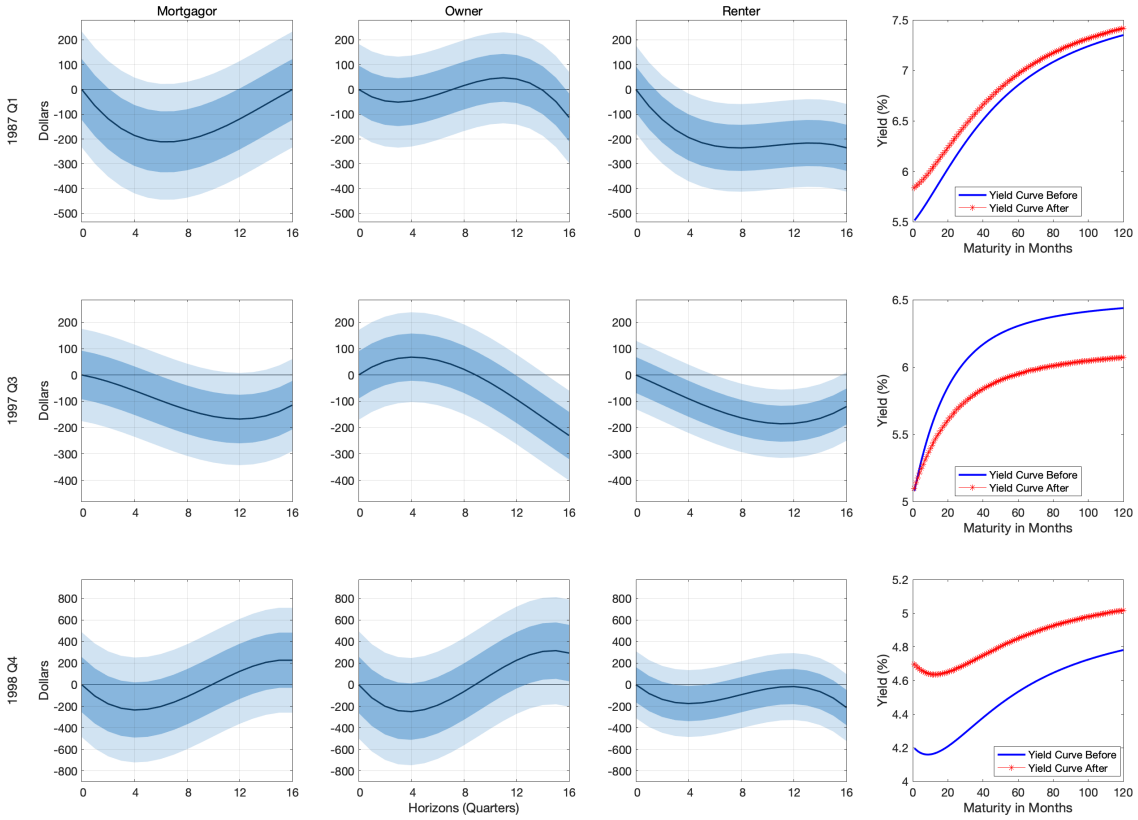


Figure A.7 plots the response of total consumption by housing tenure for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure A.8: Total Consumption Response by Housing Tenure, Unconventional Times- Levels

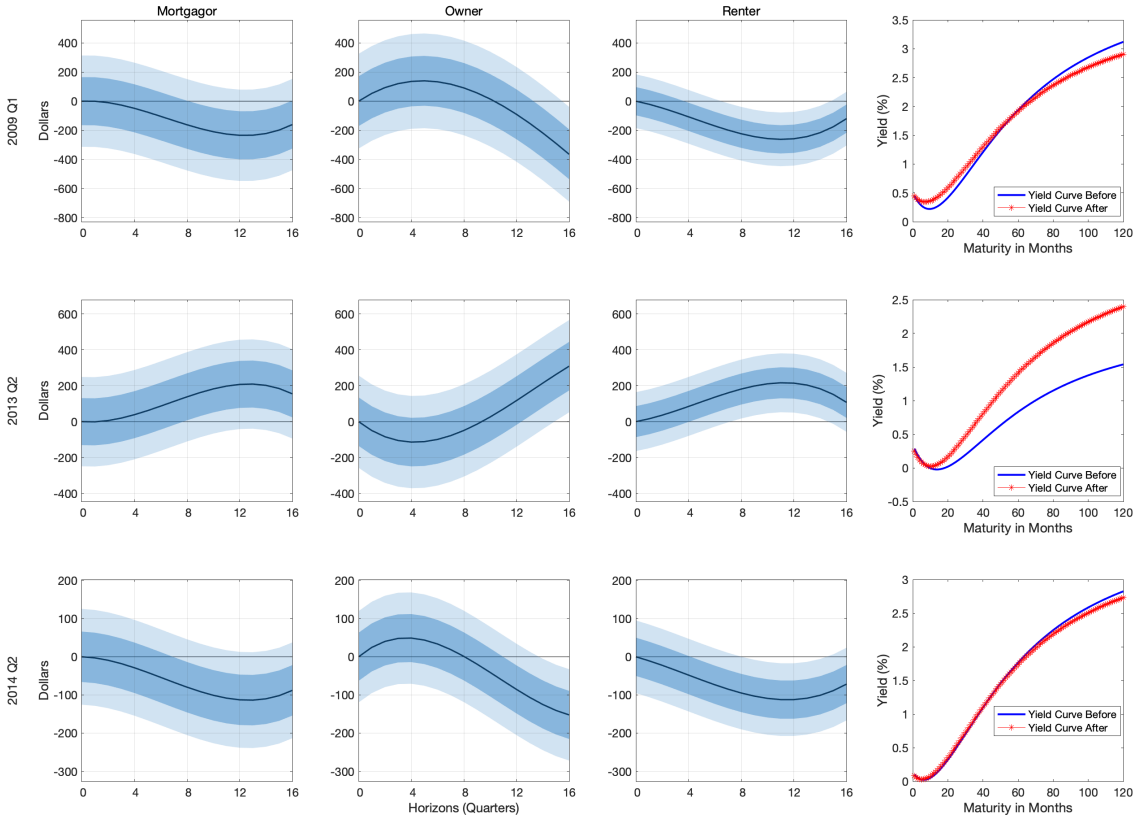


Figure A.8 plots the response of total consumption by housing tenure for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure A.9: Total Consumption Response by Housing Tenure, Conventional Times- Alternative Aggregation Measures

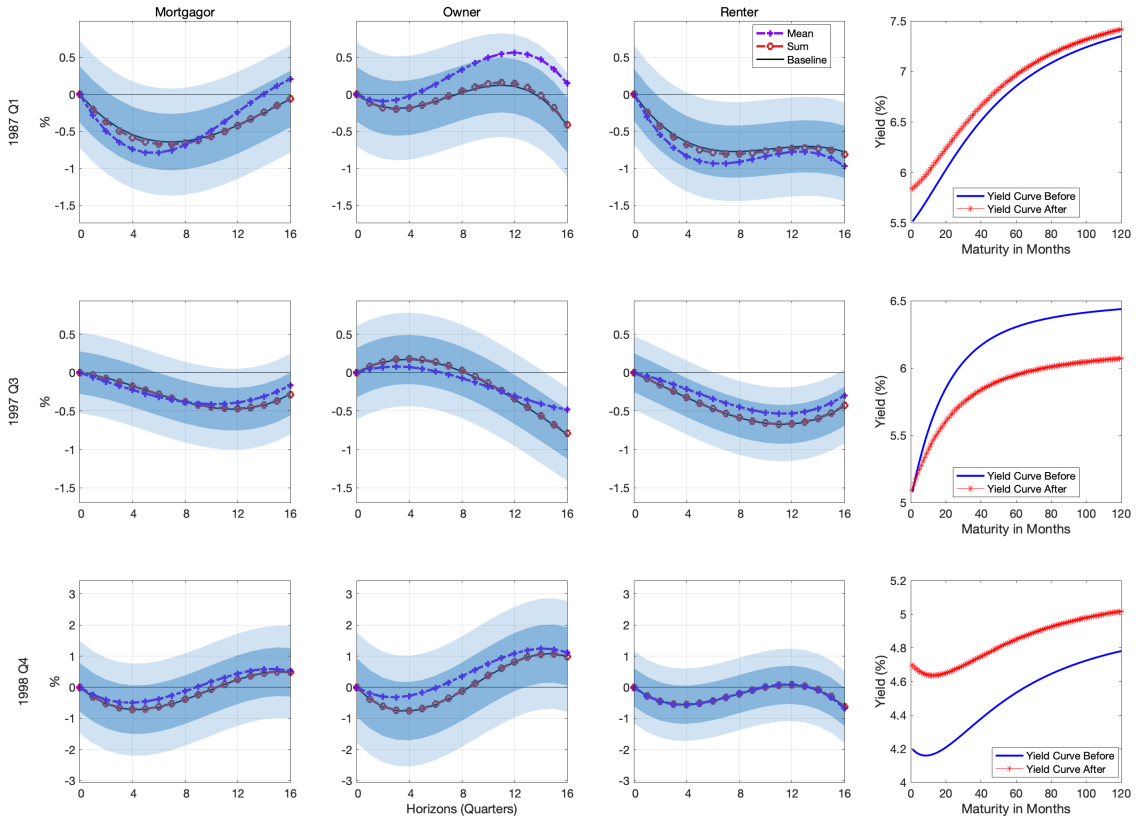


Figure A.9 plots the response of total consumption by housing tenure for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively. Each line represents a different aggregation of daily shocks. The blue diamond line represents the response obtained when we take the mean of the daily shocks, whereas the red circle line represents response obtained when we sum the each daily shock.

Figure A.10: Total Consumption Response by Housing Tenure, Unconventional Times- Alternative Aggregation Measures

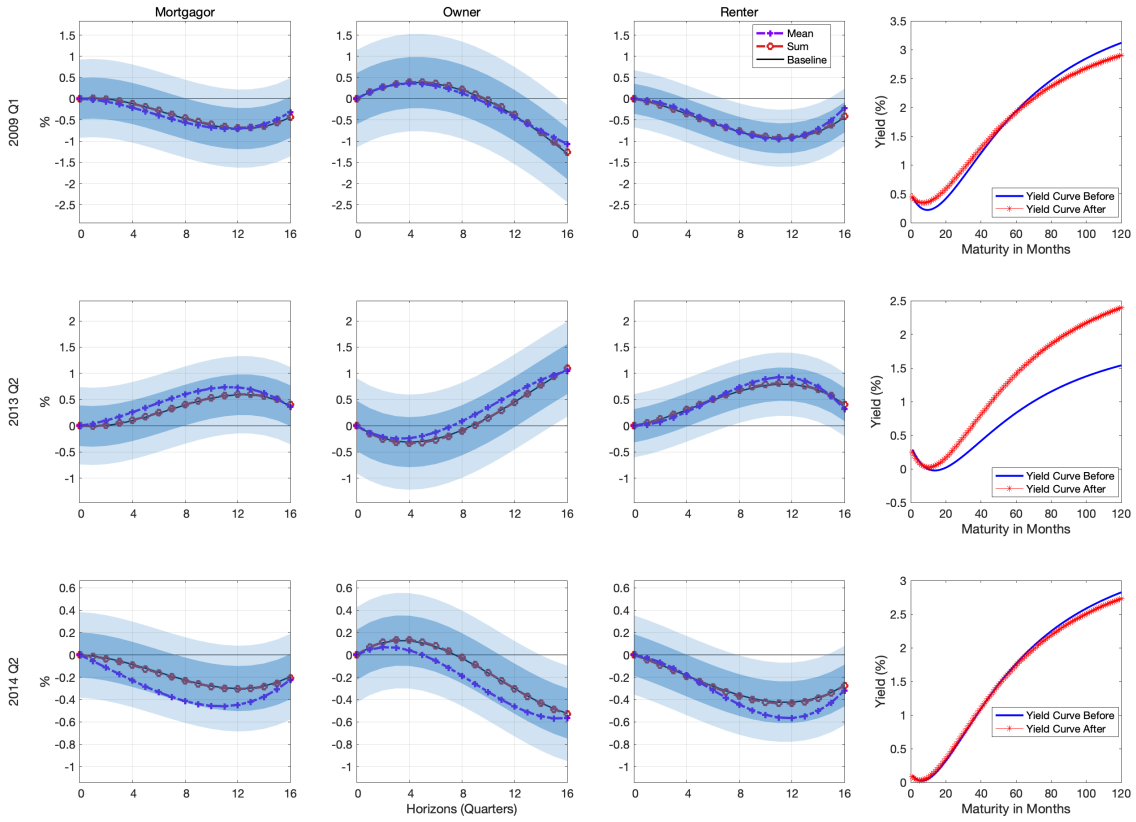


Figure A.10 plots the response of total consumption by housing tenure for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively. Each line represents a different aggregation of daily shocks. The blue diamond line represents the response obtained when we take the mean of the daily shocks, whereas the red circle line represents response obtained when we sum the each daily shock.

Figure A.11: Total Consumption Response by Age, Conventional Times- Alternative Measures

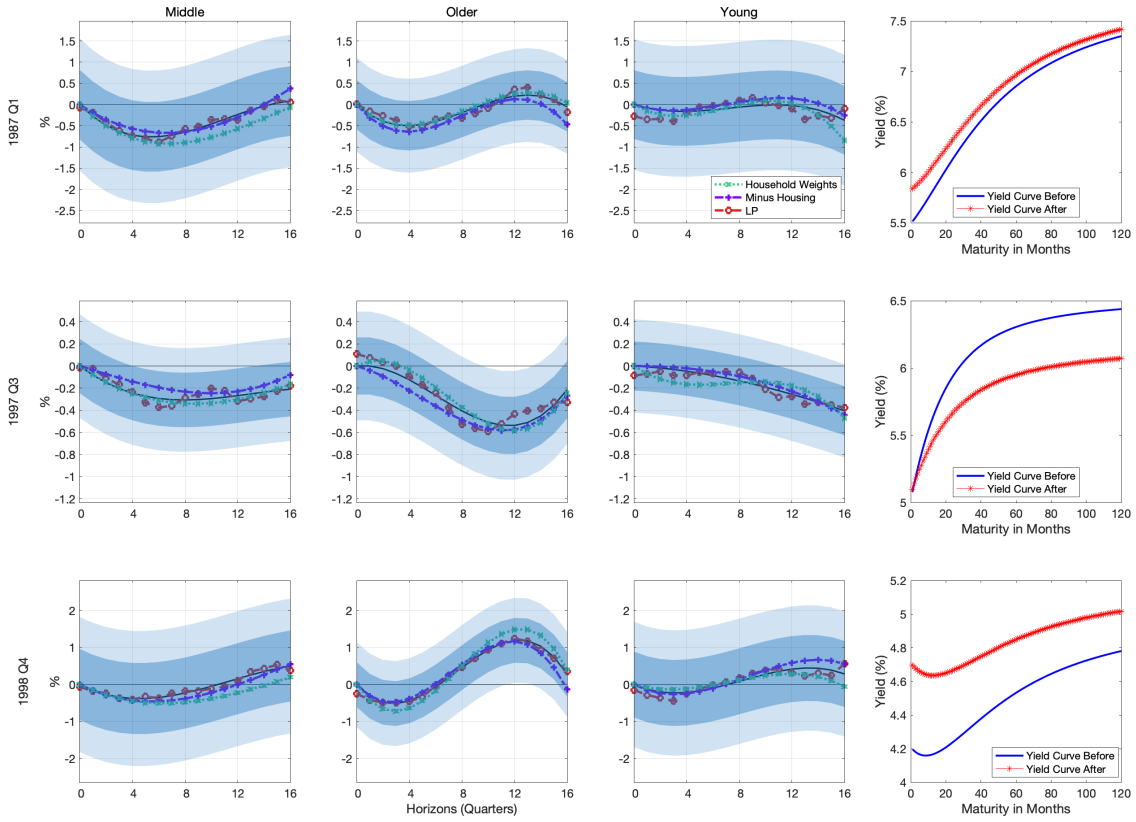


Figure A.11 plots the response of total consumption by age group for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively. Each line represents a different measure of total consumption. The green * line represents using the CEX probability weights, whereas the red circle line represents using a traditional local projection and blue diamond total consumption excluding housing costs.

Figure A.12: Total Consumption Response by Age, Unconventional Times- Alternative Measures

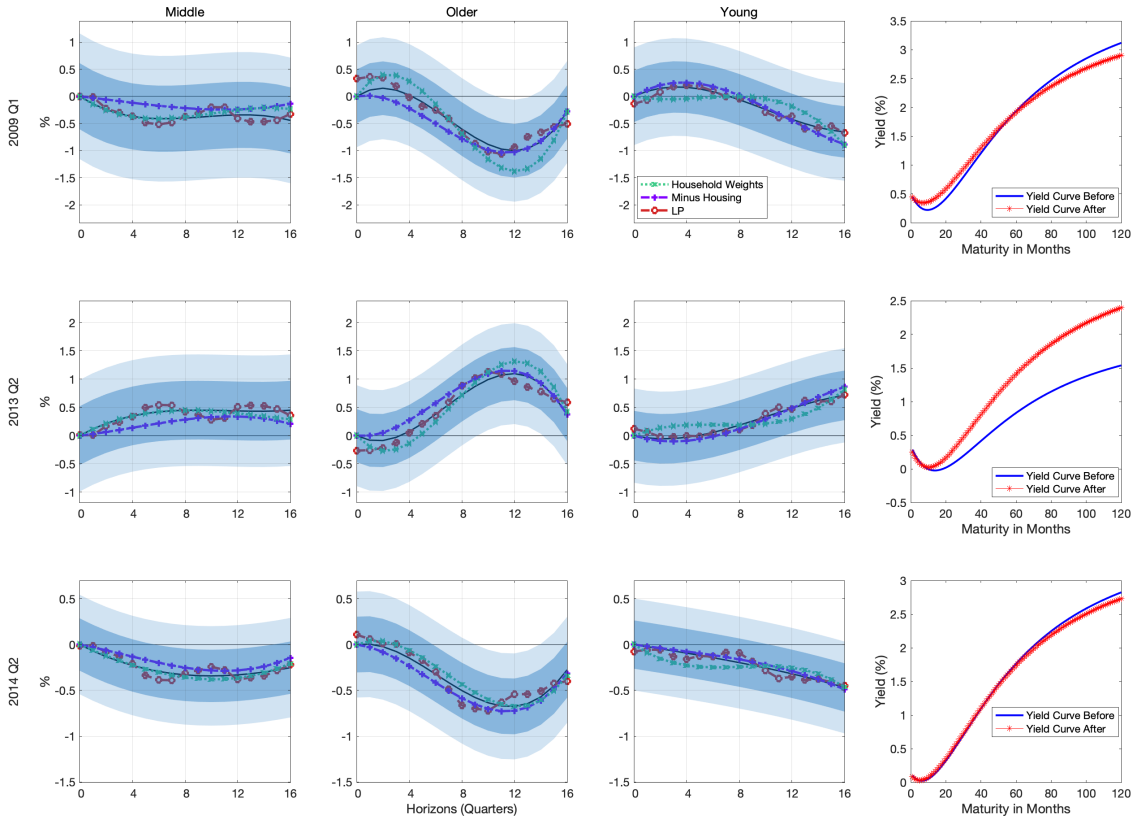


Figure A.11 plots the response of total consumption by age group for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively. Each line represents a different measure of total consumption. The green line with the * marker represents using the CEX probability weights, whereas the red circle line represents using a traditional local projection and blue diamond total consumption excluding housing costs.

Figure A.13: Total Consumption Response by Housing Tenure, Conventional Times- Levels

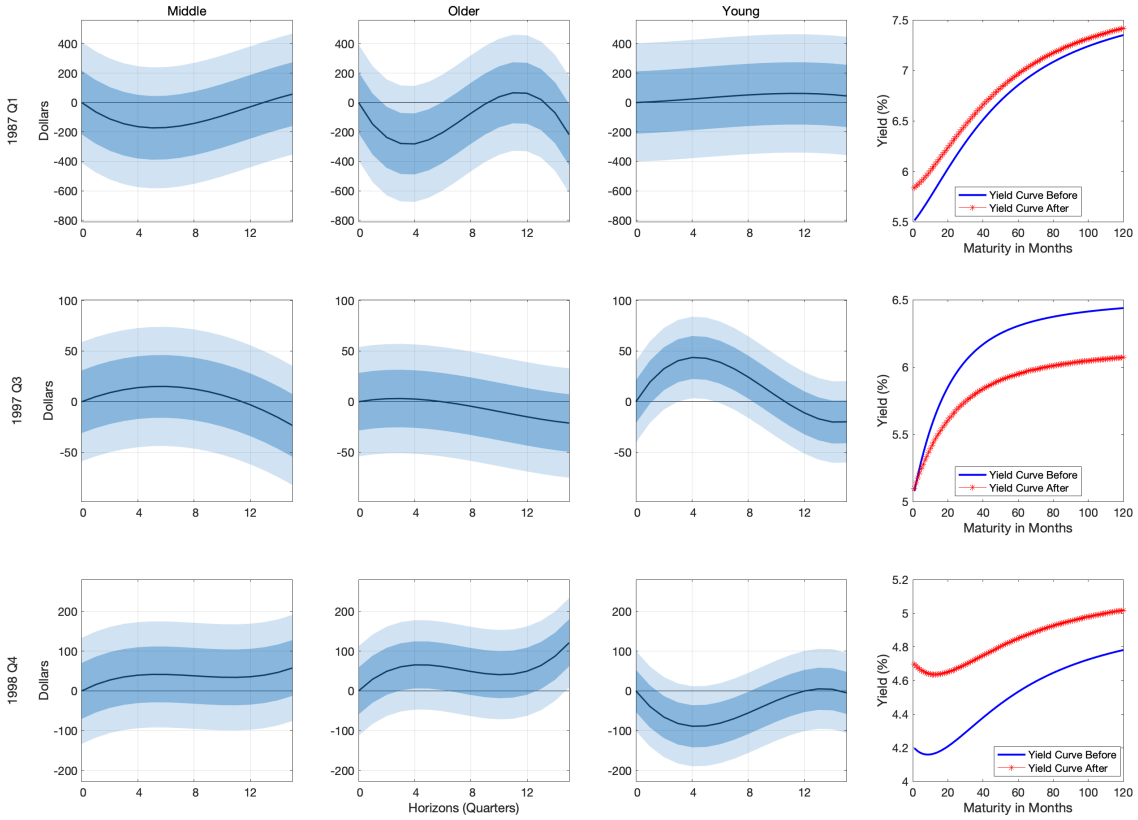


Figure A.13 plots the response of total consumption by age group for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure A.14: Total Consumption Response by Housing Tenure, Unconventional Times- Levels

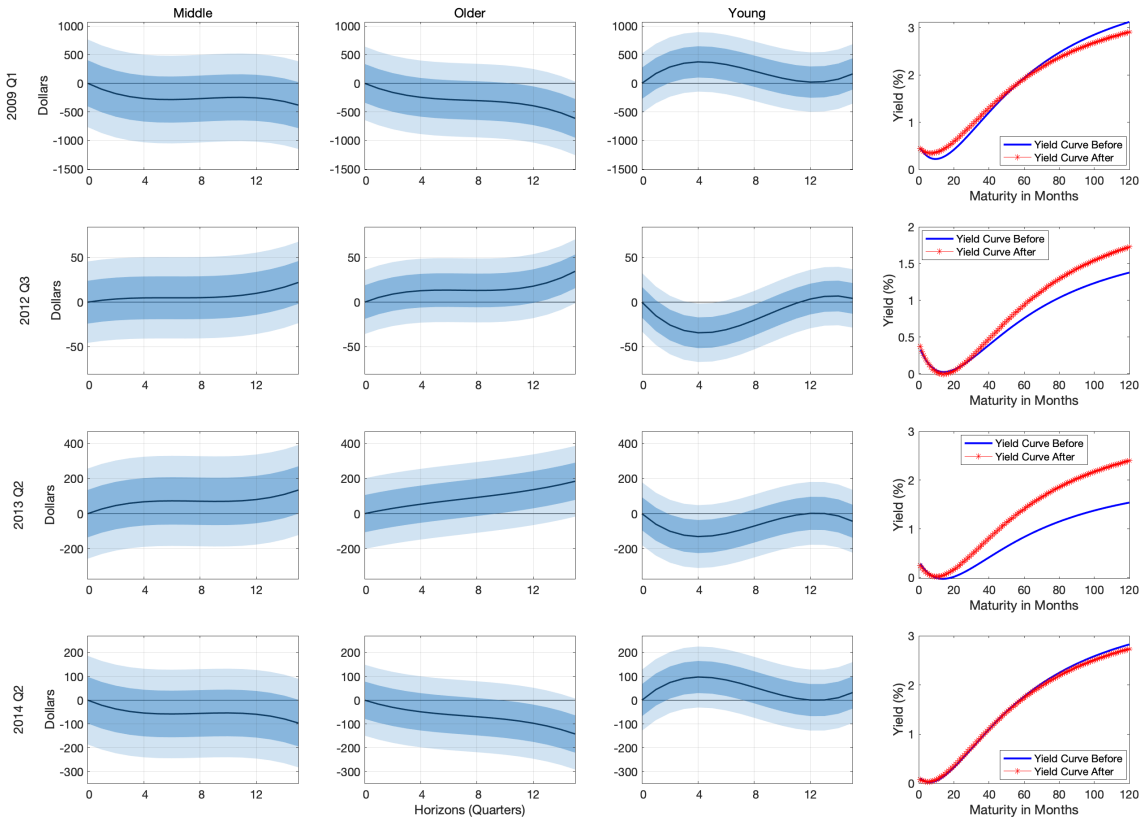


Figure A.14 plots the response of total consumption by age group for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively.

Figure A.15: Total Consumption Response by Age, Conventional Times- Alternative Aggregation Measures

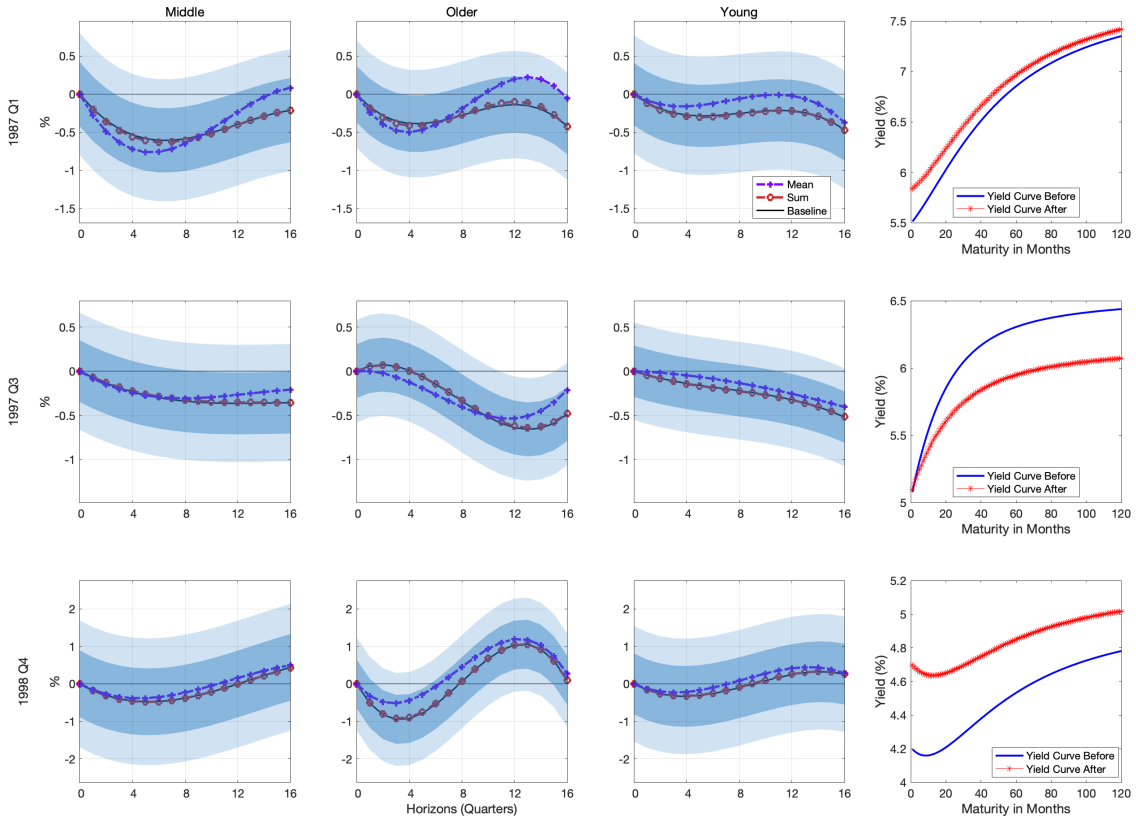


Figure A.15 plots the response of total consumption by age group for selected conventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively. Each line represents a different aggregation of daily shocks. The blue diamond line represents the response when we use the average of the shocks, whereas the red circle line represents the response obtained when we sum the daily shock.

Figure A.16: Total Consumption Response by Age, Unconventional Times- Alternative Aggregation Measures

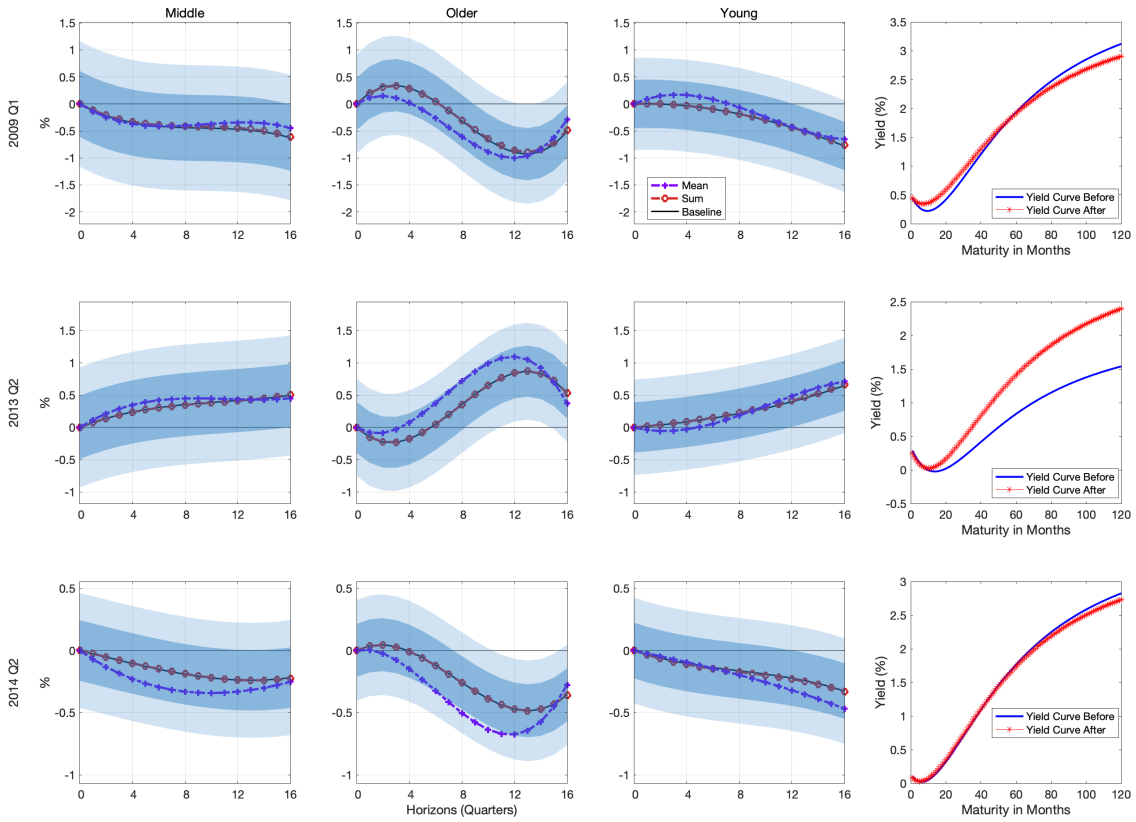


Figure A.16 plots the response of total consumption by age group for selected unconventional monetary policy shocks. The solid black line denotes the impulse response, the light an dark shaded areas denote the 68 and 90% confidence intervals, respectively. Each line represents a different aggregation of daily shocks. The blue diamond line represents taking the mean of the shocks, whereas the red circle line represents summing each daily shock.