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Revealing distributional transmission channels of monetary policy: Evidence from U.S. household-level data

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Abstract

Increasing inequality and a slow recovery have prompted interests in the redistributive effects of monetary policy. In order to improve understanding of transmission channels and to enhance the effectiveness of monetary policy, this thesis sets out to explore heterogeneous consumption responses to monetary policy shocks. To this end, U.S. Consumer Expenditure Survey data for the period 1996-2007 is analysed with households being grouped along the three dimensions of age, housing tenure, and financial activity. The results provide evidence on heterogeneous responses of different groups of households. In particular, middle-aged and older households exhibit significant changes in expenditure, as well as financially active households. The responses are found to be notably stronger for durable goods consumption. This suggests that monetary policy affects intergenerational inequality.

Keywords: Monetary policy, monetary policy shocks, inequality, heterogeneous households, consumption

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1 Introduction

Macroeconomists and policy makers have for many decades been interested in how monetary policy transmits to the real economy. Distributional consequences of monetary policy have long been considered of minor relevance however. While an extensive literature exists on the transmission of monetary policy to the real economy, research has been more limited with regards to heterogeneous responses of households along the income scale and other dimensions. The Great Recession and the subsequent slow recovery have made attention on heterogeneity in monetary policy economics more urgent (Yellen, 2016). The current monetary policy environment of uncommonly low interest rates and unconventional monetary measures adds to this and has instigated the debate over whether and in what way monetary policy affects the distribution of wealth and income in an economy. Monetary policy would have a share in the increase in income and wealth inequality in many countries. This has prompted interests in finding whether other, less explored, mechanisms might complement, amplify or even dominate the quantitative effects implied by the traditional channels of monetary policy transmission alone, for which the use of disaggregated data is required. Despite the fact that this might be more of a concern for the fiscal authorities than the central banks, it is still important for monetary policymakers to fully understand the channels of transmission of their policies and possible effects on different actors in the economy.

These developments have increased researchers' interest in the effects of household heterogeneity for monetary policy outcomes recently, and there is a growing literature. The studies vary in their methodology from macroeconomic model-based (Gornemann *et al.*, 2016; Kaplan *et al.*, 2016; Auclert, 2016) to micro-level empirical (Cloyne *et al.*, 2016; Coibion *et al.*, 2016) approaches. Moreover, the dimensions of household heterogeneity that are investigated differ, with for instance a strand of the literature dedicated to life-cycle effects (Gornemann *et al.*, 2014; Wong, 2015), and a substantial role for household indebtedness (Kiyotaki and Moore, 1997; Cloyne *et al.*, 2016; Flodén *et al.*, 2016). These studies yield different results, conclusions and policy implications, partly due to the fact that they focus on different channels. It is generally acknowledged however, that monetary policy is not distribution-neutral over the economic cycle, implying asymmetric responses which do not fully offset each other. In order for fiscal policy to correct for this, it is needed to reveal where the sources of these asymmetries lie.

This thesis sets out to explore the response of household expenditure to monetary policy shocks for different groups of households based on household-level data from the U.S. Consumer Expenditure

Survey (CEX), in order to identify the transmission channels actually at work. The goal is to reveal channels of transmission from monetary policy to redistribution and inequality. By sequentially grouping households according to age, housing tenure, and financial activity, and estimating the impulse responses of household expenditure to monetary policy shocks, this study provides evidence for heterogeneous responses across these dimensions. Expenditure is the outcome of interest here as household consumption is a large component of the aggregate economy and reflects the direct response of households to the policies in terms of welfare. The results will provide a set of stylized facts about responses of different groups of household to monetary policy that can be considered for monetary policy strategy, for instance when estimating the parameters of New-Keynesian models with heterogeneous agents as regularly used in monetary policy design.

The thesis will be structured as follows: The next section gives a discussion of the related existing literature. Section 3 presents the data used for analysis. Section 4 describes the empirical strategy of the estimation after which Section 5 presents the results. Section 6 discusses the findings and the implications after which Section 7 concludes.

2 Literature review

In the following section, an overview of the strands of the literature that this paper relates to is provided. First, the addressing of agent heterogeneity in the monetary policy literature is discussed. After that follows a discussion of income and wealth inequality in relation to monetary policy. Lastly, an outline of the channels of transmission of monetary policy to distributional outcomes as explored by the recent literature is provided.

2.1 The role of heterogeneity in monetary policy outcomes

2.1.1 Macroeconomic models with heterogeneous agents

The New Keynesian model has become the workhorse model to analyse monetary policy, and often assumes the existence of symmetric effects by using a representative agent. To analyse distributional effects, a different approach is required. A growing part of the macroeconomics literature incorporates heterogeneous agents and distributional effects into New-Keynesian models to reconsider optimal monetary policy.

Gornemann *et al.* (2016) consider heterogeneity of households in terms of labour productivity, savings and employment status and incorporate it in a New-Keynesian sticky-price business cycle model, with the feature of matching frictions. Household heterogeneity stems from differences in three dimension; current potential productivity, current wealth and current employment. Thereby, they can capture in their model economy that monetary policy affects the distribution of income and consumption through its effect on different sources of income, notably labour income and financial income. As documented from the data by Diaz-Giménez *et al.* (2011), households' sources of income tend to differ across the wealth distribution. They find that in the U.S. in 2007 wealthier households rely more on financial and business income, whereas other households receive primarily labour income or transfers. Gornemann *et al.* (2016) find that on balance, an expansionary monetary policy hurts the bottom 80 percent of the wealth distribution and benefits the wealthiest five percent. This is despite the fact that the positive effect on employment mainly benefits the lower part of the wealth distribution.

Another recent study constructing a New-Keynesian model with heterogeneous agents comes from Kaplan *et al.* (2016). The household heterogeneity in this model is reflected by idiosyncratic asset holdings and a spread of income processes and the outcome of interest is household consumption. This results in the model producing a representation of the cross-section of household portfolios, wealth distribution, and consumption behaviour in which responses to monetary policy can be simulated. They find that indirect effects on household consumption of an unexpected monetary stimulus that operate through a general equilibrium increase in labour demand, prevail over direct effects such as intertemporal substitution as was originally the focus of representative agent models. In this setting the role of financial income is thus more limited, as the role of illiquid assets is more prominent.

Alternatively, Auclert (2016) focuses on redistribution among households with different marginal propensities to consume. He argues that redistribution is not a side effect of monetary policy, but an actual complementary channel of monetary policy transmission, affecting macroeconomic aggregate outcomes. For this argument he relies on the fact that the 'winners' from stimulating monetary policy react more strongly than the 'losers', based on household micro data. Thus he not only pays attention to household groups' individual changes in spending but also aggregates spending as an outcome of redistributive effects of monetary policy measures in his analysis.

Apart from looking at distributional outcomes in terms of total household spending, there is reason to believe that not so much total expenditure but rather durable expenditure would be influenced by

monetary policy. Durable goods relate to the saving propensity agents have in response to monetary policy and can be seen as an investment and a means to smooth consumption. Sterk and Tenreyro (2015) focus on durable goods expenditure. They find, in a general equilibrium model with a parsimonious life cycle structure and no nominal rigidities, that working agents respond to monetary expansion by working and saving more and by accumulating durable goods. The durable goods sector is likely to be more responsive to monetary policy shocks and is estimated separately by Cloyne *et al.* (2016) as well.

This study adds to this strand of the literature not by specifying a model but by instead focusing on revealing the dimensions of household heterogeneity empirically. Thereby the applicability of these models can be tested and possibly improved.

2.1.2 Monetary policy and the life-cycle

Life-cycle diversity is often exploited to estimate heterogeneous effects. This thesis complements the evidence from an increasing number of studies, including Gornemann *et al.* (2014); Wong (2015); Coibion *et al.* (2016), about the role of demographics in the transmission of monetary policy.

Wong (2015) examines the effects of demographic changes for monetary policy by estimating age-specific consumption elasticities to interest rate shocks, exploiting regional variation in demographics. These elasticities are then incorporated in a life-cycle model featuring a mortgage market, revealing a loan adjustment channel that is driving the differences in consumption response to interest rate changes between age cohorts. She finds that expansionary monetary policy shocks have large and persistent effects on consumption, which are heterogeneous across age groups. The consumption elasticity of the young (under 35 years old) is found to be two to three times higher than that of the old. This paper primarily highlights the role of housing situation of different age groups, as the difference in elasticity is driven mainly by the different responses of home-owners and renters through the effect of interest rate changes on housing loan costs.

Gornemann *et al.* (2014) examine intergenerational heterogeneity both empirically and by use of a model, focusing on different additional household characteristics. Specifically they aim to explain redistribution through effects to agents' income and assets. In this setting they distinguish between young households, which represent labour income, versus old, which represent financial income. Their empirical analysis of spending and income of both age groups uses the U.S. CEX household survey data and estimates the response in consumption to monetary policy shocks, finding a fall in expenditure for

both young and old households after a monetary tightening, with a stronger effect on the old. Coibion *et al.* (2016) find that the responses of consumption by high net-worth households are larger than that of low net-worth households in the CEX data, which suggests that older households exhibit a stronger response in expenditure, which is in line with what Gornemann *et al.* (2014) find. This is competing with the results of Wong (2015) that the young have a higher consumption elasticity in response to monetary actions, possibly due to the different characteristics and mechanisms that they focus on.

Subsequently, Gornemann *et al.* (2014) present a New-Keynesian sticky-price business cycle model with heterogeneous agents and matching frictions based on the stylized findings from this analysis. Hereby they wish to determine the optimal monetary policy in aging societies. To the same end, Kara and Thadden (2010) in their early work on the topic, incorporate a demographic feature in a small-scale dynamic stochastic general equilibrium (DSGE) model to investigate macroeconomic responses to demographic shocks for the Euro area. They argue however that monetary policy need not take overall demographic changes into account, as this is a slow-moving process unlike monetary policy, and supposedly beyond the horizon of monetary policy makers.

The literature so far, consisting of divided views on intergenerational effects of monetary policy, necessitate the identification of the channels that create these opposing dynamics. Cwik *et al.* (2015) construct an overlapping generation heterogeneous agent model to explore distributional effects of monetary policy. They evaluate both the short run and the long run implications of monetary policy on different agents in their model. Three channels of transmission are considered for this, which rely on divergent effects on different sources of income and portfolio holding, the transmission channels which will be discussed in more detail in the next section. Their results suggest that life-cycle diversity gives rise to inequality both within and between the cohorts. A particular channel that they reveal is the savings redistributions channel, building on Doepke and Schneider's (2006) earlier work, as they find that agents who are at the peak of their savings in the life-cycle tend to benefit relatively more in terms of consumption from a positive monetary policy shock through a higher return on savings than the younger and older cohorts.

The evidence on redistributive effects of monetary policy on agents of different ages as examined by these papers thus remains inconclusive and depends on many characteristics that vary over the life-cycle. The empirical analysis in this paper relies on the same data source as Gornemann *et al.* (2014); Wong (2015) and Coibion *et al.* (2016) do, and given their opposing results, a division of households that goes beyond only their age will be performed in an attempt to reveal the forces explaining these

competing findings.

2.1.3 Role of household debt and asset structures

One further aspect of household heterogeneity that has received considerable attention is household indebtedness and asset portfolio. This thesis relates to the literature that emphasizes the role of debt-constrained agents in the transmission of economic shocks. Prominent examples include Iacoviello (2005); Eggertsson and Krugman (2012) and Kaplan and Violante (2014).

The studies on the distributional effects of monetary policy build on previous work on the implications of varying interest rates as most notably started by Doepke and Schneider (2006). They analysed the redistributive effects of inflation as affecting nominal asset and liability positions, at both the sectoral level and the household level, mainly reconstructing the 1970's in the United States as an exercise. They aim to identify 'winners' and 'losers' from such a period of inflation. High inflation may increase income inequality but deflation is unlikely to have the opposite effect given downward nominal rigidities. Doepke and Schneider (2006) document significant wealth redistribution in the U.S. economy following (unexpected) inflationary episodes. Their analysis is based on detailed data on assets and liabilities held by different segments of the population, from which they calculate the revaluation effects caused by inflation. The authors find that the main winners from inflation are the government as well as poor, young households, whereas the losers tend to be richer, middle age and older households (in their forties or above).

Similarly, prominent examples of theoretical studies incorporating agents constrained through debt include Kiyotaki and Moore (1997), Iacoviello (2005), and Kaplan and Violante (2014). Iacoviello (2005) describes a financial accelerator mechanism, examined through a monetary business cycle model with nominal loans and collateral constraints tied to housing values. He follows Kiyotaki and Moore (1997), where a collateral constraint governs the household's ability to extract equity from housing, emphasising the limiting role of credit constraints in reaction to shocks. Lastly, Kaplan and Violante (2014) develop a "wealthy hand-to-mouth" framework where households have to pay a transaction cost to access their net illiquid wealth, influencing their marginal propensities to consume out of income shocks. These studies stress the role of household debt in agents' ability to respond to monetary policy shocks, suggesting that liquidity constrained households are more responsive to shocks to their income. As an increase in the price of assets such as real estate is not directly accessible and spendable, this is expected to be of minor importance in the household response to monetary policy stimuli in the short

run.

When looking at the literature that focuses more on the role of housing wealth and debt in a monetary policy setting, one finds that the relationship between housing equity and consumer spending has recently become of increased interest. It has been investigated in various settings, both empirically (Rubio, 2011; Mian *et al.*, 2013; Keys *et al.*, 2014; Jappelli and Scognamiglio, 2016) and theoretically (Notarpietro and Siviero, 2015; Hedlund *et al.*, 2016) making use of various sets of household data. Laséen and Strid (2013), Walentin (2014) and Flodén *et al.* (2016) examine how monetary policy affects (housing) debt positions and mortgage payments for households and how that transmits to aggregate outcomes for Sweden. More specifically, Flodén *et al.* (2016) exploit variation in households with regards to their mortgages to establish a channel of transmission, the cash-flow channel. The argument is that households with large debt positions and mortgages with adjustable rates would be more vulnerable to monetary policy impulses relative to households with smaller debt positions and mortgages with fixed rates. To this end, they estimate the marginal propensity to consume out of a change in interest expenses for households, using longitudinal household level data from Sweden. Keys *et al.* (2014) perform a similar analysis for the U.S. and subsequently make use of regional variation in mortgage contract types to estimate the impact on broader economic outcomes. They find that regions more exposed to mortgage rate changes experienced a faster and stronger pass-through of monetary policy to consumption and employment growth. In line with this, Flodén *et al.* (2016) find a stronger response in consumption to changes in interest rates for highly indebted households with adjustable interest rate mortgages, implying that monetary policy has a stronger effect for debt-constrained households.

This thesis will contribute to this field of research by estimating expenditure response of households based on their housing tenure, in a similar way as done for the U.K. and U.S. by Cloyne *et al.* (2016). Cloyne *et al.* (2016) aim to quantitatively examine the ways in which mortgage debt may influence the transmission of monetary policy to household spending. They exploit differences between groups of household with a mortgage and without a mortgage, assuming that households with mortgage debt are more likely to be liquidity constrained. The responses in spending of these housing tenure groups in the U.K. and the U.S. are estimated and compared, as they have differently structured mortgage markets. The group of mortgagors is found to react more strongly in their expenditure than outright home-owners, particularly when looking at durable consumption, suggesting that this group drives aggregate results. This is explained by the notion that mortgagors are liquidity-constrained, and once

interest rate changes alter their interest payments, it is reflected in expenditures. The direct effect of monetary policy on cash flows is found to be limited through this channel, and the general equilibrium effect of monetary policy on income plays a more significant role for households. In general however, they find that a cut in the policy rate raises both durable and non-durable expenditure.

Now that the presence, importance and effects of several dimensions of household heterogeneity for the transmission of monetary policy have been established and reviewed, the implications of monetary policy for outcomes in terms of inequality will be discussed in the next section.

2.2 Inequality outcomes

Redistributional developments in general have gained attention in recent years from various scholars and the public. Rising income and wealth inequality is seen as a barrier to growth for modern economies. The recent financial crisis has exacerbated income and wealth inequality in many advanced economies. This paper relates to the recent literature on this topic because redistributional effects of monetary policy are increasingly considered as a major contributing factor to these developments.

Thomas Piketty (2014) famously revived the discussion on inequality in the last decades with his book, for which he had done years of research on the dynamics of wealth and income for mostly the United States (Piketty and Saez, 2003) and Europe. He attributes the rise in inequality to the fact that the rate of return on capital is higher than the economic growth rate in the long term which results in the concentration of wealth with capital-holders in the top of the wealth distribution as opposed to people relying on labour income on the lower end of the wealth distribution.

Saez and Zucman (2016) more closely examined household income and wealth distribution in the U.S. since 1913 by combining income tax returns with macroeconomic household balance sheets. They find that wealth concentration has continuously increased since 1978. The data show that the top 0.1% wealth share has risen from 7% in 1978 to 22% in 2012. They attribute the increase in wealth inequality in recent decades to similar developments as Piketty (2014) does, namely the upsurge of top incomes combined with an increase in savings rate inequality. Again the role of capital earnings is pivotal.

A measure that is often used in economics to quantify inequality is the Gini index. Cingano (2014), in a study for the OECD, documents an increase of the household income as measured by the Gini inequality measure. He finds an increase in the Gini coefficient from 0.305 in 1980 to 0.39 in 2012, for the United states, which is in line with other studies employing Gini coefficients (Diaz-Giménez *et al.*,

2011). Besides the increasing top income shares, Cingano (2014) identifies a slowing development at the bottom during upturns and even decreasing income during downturns. He also looks into the economic consequences of increased inequality, and finds that human capital is a channel through which inequality may affect economic growth, as skill development is depressed at the lower end of the distribution. Reducing inequality is thus not only necessary to reach higher social outcomes, but also aggregate economic development. This can be achieved by for instance implementing well-targeted taxes and transfers.

There are many factors in the economy driving these developments of increased inequality. O’Farrell *et al.* (2016) relate the developments in inequality in developed countries as sketched by the aforementioned studies to monetary policy as a two-way interaction. Monetary policy easing is found to have ambiguous effects on inequality but can be examined via its impacts on returns on assets, the cost of debt servicing and asset prices. In their cross-country analysis they however find these effects to be rather small. Reversed, higher inequality does not seem to significantly affect the effectiveness of monetary policy in boosting private consumption via wealth effects. The relevance of differences in the size and composition of household financial assets for the transmission of monetary policy rather than the distribution is confirmed by their OECD cross-country data.

Due to its information richness, the CEX Survey data is used frequently for studies of inequality in the U.S. (Primiceri and van Rens, 2007; Coibion *et al.*, 2016), as it will be in this thesis. The effects of contractionary monetary policy shocks on inequality in the U.S. have been empirically investigated by Coibion *et al.* (2016). They show that contractionary monetary policy shocks by the Federal Reserve have historically been followed by persistent increases in income and consumption inequality as computed from CEX household data. The effects that they find are economically large for consumption and expenditure inequality, and moderate for total income inequality, but the effects on earnings inequality are much smaller. The contribution of monetary policy shocks to labour earnings inequality is approximately ten percent for total income in the long run and over twenty percent for consumption and expenditure inequality. These findings are related to some of the channels underlying these distributional consequences of monetary policy. They aim to address all channels of transmission simultaneously, finding that these imply that the effect of monetary policy on overall economic inequality is ambiguous. Davtyan (2016a) interestingly finds the opposite effect for the influence of monetary policy shocks on income inequality in the U.S., namely that a contractionary shock decreases income inequality by 0.4 percentage points as measured by the Gini index.

Mumtaz and Theophilopoulou (2016) estimate the impact of monetary policy on inequality in the U.K., and find that contractionary monetary policy shocks lead to a deterioration in earnings, income and consumption inequality. Their analysis of micro level information suggests that the negative effect is especially large at the bottom of the income distribution and has been intensified by the recent policy of quantitative easing. The effects on interest rates and asset prices are often named as the main channels through which monetary policy affects wealth inequality, with a particular role for house prices (Domanski *et al.*, 2016).

Lastly, some research has linked rising inequality to credit booms and financial crises (e.g. Rajan, 2010; Kumhof and Rancière, 2015), therefore suggesting a potential link from inequality to macroeconomic stability, which is relevant for the effectiveness of monetary policy as well.

This strand of the literature suggests that monetary policy certainly has a share in inequality dynamics. This applies to income inequality, wealth inequality and consumption inequality. The latter will be addressed in this thesis. Changes in inequality imply that there are redistributive developments present, so it is useful to detect which household characteristics are driving this in order for policy makers to act upon it. In order to gain an accurate understanding of what is driving the results of heterogeneous responses to monetary policy as discussed in the preceding sections, it is instrumental to think in terms of the channels through which this transmission takes place. Therefore, before turning to the analysis, a review of the distributional channels of transmission of monetary policy as documented in the literature will follow.

2.3 Channels of transmission

There is a growing branch of the literature that seeks to study alternative channels for the transmission of monetary policy, which can complement the standard channel based on nominal rigidities. This provides a foundation upon which empirical analysis of household responses can be conducted.

Various channels have been discussed in the literature, and the following list consists of channels for which significant support exists. Nakajima (2015) divides the redistributive channels in two groups, the inflation channel and income channels. Auclert (2016) on the other hand, more precisely formulates three main channels of redistribution of transmission of monetary policy which can result in an effect on aggregate expenditure. He argues from the intuition that marginal propensities to consume from monetary expansion are heterogeneous. Coibion *et al.* (2016) cites the same and adds two more channels. Here the channels are listed and clarified:

i) Income composition channel

Business, financial and labour income as well as transfers all respond differently to monetary stimuli. For instance, lower interest rates typically tend to diminish income from financial assets, but stimulate and raise business income. Labour income and transfers respond in a later stage with a few lags, through employment developments. For this channel, the heterogeneity of households with regard to their primary source of income determines the distributional effect (Coibion *et al.*, 2016). Empirical studies have identified this as the most important channel (Coibion *et al.*, 2016) for the U.S., emphasizing the movements of financial income and countercyclical transfers in the short term.

ii) Earnings heterogeneity channel

Moreover, labour earnings' response to monetary stimuli are not symmetric and dependent on wage rigidities, the substitutability of labour with capital and labour supply behaviour. The responses in total earnings from labour and profits that are induced by monetary expansions may be unequal (Auclert, 2016). In downturns, agents at the margins might respond more intensely to monetary actions because they have a higher risk of finding themselves unemployed.

iii) Financial segmentation channel

Households participating actively and frequently in the financial market are in a superior position to benefit from the positive effects of policy rate changes. Williamson (2008) in his attempt to explore the nonneutrality of money addresses this channel by modeling 'connected' versus 'unconnected' economic agents, that is agents who trade in the financial markets frequently and agents who do not. He finds that in the short run, a stimulating measure in the form of central bank money injection results in a redistribution of wealth towards connected economic agents from the unconnected ones.

iv) Portfolio channel

A household portfolio's asset structure determines how much a household is influenced by a policy rate change. For instance, households holding cash rather than other types of securities will be harmed by expansionary monetary policy that is inducing inflation (Davtyan, 2016b).

v) Savings redistribution channel

Also named the Fisher channel from unexpected inflation after Irving Fisher (1933). Unexpected increases in inflation revalue nominal balance sheets, resulting in nominal creditors losing and nominal

debtors gaining (Doepke and Schneider, 2006). Net nominal positions (NNPs) quantify the exposures to unexpected increases in the price level due to monetary policy actions.

vi) Interest rate exposure channel

This channel can be analysed by considering durations of all liabilities, including consumption paths, and assets, including human capital. Hereby balance sheet exposure to interest rates can be computed. Flodén *et al.* (2016) and Cloyne *et al.* (2016) focus on the cash-flow channel, as influenced by the move in mortgage payments. The budget constraint of debtors is directly affected by the interest rate change through these changes in interest payments. For this, the dimension of adjustable interest rates and mortgage market structures are important.

These channels illustrate the complex dynamics of monetary policy to redistribution and heterogeneous household responses, making analysis challenging and the use of disaggregated data necessary. It is however useful to consider the channels when evaluating household responses to monetary policy from the data. A few important dimensions of household heterogeneity can be derived from these theoretical channels. First, the types of sources of income that a household relies on is differently exposed to monetary policy. Second, the extent to which a household is engaged in financial activities determines the household's exposure. Lastly, the sort and amount of assets and liabilities that a household holds is of importance. All of these characteristics are determinants of heterogeneous responses over the life-cycle. This will be considered in the further analysis.

3 Data

This section presents the dataset, discusses the strategy of grouping households by characteristics relevant for uncovering household heterogeneous responses to monetary policy, and the identification of the monetary policy stance and shocks.

3.1 Household data

In looking at the disaggregated effects of monetary policy, one faces a number of empirical and econometric challenges. Specifically, good quality micro data with rich coverage of both expenditures and income and asset holdings is needed, for an extended period of time. Few datasets include all this information, as some authors in the field have already concluded (Cloyne *et al.*, 2016; Flodén *et al.*,

2016). This thesis uses the rich micro data from the Consumer Expenditure Survey (CEX) for the U.S., for its extensive coverage of household expenditure in particular. Household spending is the most important part of aggregate demand, and will be the outcome of interest in this analysis. Moreover, estimating consumption, being the counterpart of saving, is instructive as it allows for analysis of household propensity to consume and save in response to monetary policy actions.

The CEX is a renown dataset and is, besides in many studies on household consumption in the U.S., used for constructing weights of the Consumer Price Index (CPI). It is provided by the Bureau of Labor Statistics and consists of two surveys, an interview survey and a diary survey. This dataset has also been used for a similar purpose by among others Wong (2015); Cloyne *et al.* (2016); Coibion *et al.* (2016).

In this thesis the period from the first quarter of 1996 until the fourth quarter of 2007 will be considered. The availability of the CEX data allows for analysis from 1996 onwards and in this study the period after 2007 will not be considered to abstract from issues surrounding the zero lower bound on interest rates.

Table 1: Number of households per year

Year	Households
1996	8,444
1997	7,128
1998	7,200
1999	10,459
2000	10,023
2001	9,740
2002	10,094
2003	10,484
2004	11,667
2005	10,880
2006	9,410
2007	11,209
Total	116,738
<i>Source: CEX data</i>	

Table 1 shows the number of respondent households that are available per year in the period that is studied in this thesis.¹ The respondents are selected to be representative for the U.S. population. Each household reports once per quarter for up to four consecutive quarters. They are interviewed at different points in time, and report on, among other things, their consumption over the past three months. In order for these three month periods to coincide with calendar quarters, responses need to

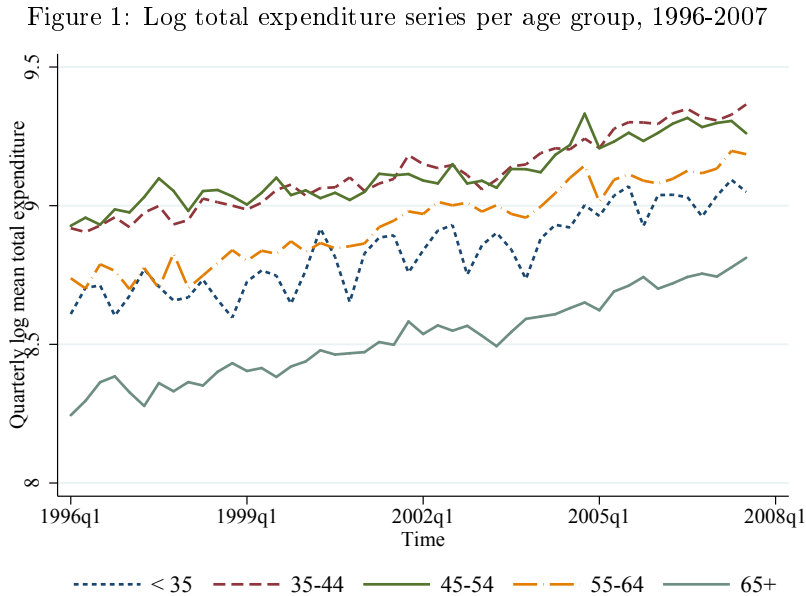
¹As households report for multiple quarters, the number of observations per year is higher than reported in table 1

be adjusted.²

3.1.1 Household expenditure series

Expenditure in the CEX is reported quarterly, concerning the previous three months. For the main analysis in this thesis, total household expenditure is the outcome of interest. Total expenditure includes both durable (housing, transport, education etc.) and nondurable (food, alcohol, clothing, entertainment) consumption. In robustness checks, expenditure on only durable goods will be analysed as literature suggests durable consumption to be more sensitive to monetary policy shocks (Sterk and Tenreyro, 2015; Cloyne *et al.*, 2016).

Figure 1 illustrates the development of total expenditure as reported by the households in the CEX over the period 1996 quarter 1 to 2007 quarter 4. Total expenditure on average has risen for households of all ages over this period in a steady pace. The oldest cohort of retirees (65+) is in the bottom of the expenditure distribution and the middle-aged (35-44, 45-54) are leading in the top of the distribution. The logs of total expenditure are used to adjust for outliers and for the sake of easing the interpretation of results. To capture the seasonality of expenditure as is apparent in figure 1, quarterly dummies will be included in the analysis.



Source: CEX data

²See Appendix A for more details on the processing of CEX data

3.1.2 Grouping households

The CEX is a panel only to the extent that the households are interviewed for four subsequent quarters. Each year, different households are selected and interviewed. So there is only limited possibility of following individual units over time, making the analysis with a time series of monetary policy shocks challenging. The availability of sets of rich household level panel data is low in many countries and periods, and scholars have found ways to solve this problem, of which one will be used in this analysis. Despite the lack of tractability of one specific household over the years, it is possible however to follow groups of people from one survey to another (Browning *et al.*, 1985; Deaton, 1997). The method of creating pseudo-cohorts from individual household survey observations to allow for panel analysis has been used among others by Blundell *et al.* (1994) and Attanasio and Weber (1995); Attanasio *et al.* (2009). Members of a group of households (e.g. mortgagors, young/old) are randomly selected into each survey year, and are therefore not subject to selection bias. By this method of grouping households a pseudo-panel is created, and one can capture many of the properties of actual panel data. Cohorts are often interesting in their own right, and questions about the gainers and losers from economic development are regularly addressed by following such groups over time (Deaton, 1997). In this semi-aggregated structure the data provides a link between the microeconomic household-level data and the macroeconomic outcomes of interest. This method is suitable for the purpose of this thesis in its attempt to identify heterogeneous responses to monetary policy from different households in the U.S. as certain relevant characteristics will be used to divide the sample in groups of interest over a multitude of years.

To allow for using groups of households as a panel as suggested by Deaton (1997), two concerns need to be addressed. The first is to provide evidence that monetary policy (high frequency) does not significantly affect the shares of households in each group (slow-moving), that is to make sure that compositional change is not driving the results (Cloyne *et al.*, 2016). If monetary policy has an effect on households' decision to change their share of income from a certain source, then heterogeneous effects found in this analysis can be attributed to compositional change. Secondly, selection of households into a household group has to be considered. These will be addressed in the robustness checks.

Age cohorts The first obvious dimension of interest by which the households will be divided is age. As the literature discussed in subsection 2.1.2 established, age-specific consumption elasticities to interest rate shocks exist and are expected to prevail in the household data at hand. Age will be

a characteristic by which the households are clustered for all subsequent groupings as well, further complemented with other characteristics³. Table 2 shows the number of observations per age group in the analysis for period 1996-2007.

Table 2: Household groups - age cohorts

	Observations	Share (%)
<35	82,218	24.58
35-44	71,014	21.23
45-54	66,325	19.83
55-64	46,594	13.93
65+	68,320	20.43
Total	334,471	100

Source: CEX data

Housing tenure groups Following Cloyne *et al.* (2016); Flodén *et al.* (2016), a household characteristic that has been found to be relevant for household responses is their status of housing. This is because whether a household is mortgagor, renter or outright owner is likely to indicate the household’s net nominal position and vulnerability to changes in the interest rate environment and market for credit. Moreover, this feature lends itself for grouped analysis well as households are unlikely to change their housing tenure in response to a monetary policy shock, and it can thus be considered as relatively fixed.

The CEX includes housing tenure status for all households divided into six possible statuses: owned with mortgage, owned without mortgage, rented, occupied without payment of cash rent, and student housing, as summarized in table 3 for the whole period. As the group that occupies without payment of cash rent and the student housing group consist of relatively few households, and are not sufficiently represented in all age cohorts, they will not be considered in further analysis. To make sure that the distinction by housing tenure is not picking up life-cycle effects, age cohorts will be maintained continuously. So groups will be formed by two dimensions simultaneously: age and housing tenure. Naturally, the share of households renting decreases with age and the share of households owning outright increases with age. The share of mortgagors is biggest for middle-aged groups. All three important tenure groups are sufficiently represented in every age group however.

Closer analysis of this feature of households will contribute towards revealing the savings redistribution channel (v) and the interest rate exposure channel (vi).

³Household age is given by the age of the reference person of the consumer unit. This is the first member mentioned by the respondent when asked to list the members of the consumer unit, owning or renting the home.

Table 3: Household groups - housing tenure

	Observations	Share (%)
Owned with mortgage	136,789	40.90
Owned w/o mortgage	83,542	24.98
Rented	107,545	32.15
Occupied w/o payment of cash rent	3,355	1 .00
Student housing	3,240	0.97
Total	334,471	100

Source: CEX data

Source of income groups Another relevant dimension of variation in the household data is sources of income. One can divide these into four main sources: labour income, financial income, business income, and transfers. Labour income is defined as earnings from salary. Business income is earning derived from both farming and non-farming business, partnerships and professional practices. Financial income is regular earnings from dividends, royalties, estates, or trusts, and amount of interest on savings accounts or bonds. Income from other sources includes transfers, benefits and social security like pensions.

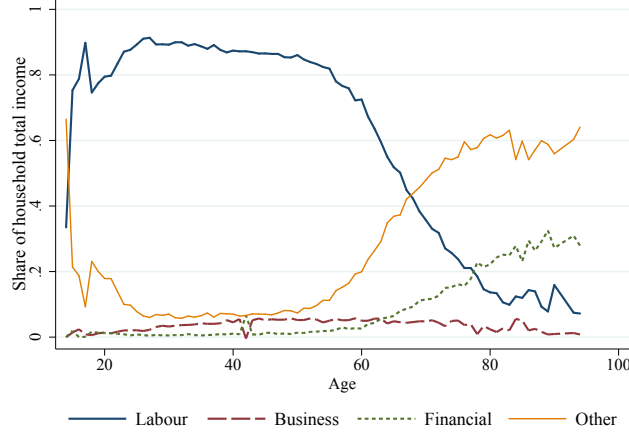
When studying income shares over the demographic cycle by decomposing the households in age groups, a clear pattern emerges of high labour income for young and especially middle-aged households, and a bigger share of income from transfers and financial sources for older households. This is illustrated in table 4 and figure 2. This is a natural pattern and is in line with the literature on demographics as reviewed in section 3.2. This suggests that if monetary policy effects on the particular sources of income vary, monetary policy will affect household groups' spending to a different extent.

Table 4: Income shares by age groups

Age group	Share of income				Frequency	Sample Share (%)
	Labour	Business	Financial	Other		
<35	0.8647	0.0258	0.0085	0.1010	31,455	30.63
35-44	0.8711	0.0314	0.0250	0.0724	22,470	21.89
45-54	0.8437	0.0538	0.0133	0.0892	19,808	19.3
55-64	0.7023	0.0550	0.0353	0.2074	13,257	12.92
65+	0.2757	0.0400	0.1659	0.5183	15,664	15.26
					102,632	100

Source: CEX data

Figure 2: Shares income sources, 1996-2007



Source: Author's rendering of CEX data

Financially active An income source that is influenced particularly strongly by monetary policy through interest rates is financial income. To test how this transmits to expenditures of households, groups dependent on income from financial activities are constructed. With the CEX data at hand, whether households are participating in the financial markets can be inferred from whether they derive any regular income from financial activities. Financial income is defined as income from dividends, royalties, estates or trusts and amount of interest on savings accounts or bonds received by the household in the past 12 months for the baseline analysis. As a robustness check another measure of financial activity will be investigated. Table 5 shows the division of households into these groups. This dimension allows for examination of both the income composition channel (i) and the financial segmentation channel (iii).

Table 5: Household groups - financial income

	Observations	Share (%)
Financially inactive	178,830	79.15
Financially active (1-500 USD)	26,357	11.67
Financially very active (>500 USD)	20,740	9.18
Total	225,927	100

Note: The USD amounts are the sum of regular financial income over past 12 months.

Source: CEX data

3.1.3 Sample limitations

The CEX is said to not include the very upper end of the income distribution (i.e. the top 1%), which might result in underestimating the extent of divergent reactions to monetary policy among groups of households. Moreover, concerns have been raised about the possible understating of consumption by respondents in the CEX panel compared to aggregate data (Attanasio *et al.*, 2012; Sabelhaus *et al.*, 2013; Coibion *et al.*, 2016). This needs to be considered when interpreting the results. It will have only limited implications for this analysis however, as it is response of consumption to shocks that is considered and not overall levels.⁴

3.2 Monetary policy measures

Estimation of the effects of monetary policy on any outcome depends crucially on the measure that is used to define monetary policy. There exist various measures in the recent literature, varying with the sort of effect estimated, assumptions and beliefs. If one wishes to establish the true relationship between monetary policy and the real economy, one must construct a measure cautiously as there is chance of substantial endogenous components in the analysis. The measure chosen in this thesis will be discussed in this subsection. A distinction will be made between the monetary policy stance, or the level, and the surprise part of monetary policy, or monetary policy shocks. Both are likely to play a role in the household income and decisions process.

3.2.1 Monetary policy stance

The conventional monetary policy tool as set by the Federal Reserve is the target funds rate as decided upon around Federal Open Market Committee (FOMC) meetings. This indicates the monetary policy stance. The mean quarterly federal funds rate is shown in figure 7 in the appendix.

3.2.2 Romer and Romer (2004) monetary policy shocks

Romer and Romer (2004) developed their measure of U.S. monetary policy shocks for the period 1969-1996. Their goal was to derive a measure free of systematic responses to information about future

⁴The two surveys that make up the CEX are sample surveys and are subject to two types of errors, non-sampling and sampling. The latter simply occurs because the surveys are taken by a sample of the population, not the entire population. Non-sampling errors can be attributed to many sources, such as differences in the interpretation of questions, inability or unwillingness of the respondent to provide correct information, mistakes in recording or coding the data obtained, and other errors of collection, response, processing, coverage, and estimation for missing data. The full extent of non-sampling error is unknown.

developments, for the outcomes to be free of endogeneity and participatory movements. In their case, they use their new measure to analyse the responses of output and inflation to monetary developments and show that, by this measure, negative monetary policy shocks have large and significant effects on output and the price level. By now, their measure is a widely used identification tool to tackle the reverse causality problem between interest rates and consumption and to isolate the true surprise part of monetary policy actions (Cloyne *et al.*, 2016; Coibion *et al.*, 2016). For use in this analysis the measure is computed and extended until the end of 2007⁵.

In their narrative approach to monetary policy shocks, Romer and Romer (2004) rely on the assumption that the Greenbook forecasts as presented before the FOMC meetings contain the vast majority of the useful information about future economic developments upon which the Federal Reserve bases its policy decision. The significant role of the Greenbook forecasts in policy discussions, combined with the relative precision of the forecasts, suggests that this is a valid assumption. The three key forecasted variables that are included in the estimation are growth rate of real GNP/GDP, the real GNP/GDP deflator and the unemployment rate. It is assumed that including four quarters of forecasts per variable per meeting reflects the set of information that was relevant at the time for the FOMC. Because output growth and unemployment are so closely related, only the longer horizon is included for output growth. reflect changes in taste or operating procedure that moves independently of economic developments⁶.

Specifically, Romer and Romer (2004) regressed the intended change in the federal funds rate around a meeting of the FOMC on the internal forecasts reported in the Fed's Greenbook of inflation, real output growth and the unemployment rate. The residuals from this estimation, thus the change in the policy rate that could not be predicted by any forecasts, reflect the true monetary policy shock free from endogeneity as defined by Romer and Romer, occurring each FOMC meeting. They may reflect changes in taste or operating procedure that move independently of the economic developments included in the estimation, and are thus unexpected and exogenous. A quarterly measure of MP shocks is constructed by summing the orthogonalized innovations to the FFR from each meeting within a quarter.

⁵Greenbook forecasts are available on the Board of Governors website (<http://www.federalreserve.gov>)

⁶A graphical representation of the underlying data series is depicted in figure 8 in the Appendix

The specific equation that is estimated is:

$$\Delta f_m = \alpha + \beta f b_m + \sum_{i=-1}^2 \gamma_i \widetilde{\Delta y_{mi}} + \sum_{i=-1}^2 \lambda_i (\widetilde{\Delta y_{mi}} - \widetilde{\Delta y_{m-1,i}}) + \sum_{i=-1}^2 \varphi_i \widetilde{\pi_{mi}} + \sum_{i=-1}^2 \theta_i (\widetilde{\pi_{mi}} - \widetilde{\pi_{m-1,i}}) + \rho \widetilde{u_{m0}} + \epsilon_m \quad (1)$$

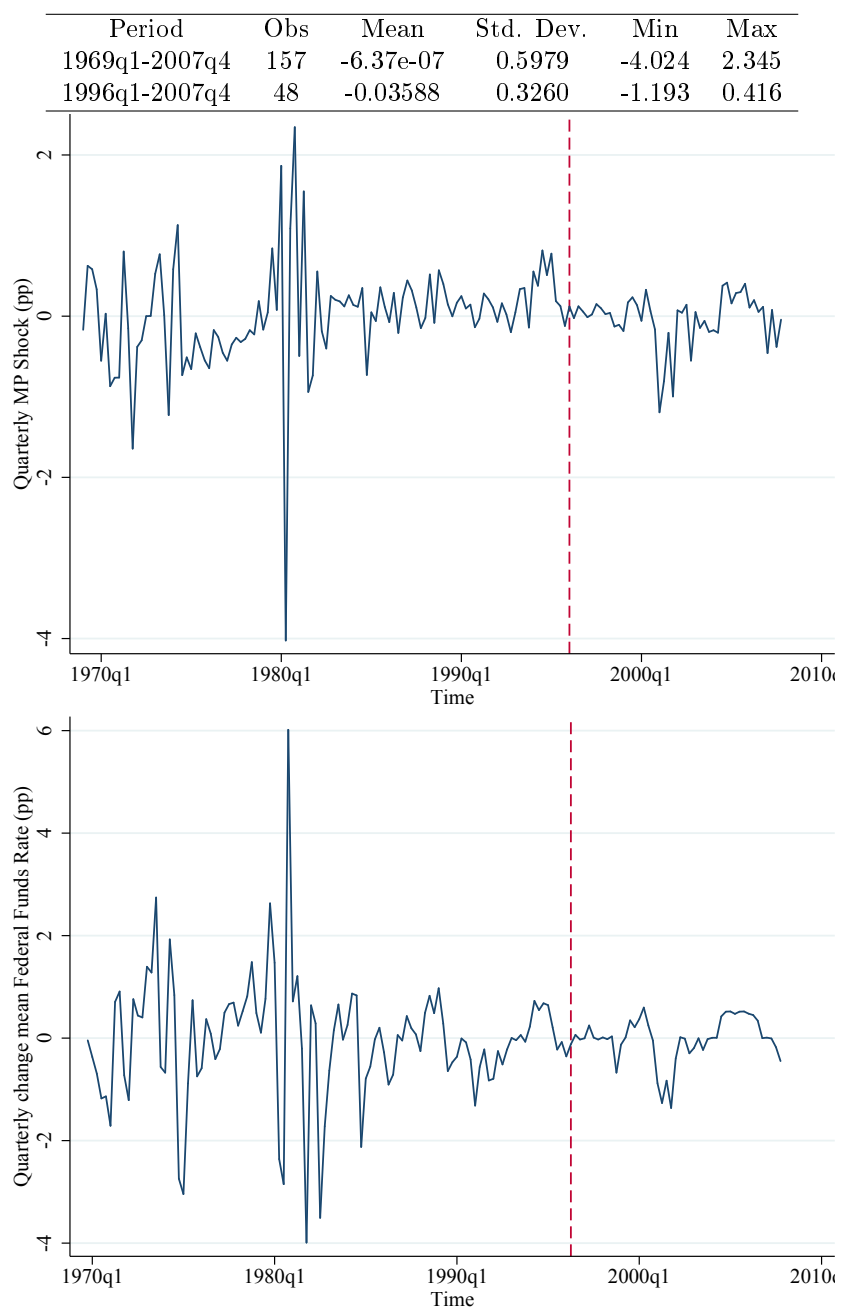
where:

- Δf_m is the change in the intended funds rate around FOMC meeting m . $f b_m$ is the level of the target funds rate before the change in the meeting m (included to capture any mean reversion tendency).
- $\widetilde{\Delta y}, \widetilde{\pi}$ and \widetilde{u} are the forecasts of inflation, real output growth, and the unemployment rate. Both the current forecast and the change since the previous meeting are used, based on the assumption that both changes and levels influence Federal Reserve policy.
- The i subscripts refer to the horizon of the forecast: -1 is the previous quarter, 0 the current quarter, 1 the next quarter, 2 the quarter after that.

The computed measure for the period 1969-2007 is presented in the top panel in figure 3. The period from 1969-1996 has the original shocks as presented in Romer and Romer (2004), from 1996 onwards the residuals are computed by estimating equation 1 from more recent Greenbook forecasts. The output of this regression can be found in table 9 in the appendix.

From figure 3 it becomes clear that the computed monetary policy shocks are very closely related to the change in federal funds rate. As the monetary policy shocks are only a part of the change in federal funds rate, namely the surprise part, the magnitude of the shocks is not quite as large as the quarterly changes are. Both the change in the funds rate and the shocks were notably bigger during the 1980's (Volcker disinflation period) than in the period that will be considered now.

Figure 3: Quarterly monetary policy shocks and quarterly change in federal funds rate, 1969-2007



Note: Dashed line indicates the start of the period of analysis

Source: Federal Reserve Bank of St. Louis

4 Empirical strategy

The aim of the analysis is to examine the effect of monetary policy on spending of different groups of households. The variable of interest is thus the change in total expenditure of the different sorts of households. Therefore, as explained above, the households are grouped in pseudo-cohorts, c , based on characteristics such as age that are expected to influence the response to monetary policy shocks and illustrate heterogeneity and redistribution.

4.1 Local projection method

Òscar Jordà's (2005) local projection method is used to estimate impulse responses, similar to Ramey and Zubairy's (2014) linear model. This method is based on local projections that do not require specification and estimation of the unknown true multivariate dynamic system itself, as opposed to traditional time-series impulse response function (IRF) analysis. It involves the estimation of sequential regressions for different horizons h for the dependent variable on the shock variable and controls at time t . In this method, the dependence of the IRF estimates on the specification of the data generating process is reduced compared to IRF computation from a vector autoregressive model (Teulings and Zubanov, 2010). Therefore, the method is rather generally applicable and used for various estimations (Auerbach and Gorodnichenko, 2013; Favara and Imbs, 2014; Romer and Romer, 2015), especially in the literature on fiscal multipliers (Auerbach and Gorodnichenko, 2013; Owyang *et al.*, 2013; Jordà and Taylor, 2016) in which unanticipated fiscal shocks are employed similar to the monetary shocks in this specification.

The local projections estimate of the IRF of expenditure X to a monetary policy shock MPS , h periods after the shock is the estimated coefficient on MPS in the regression of X_{t+h} , on the regressors measured at time t and chosen lags. So for every local projections estimate, a new regression is estimated on horizon h , which is independent of the rest of the set of estimates, which makes it more robust to probable misspecification of these intermediate values. It therefore does not restrict the shape of the IRF. At the same time, this results in lower efficiency of the local projections estimate however, and dynamic interactions may be underestimated. Moreover, as the horizon increases, there is a loss of observations from the end of the sample.

Values of the regressors between time t and $t+h$ are eliminated, so all intermediate values of X are disregarded in the estimation by the separate and successive leading of the dependent variable. This

would result in serially correlation in the error terms, so an OLS approach with serial correlation-robust adjusted standard errors is estimated, by the Newey-West correction method (Newey and West, 1987).

The local projection is finally given by a vector of estimates $\{\beta_{hi}\}_{h=0,1,\dots}$ collected from the estimation of equation 2, and will be plotted to yield the impulse response curve. Each estimate of β_h captures the effect of the monetary policy shock at horizon h .

4.2 Baseline specification

The baseline estimation will be conducted separately for every dimension of groupings: age, housing tenure, and financial activity. The following equation is estimated for every group c , for horizon h from 0, ..., H :

$$X_{t+h} = \alpha_h X_{t-1} + \beta_h MPS_t + \gamma_h Z_{t-1} + \theta_h + \mu_{h,t} + \delta_h D_h^Q + \varepsilon_{t+h} \quad (2)$$

where the t subscripts index time, and the h subscripts denote the horizon (quarters after time t) being considered.

X_t is household total expenditure in group c in quarter t . MPS_t is the monetary policy shock as defined by Romer and Romer (2004) in quarter t ⁷. The coefficient β_h estimates the response of expenditure X at time $t+h$ to the shock (MPS) at time t . Horizon h is considered running from 0 to 10 quarters. That is, horizons up to two and a half years after time t are considered. This is because the lag length and the dimension of the vector X_t imposes certain constraints in terms of degrees-of-freedom on the maximum practical horizon h for the sample size used here (Jordà, 2005).

D_h^Q are quarterly dummies to capture seasonal effects as CEX data is not seasonally adjusted. Z_t is a vector control variables including mean family size, number of earners in the household and total household income. All control variables enter once lagged, to ensure exogeneity with respect to the monetary policy shock. These controls are solely added to make the estimation more efficient, it will not yield a more exact estimate of the coefficient on MPS because MPS is assumed to be independent of any other influences on household expenditure and is thus uncorrelated with the error term.

θ_h is a cohort fixed effect, and $\mu_{h,t}$ is the linear time trend variable.

A number of additional variations of the baseline estimation are considered in the subsection on robustness later.

⁷A performed Dickey-Fuller test for unit root shows that the series of monetary policy shocks is stationary ($Z_t = -13.496$) so the shocks need not be first differenced.

5 Results

In this section, the results of estimating the local projection estimates for the different household groups as specified above are presented and discussed.

When interpreting the results, it is important to keep in mind that expenditure responses are reported as a result of a positive monetary policy shock. That is, the household's response to an unexpected one percentage point increase in the federal funds rate in terms of total expenditure is estimated. Therefore, a positive coefficient sign indicates an increase in total expenditure in response to a positive monetary policy shock.

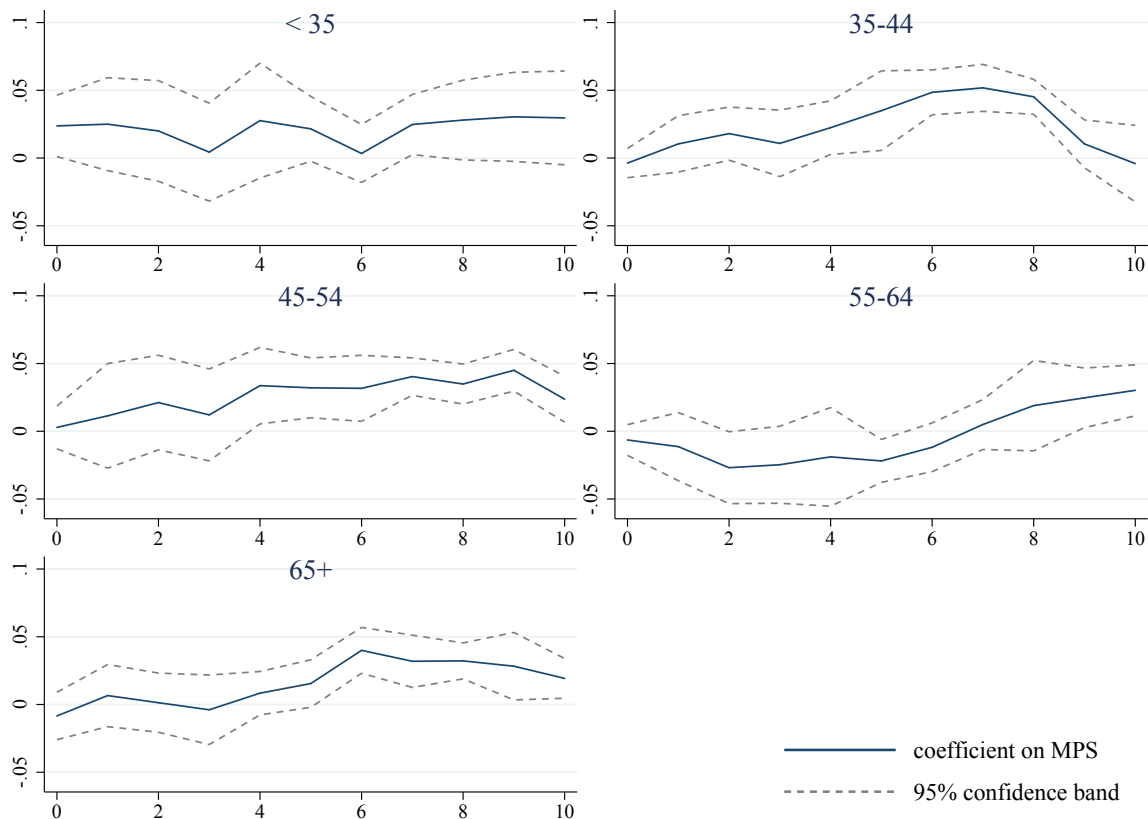
5.1 Age groups

The first dimension along which the households are grouped is age. Figure 4 shows the projected impulse responses of mean total household expenditure to a one percentage point monetary policy shock for each age group. That is, it plots the coefficient on the monetary shock variable in equation 2 for all horizons, surrounded by a 95% confidence band. Table 6 presents the point estimates and standard errors from the regression for the age groups.

The impulse responses show a heterogeneous response of the various age groups to the monetary shock. The youngest households, below 35, exhibit a weakly significant positive response in expenditure in the contemporaneous quarter and seven quarters ahead, but negligibly small. The middle-aged groups (35-44 and 45-54) show a noticeably different reaction. The impulse response functions for both show no significant response for the first four quarters after the shock, but then expenditure increases significantly for both groups, for the younger group it continues to increase for four quarters and for the older group it lasts for the rest of the horizon that is estimated. Middle-aged households thus exhibit a delayed but significant and lasting positive expenditure response up to as high as 5 percent to a positive monetary policy shock. The same applies to the oldest household groups, the pensioners. The cohort of age 55-64 however deviates. For them there is a significant dip in their expenditure after five periods, after which it picks up again and is strongly significantly positive towards the end of the horizon, which is 2.5 years after the shock. This might be due to the fact that this group is nearing retirement and therefore chooses to save more instead of spend more in response to a positive monetary shock. One would need to verify this by looking at the household's savings however.⁸

⁸This is not possible with the household data at hand however, as savings in the CEX survey are not reported frequently enough to conduct an analysis with monetary shocks.

Figure 4: Impulse responses - age groups



Apart from the cohort of 55-64 year-olds, the results are rather consistent in that the older groups all increase their spending after a lag of approximately 6 quarters. These findings are to a certain extent in line with the literature. That is, according to some studies (Gornemann *et al.*, 2014; Coibion *et al.*, 2016), older households are expected to react more strongly in their spending to monetary impulses than younger households. It has to be noted however that there are also studies finding the opposite effect (Wong, 2015). The next step is now to identify which characteristics of these age cohorts drive these differences. These results dismiss, or at least do not detect evidence for, the theory that households would substitute from spending to saving as a result of a higher interest rate environment. One can hypothesize that the increase in expenditures for older households, except 55-64, is due to the presence of the income composition channel (i) through which the older households, who typically hold more savings and financial assets, earned more financial income and spent it after some time. To confirm this hypothesis financial activity will be investigated further.

Table 6: Regression output - age groups

h	<35	35-44	45-54	55-64	65+
0	0.0237 <i>0.0116*</i>	-0.0037 <i>0.0055</i>	0.0028 <i>0.0081</i>	-0.0064 <i>0.0058</i>	-0.0085 <i>0.0089</i>
1	0.0250 <i>0.0175</i>	0.0104 <i>0.0106</i>	0.0114 <i>0.0197</i>	-0.0113 <i>0.0128</i>	0.0066 <i>0.0117</i>
2	0.0200 <i>0.0190</i>	0.0180 <i>0.0100</i>	0.0212 <i>0.0178</i>	-0.0269 <i>0.0135</i>	0.0013 <i>0.0111</i>
3	0.0044 <i>0.0184</i>	0.0108 <i>0.0125</i>	0.0121 <i>0.0173</i>	-0.0247 <i>0.0145</i>	-0.0039 <i>0.0131</i>
4	0.0276 <i>0.0216</i>	0.0224 <i>0.0101*</i>	0.0337 <i>0.0144*</i>	-0.0189 <i>0.0186</i>	0.0084 <i>0.0082</i>
5	0.0216 <i>0.0122</i>	0.0350 <i>0.0150*</i>	0.0321 <i>0.0113*</i>	-0.0219 <i>0.0081*</i>	0.0155 <i>0.0090</i>
6	0.0034 <i>0.0109</i>	0.0485 <i>0.0085**</i>	0.0317 <i>0.0124*</i>	-0.0118 <i>0.0092</i>	0.0400 <i>0.0086**</i>
7	0.0248 <i>0.0113*</i>	0.0518 <i>0.0088**</i>	0.0404 <i>0.0071**</i>	0.0050 <i>0.0094</i>	0.0319 <i>0.0098**</i>
8	0.0280 <i>0.0150</i>	0.0452 <i>0.0066**</i>	0.0349 <i>0.0075**</i>	0.0189 <i>0.0170</i>	0.0322 <i>0.0068**</i>
9	0.0304 <i>0.0168</i>	0.0104 <i>0.0090</i>	0.0450 <i>0.0079**</i>	0.0247 <i>0.0112*</i>	0.0283 <i>0.0127*</i>
10	0.0296 <i>0.0177</i>	-0.0041 <i>0.0144</i>	0.0237 <i>0.0086*</i>	0.0302 <i>0.0096**</i>	0.0193 <i>0.0075*</i>

Note: * $p < 0.05$; ** $p < 0.01$

Note: The coefficients on MPS are reported and the respective standard error for each horizon h.

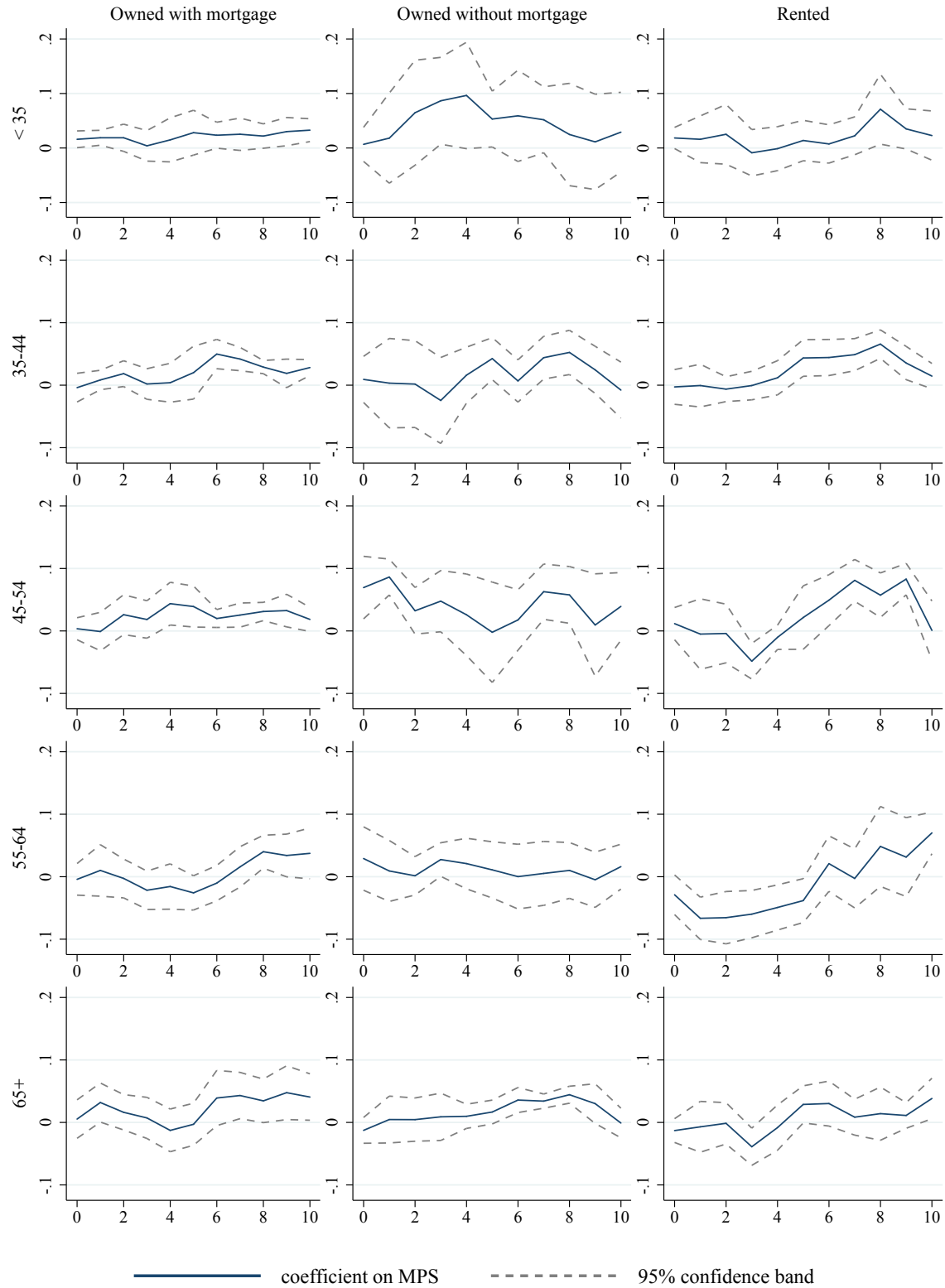
5.2 Housing tenure groups

The second dimension of household heterogeneity that is examined is the dimension of housing tenure in combination with age. The types of households that are considered for this are: owners with and without mortgage, and renters. This setup allows for evaluating whether the differential responses as observed in figure 4 reflect purely different consumption elasticities over the life-cycle or whether housing tenure is the driving characteristic behind it. According to Cloyne *et al.* (2016), house-owners with a mortgage are expected to respond more strongly to the monetary impulse because they are likely to be liquidity constrained. The constraint that stems from their limited ability to extract equity from housing wealth would result in stronger consumption fluctuations as they are unable to smooth consumption.

The impulse responses of mean total household expenditure to a positive one percentage point monetary policy shock are depicted in figure 5 below⁹.

⁹Due to limited space, not all regression outputs are provided in tabular form here. All regression outputs can however be made available upon request.

Figure 5: Impulse responses - housing tenure groups



Note: Plotted are the coefficients on the monetary policy shock in equation 2, measuring the response in total household expenditure in percentage change to a positive monetary policy shock of one percentage point.

In figure 5, the curves are not quite according to expectation based on the literature. First looking at the response functions for mortgagors, it is apparent that for every age group, towards the end of the horizon the response in total expenditure is positive and significant. This is not in line with the expectation that mortgagors are liquidity constrained and need to decrease their spending when interest payments go up because of higher interest rates after a contractionary monetary policy shock. The significance is not high however and results towards the end of the estimation horizon should be interpreted with caution. The group of owners without mortgage exhibits rather inconsistent responses across the age groups. The young group of outright owners gives a strong positive response in the third to fifth quarters after the shock, whereas for a few other age groups of outright owners a significant response only occurs later. The group of 45-54 year-olds shows a stark positive response in total spending in the first period after the shock. It is unclear what the origin is of this peak. 55-64 year-old outright owners show no response to the monetary policy shock on any horizon, despite that one would expect these to be the most wealthy households with a large amount of assets that are vulnerable to interest rate effects. Moreover, for all outright owners the responses appear to be more volatile than in the other two groups, possibly because of more heterogeneous composition of the underlying group of households. In the group of renters the only negative significant responses are to be found, namely in the three older groups. These responses are not long-lasting however. To relate this to the literature: Wong (2015) finds no response in consumption for renters, and Cloyne *et al.* (2016) finds a response of the same magnitude as for mortgagors. The findings here are that the response of renter to monetary policy shocks is actually strongest and most volatile. Table 10 in the appendix shows that renters are more represented in the lower income classes and that mortgagors are more represented in the higher income classes. Despite the fact that income is a control variable in the analysis, there may well be other characteristics related to income that are unobserved here that influence spending.

The functioning of the savings redistribution channel (v) and the interest rate exposure channel (vi) are thus not convincingly revealed by this analysis. It can however also not be rejected that housing tenure plays a role in household responses to monetary policy either.

5.3 Financial activity groups

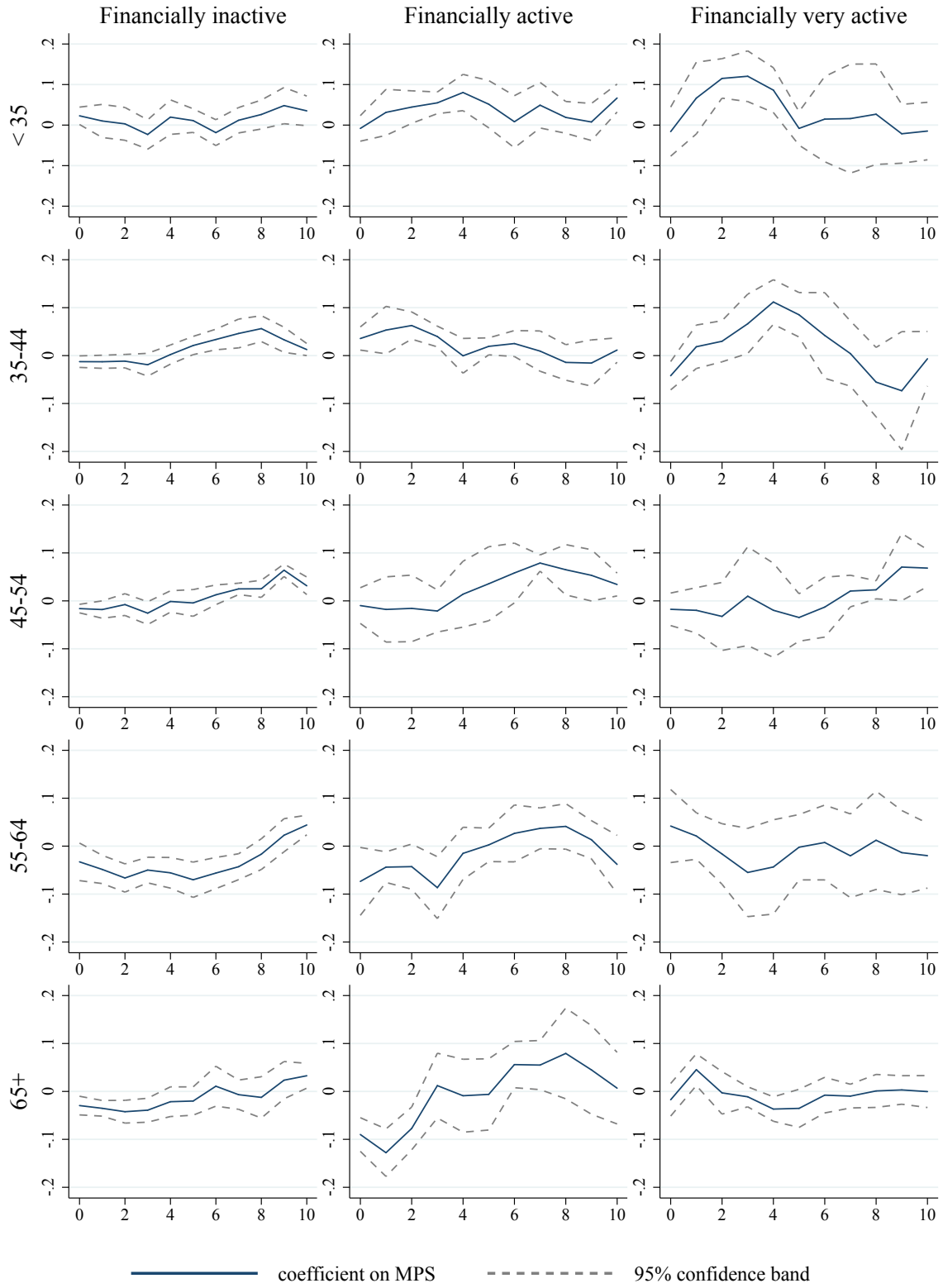
The last dimension of grouping that is investigated before turning to the robustness checks is financial activity. Financially inactive households are defined as households that derive no income from financial sources, which is regular income from dividends, royalties, estates, or trusts, and amount of interest on

savings accounts or bonds as reported in the survey for the last 12 months. Financially active derive income from such sources, but relatively little (500 USD), financially very active households derive more than 500 USD from financial income. Figure 6 shows the results of estimation equation 2 for every group separately.

The results for the financially inactive households look very similar to the results for the age groups overall. This is as expected as the majority of households qualifies as financially inactive. The only remarkable point of difference is that the negative response in spending for the group of age 55-64 is stronger and persists longer. The results that are of particular interest in this part of the analysis are the responses of the financially active households. The first thing that stands out is that the responses are more volatile. The two youngest household groups show a positive and relatively immediate spending response earlier on the estimation horizon, around the second to the fourth quarter after the shock, for the financially active groups. This is in line with the literature and can be explained by the financial segmentation channel (iii) which says that financially 'connected' agents tend to benefit more from the positive effects of policy rate changes. These transmit to the financial markets and yield higher financial income. Hereby also the income composition channel (i) is activated. For the middle-aged financially active groups, this effect is observed only later on the horizon. Surprisingly, for the oldest and financially very active households, there is hardly any response estimated at all. Even more unexpected is the stark decrease in spending for the pensioners that are moderately financial active (bottom middle panel). Their expenditure picks up again only in a later quarter.

Table 11 in the appendix shows that the higher income classes contain more households that are classified as financially active and financially very active. So just as was the case for the housing tenure groups, despite that a control variable for income is included, a division of households by financial activity might be implicitly picking up on other unobserved household characteristics that are influencing spending in response to monetary policy shocks.

Figure 6: Impulse responses - financial activity groups



6 Robustness

In this section four additional exercises are reported that have been conducted to check the robustness of the results as presented above. The results are documented in the appendix.

6.1 Additional lags

In the regression outputs of the estimations of equation 2, the variable of lagged total expenditure is not always significant, indicating that perhaps more lags of the variable are required in the analysis.

Akaike information criterion (AIC) and Schwarz' Bayesian Information Criterion (SBIC) test statistics yield for most groups an optimal lag length of between 2 and 4. As a robustness check, the analysis will be done including 4 lags of total household expenditure. The resulting response functions can be seen in figures 9, 10, and 11 in the appendix.

These added variables in the specification are rarely significant and do not change the results fundamentally. This adds towards the conclusion that no obvious patterns of heterogeneous responses of households grouped by housing tenure can be deducted from the results of this analysis for this data, and that financially active households have a stronger expenditure response to monetary policy shocks.

6.2 Durable expenditure

In this robustness check, total household expenditure in the baseline specification is replaced by durable goods expenditure. Durable goods expenditure is computed by summing household expenses on maintenance, repairs, transportation, household equipment and household operations. Housing and rental-related costs are excluded from this definition. Hereby the NIPA (National Income and Product Accounts) definition is followed.¹⁰

Results can be seen in figure 12, 13, and 14 in the appendix. They show that the estimated coefficient for expenditure response to a positive monetary policy shock tends to be larger, both positive and negative, for durable expenditures than for overall expenditures. This suggests that durable goods expenditure is more sensitive to monetary policy stimuli, which is in line with the literature (Sterk and Tenreyro, 2015; Cloyne *et al.*, 2016). Buying durables can be seen as an alternative way to save

¹⁰The NIPA are part of the national accounts of the U.S.. The Bureau of Economic Analysis define durable goods as goods that are expected to last more than a year (furniture, appliances, cars, etc.) and to have little or no secondary resale market.

Table 7: Household groups - securities

	<35	35-44	45-54	55-64	65+	Total
Not holding securities	51,415	41,560	37,646	26,389	39,735	196,745
Holding securities	4,460	6,650	6,732	5,213	6,127	29,182
Total	55,875	48,210	44,378	31,602	45,862	225,927

Source: CEX data

resources.

When looking at durable goods expenditure, household heterogeneity is more pronounced. The amplified responsiveness is especially visible in the division of groups into financial activity, for the financially active and very active. The percentage increase or decrease of durable expenditure of these households in response to a positive monetary policy shock is about twice as big as for total expenditure. Changes in expenditures on durable goods are thus a key driver of the observed changes in total household expenditure in response to monetary policy actions.

6.3 Alternative specification of financial connectedness

In the baseline specification, financial connectedness of households is defined as the amount of income that households derive from financial sources which is regular income from dividends, royalties, estates, or trusts, and amount of interest on savings accounts or bonds as reported in the survey for the last 12 months. Alternatively, one could deduct how active a household is in the financial markets from whether a household holds any securities. The CEX household survey contains a question on the estimated market value of all stocks, bonds, mutual funds and other such securities held by the consumer unit on the last day of last month. By households' response to this question, an alternative grouping of households is performed. The number of observations per resulting group are reported in table 7. One can observe that households holding securities are relatively evenly represented per age group.

Figure 15 in the appendix shows the impulse responses of total expenditure of these groups to monetary policy shocks. In this classification, a similar difference in responses between financially inactive and active young households is found. The group of under 35 that is in possession of securities reacts rather strongly positively to a positive monetary policy shock, and increases expenditure with around ten percent in the 5th period after a shock. Moreover, the decrease in expenditure for older households is again apparent. Overall, the responses are more pronounced for the households holding securities, which corresponds to the existing literature.

6.4 Compositional change

One of the concerns that raises from performing group analysis, is that the results do not reflect a causal effect because of compositional changes. If compositional changes are triggered by the monetary policy shock, meaning that households move between groups, i.e. from renters to mortgagors, then the results will be biased.

For the age cohorts, this is naturally not a concern as age is a fixed characteristic. To address this issue in the groups that are assigned by housing tenure, those households that changed housing tenure over the period they are in the survey are already excluded. To further control for this and check the sample, figure 16 in the appendix displays the shares of households that are in particular housing tenures over the years 1996-2007. It shows that there are no considerable net inflows or outflows occurring in the period. While this does not exclude the possibility of households changing tenure, it does suggest that there is no tendency for a certain movement, i.e. renting to owning, in response to monetary policy shocks. The monetary policy shocks occur at a higher frequency and are unlikely to move households.

For the groups according to financial activity, this is a more prominent concern. Besides the fact that financial activity seems to be a status that is more sensitive to monetary policy intuitively, changes in the survey definitions of financial income cause some difficulties in this dimension. Figure 17 in the appendix shows the shares of households in the respective financial activity groups over the years. After several years of stable shares (1996-2003), there is a sudden jump in the shares. Inactivity drops significantly and activity picks up around the year 2004. The stable levels of shares hereafter suggest that this does not reflect a change in response to monetary policy, as monetary policy shocks occur continuously and there was no significant event around that time. This analysis has failed to deal with this shortcoming of the survey data in this dimension of grouping and thus the limitations of this part of the analysis are admittedly greater.

7 Discussion

In the following, the validity, limitations, and implications of the results will be discussed.

7.1 Validity and limitations

This thesis set out to establish heterogeneous responses to monetary policy along different dimensions of household characteristics and whether this relates to rising levels of household expenditure. This outcome reflects changes in income and in propensity to consume as a result of monetary policy changes. In the empirical methodology of this thesis and with the data available it is however not possible to estimate the response of income to monetary policy shocks at a sufficiently high frequency. The analysis is therefore limited in the sense that effects could be further disentangled by including accurate income effects. The same applies to accurate household savings information. Access to an actual panel dataset of all these household characteristics would allow for an inclusive addressing of the questions left insufficiently answered after this study. It will remain challenging however to uncover all the economic forces involved in the transmission of monetary policy.

The different groupings of households and impulse responses that are estimated provide evidence of a heterogeneous effect of monetary policy on households along the dimensions of age, housing tenure and financial activity. The effects are at times consistent with the literature and at times not, leaving room for further investigation of underlying dynamics in specific groups. For some cases, one can only hypothesize, based on the theory and existing literature, what might be driving the results. Due to the at times questionable magnitudes of the impulse responses, conclusions about aggregate outcomes based on magnitude will be avoided. For various groups the results have proven to be robust to several specification variations and consistent though, which gives confidence to draw conclusions about the direction and relative size of expenditure responses across groups of households. This is ultimately more essential in identifying which channels are in force than the magnitude of effects. Although the standard errors on longer horizons do not necessarily reflect higher uncertainty of the estimation, one could consider taking the responses on a horizon longer than 2 years to single high frequency monetary policy shocks as less relevant.

The findings with regards to the presence of the savings redistribution channel (v) and the interest rate exposure channel (vi) were to be addressed by the grouping of households by age and housing tenure. This did not yield the expected results however. This can be due to various limitations.

Firstly, housing tenure might not be an accurate measure of how liquidity constrained a household is, which is expected to be of essential importance in the response to monetary policy. Secondly, housing tenure as a proxy for households' sensitivity to interest rates is also questionable, as this depends on the structure of the underlying mortgage market as discussed in the literature. It is thus possible that the results were not as expected because of unobserved crucial characteristics.

The grouping of households according to their degree of financial activity however yields results that are more in line with the literature, namely that households that are more involved in financial markets or hold more securities are more responsive to monetary policy stimuli. This result is the case for most household groups in the analysis, and is not very sensitive to alternative specifications. There is thus evidence pointing towards the presence of the income composition channel (i) and the financial segmentation channel (iii).

An important feature of the analysis to note is that the response of households to positive monetary policy shocks are presented. Monetary policy shocks move both ways however, as illustrated in figure 3. The outcomes of movements in monetary policy obviously depend on the course of monetary policy, whether it is expansionary or contractionary. In the period studied, 1996 to 2007, the movements of the shocks have actually been predominantly negative. This means that over the whole period the households would have responded to more negative monetary policy shocks, for which the results should be reversed.

7.2 Inequality implications

An objective of this thesis is to add to the discussion about increasing economic inequality in developed countries in the last decades. To this end, heterogeneous responses of groups of households are estimated. It has been established that monetary policy induces heterogeneous responses in terms of expenditure. This suggests that redistribution of consumption occurs following monetary adjustments. As outlined in section 2.2 there is an existing literature on the inequality implications of monetary policy. The role of monetary policy as influencing the return on assets, with housing wealth in particular, has often been named as a main driver of the contribution of monetary policy to inequality. In the impulse responses of households grouped by age, it is indeed apparent that the youngest households, who are likely to be the ones holding fewest assets, hardly change their expenditure after monetary policy shocks. The identification of heterogeneous expenditure responses of households dependent on their financial activity is particularly relevant for this outcome. The evidence here suggests that financially

active households react more strongly to monetary policy stimuli. This means that monetary policy can result in redistribution of wealth, or at least expenditure, from households that don't hold financial assets to households that do, and vice versa. As more wealthy households tend to hold more financial assets, this leads to accumulation of wealth at the top of the income distribution. This is in line with the literature (Coibion *et al.*, 2016). Again, more extensive investigation of the size and composition of households' asset portfolios would provide valuable additional insights into these findings.

These concerns about the contribution of monetary policy to inequality have been particularly dominant since interest rates have reached the zero-lower bound and unconventional monetary policy tools like quantitative easing have been employed. These tools are said to have intensified the distributional effects through its impact on asset prices. This study has refrained from investigating this period, and it would be highly interesting to compare the findings for the period before the zero-lower bound to the period after to test the validity of the views held by the public with regards to the effects of unconventional monetary interventions. In the empirical methodology of this thesis the effects of unconventional monetary policy tools like asset purchase programmes was not incorporated as this would require a different specification of monetary policy shocks than the one employed here. The results of this study on the stronger response of financially active households to positive monetary policy shocks suggest that the effect of unconventional monetary policy tools on asset prices would indeed intensify this redistributive response. The similarities between the monetary policy tools employed in the U.S. and the Eurozone and the apparent recognition of both central banks to give more thought to distributional effects of their monetary policy (Draghi, 2016; Yellen, 2016) implies that findings could to a certain extent be generalizable for both currency areas.

Admittedly, the inequality implications considered in this study are mostly short-term. In the longer term, monetary operates through macroeconomic channels that are not considered here. Monetary policy facilitates economic growth through stable price levels and aims to reduce unemployment. Arguably, this has positive distributional effects as this benefits the households at the bottom of the wealth distribution, who heavily rely on labour income, the most (Draghi, 2016).

8 Conclusion

Increasing inequality and a slow recovery have prompted interests in the redistributive effects of monetary policy in order to improve understanding of channels of transmission and to enhance the effectiveness of monetary policy. This thesis set out to explore heterogeneous responses in terms of expenditure of different groups of households to monetary policy shocks. To this end, disaggregated household-level data is analysed and households have been grouped according to three dimensions: age, housing tenure, and financial activity. The impulse responses of expenditure of these groups are estimated using Jordà's local projection method (2005) and monetary policy shocks as constructed by Romer and Romer (2004).

The results provide evidence of heterogeneous responses of different groups of households in the period 1996-2007 based on data for U.S. households from the CEX survey. The general findings are that middle-aged and older households tend to react more strongly to monetary policy impulses and that a positive monetary policy shocks for most of these groups induces a delayed and positive change in total household expenditure. Households that participate in financial markets exhibit a relatively large response to monetary policy as well, suggesting that they are more exposed to interest rate changes through financial income. These effects are intensified when considering expenditure on durable goods. These outcomes hint at the presence of the income composition channel and the financial segmentation channel of transmission.

The contribution of monetary policy to intergenerational inequality is suggested by the results. Although most of the findings are robust to alternative specifications of the estimation, inconsistent patterns of expenditure for some groups point towards the fact that closer analysis of additional household characteristics and channels of transmission is needed in order to get a profound understanding of the transmission of monetary policy to redistribution and inequality. The specific effects of monetary policy shocks on redistribution in the current zero lower bound economic environment is left for future research.

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A Appendix

CEX data

This section describes the aggregation of CEX data and the construction of variables in more detail.

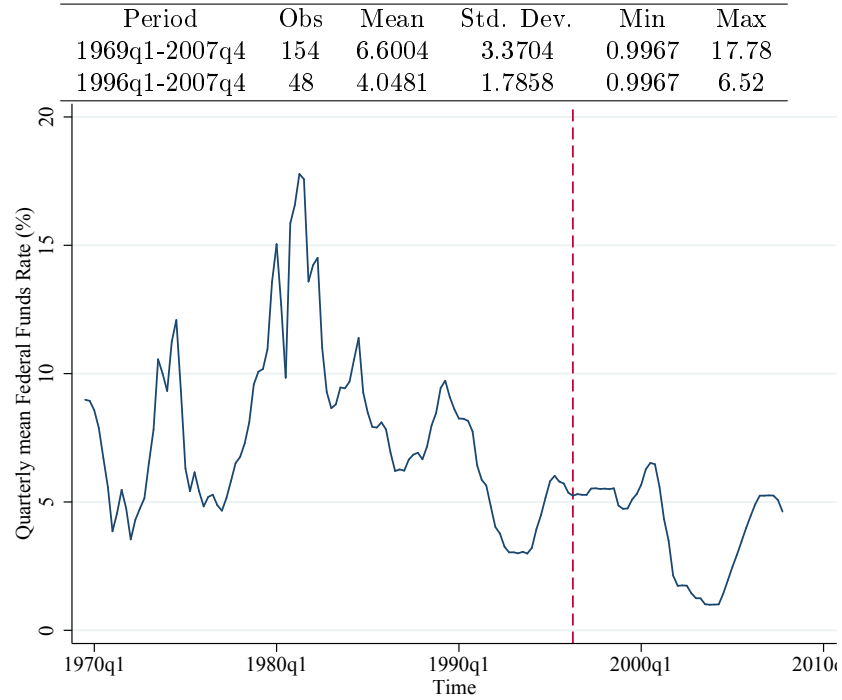
Firstly, what is defined as a household in this thesis is referred to as a consumer unit in the Consumer Expenditure survey. A consumer unit consists of all members of a particular housing unit who are related by blood, marriage, adoption, or other legal arrangements. Relations within a consumer unit can also be defined through being financially dependent in at least two of the following major expense categories: food, housing, and other living expenses.

Because as in any survey false reporting can occur, certain observations are excluded or corrected for the analysis. Households that report zero or negative expenditure on food are dropped. Furthermore the few households that report negative expenditure for categories where this is not a viable answer are dropped. For parts of this study, households that report negative labour income are dropped. To reduce the influence of outliers, all income and spending variables are winsorized at bottom and top 1 percent (Hastings Jr *et al.*, 1947).

Expenditure is reported on a quarterly frequency, concerning the three months before the interview. This does not necessarily coincide with calendar quarters. In order to obtain the expenditure series in calendar quarterly frequency from monthly frequency expenditure from across separate interview surveys is matched.

Supporting tables and figures

Figure 7: Quarterly Federal Funds Rate, 1969-2007



Note: Dashed line indicates the start of the period of analysis

Source: Federal Reserve Bank of St. Louis

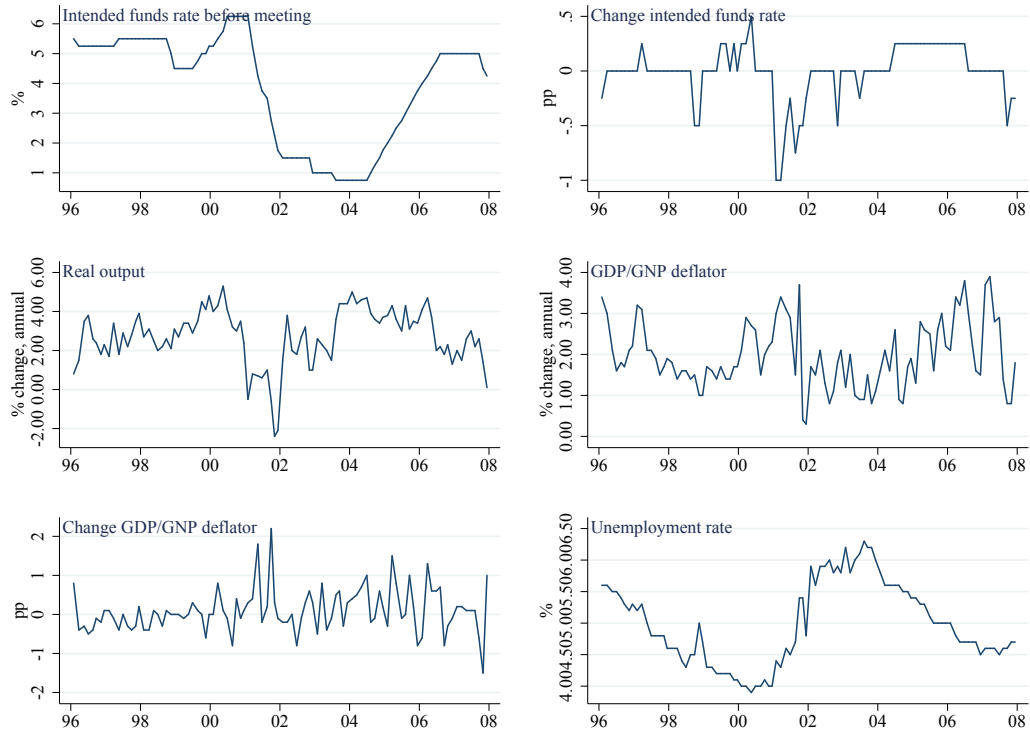
Table 8: Summary statistics - underlying data Romer and Romer shocks

Variable	Mean	Std. Dev.	Min	Max
Intended funds rate before meeting (%)	3.8542	1.8399	0.75	6.25
Innovation intended funds rate (pp)	-0.0156	0.2586	-1.00	0.50
Real output forecast (%)	2.7063	1.4345	-2.40	5.30
Innovation output forecast (pp)	-0.0396	0.8698	-2.70	3.20
GDP/GNP deflator forecast (%)	1.9625	0.8113	0.30	3.90
Innovation GDP/GNP deflator forecast (pp)	0.0948	0.5601	-1.50	2.20
Unemployment rate (%)	4.9896	0.6447	3.90	6.30

Note: The forecasts reported here pertain only to the current quarter of the corresponding FOMC meeting

Source: Federal Reserve Greenbook forecasts

Figure 8: Underlying data series Romer and Romer shocks, 1996-2007



Note: Presented are the forecasted values for the current quarter, and the innovations in the forecast.

Source: Author's rendering of Federal Reserve Greenbook forecasts

Table 9: Regression output Romer and Romer monetary policy shocks

	Change in intended funds rate
Level of the intended funds rate before the meeting	-0.123 (0.030)**
Forecast % change in GDP/GNP, previous quarter	0.019 (0.017)
- current quarter	0.099 (0.029)**
- one quarter ahead	0.030 (0.040)
- two quarters ahead	-0.026 (0.035)
Innovation forecast % change in real GDP/GNP, previous quarter	-0.007 (0.022)
- current quarter	-0.007 (0.032)
- one quarter ahead	0.035 (0.035)
- two quarters ahead	0.054 (0.035)
Forecast % change in the GDP/GNP deflator, previous quarter	0.026 (0.030)
- current quarter	0.063 (0.036)
- one quarter ahead	0.153 (0.080)
- two quarters ahead	0.142 (0.090)
Innovation forecast % change in the GDP/GNP deflator, previous quarter	0.022 (0.055)
- current quarter	-0.063 (0.049)
- one quarter ahead	-0.128 (0.099)
- two quarters ahead	-0.029 (0.124)
Forecast for unemployment rate, current quarter	-0.145 (0.059)*
_cons	0.161 (0.368)
R^2	0.64
N	96

Note: * $p < 0.05$; ** $p < 0.01$

Table 10: Housing tenure by income class

Annual income before tax	Owned with mortgage	Owned w/o mortgage	Rented	Total
Less than \$5,000	1,569	2,274	6,450	10,293
\$5,000 to \$9,999	1,948	5,856	12,099	19,903
\$10,000 to \$14,999	3,203	8,625	11,781	23,609
\$15,000 to \$19,999	3,786	7,742	9,754	21,282
\$20,000 to \$29,999	9,615	12,194	16,271	38,080
\$30,000 to \$39,999	11,991	8,585	12,472	33,048
\$40,000 to \$49,999	12,544	6,055	8,515	27,114
\$50,000 to \$69,999	24,113	8,051	9,245	41,409
\$70,000 and up	50,288	11,384	7,629	69,301
Missing	17,732	12,776	13,329	43,837
Total	136,789	83,542	107,545	327,876

Table 11: Financial activity by income class

	Financially inactive	Financially active (1-500 USD)	Financially very active (>500 USD)	Total
Less than \$5,000	7,376	782	237	8,395
\$5,000 to \$9,999	12,894	830	425	14,149
\$10,000 to \$14,999	14,259	1,229	832	16,320
\$15,000 to \$19,999	12,303	1,268	1,068	14,639
\$20,000 to \$29,999	21,254	2,620	2,322	26,196
\$30,000 to \$39,999	17,846	2,810	2,036	22,692
\$40,000 to \$49,999	14,211	2,567	1,771	18,549
\$50,000 to \$69,999	20,287	4,661	3,027	27,975
\$70,000 and up	28,793	9,085	8,706	46,584
Missing	29,607	505	316	30,428
Total	178,830	26,357	20,740	225,927

Note: Income classes are based on annual income before taxes

Figure 9: Impulse responses - age groups with added lags

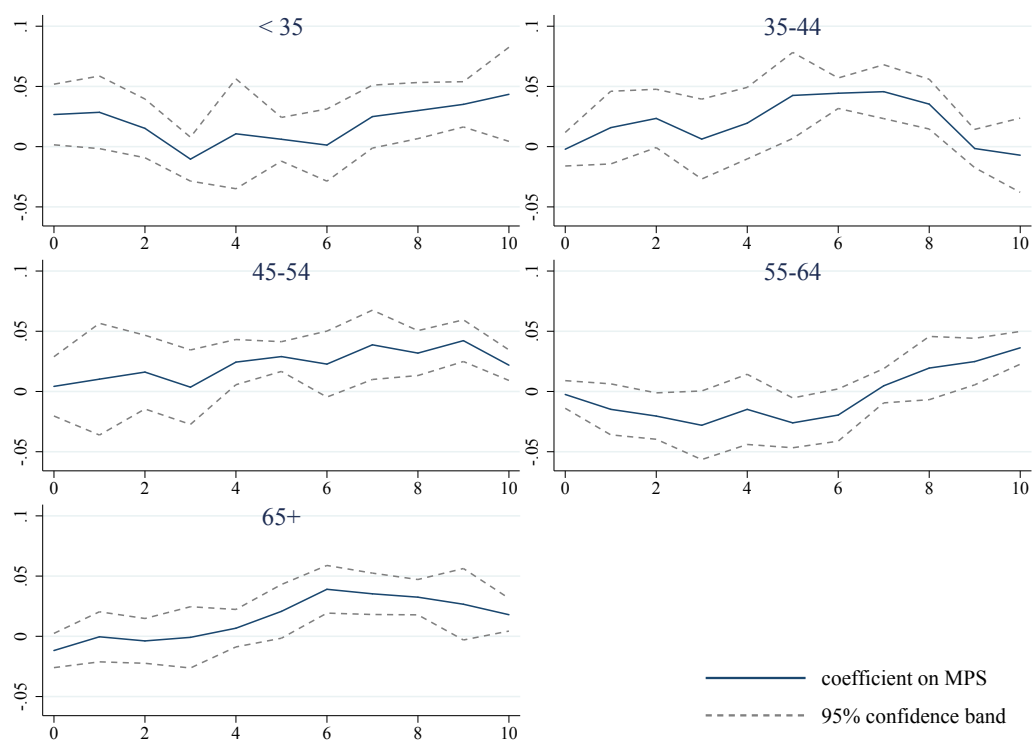


Figure 10: Impulse responses - housing tenure with added lags

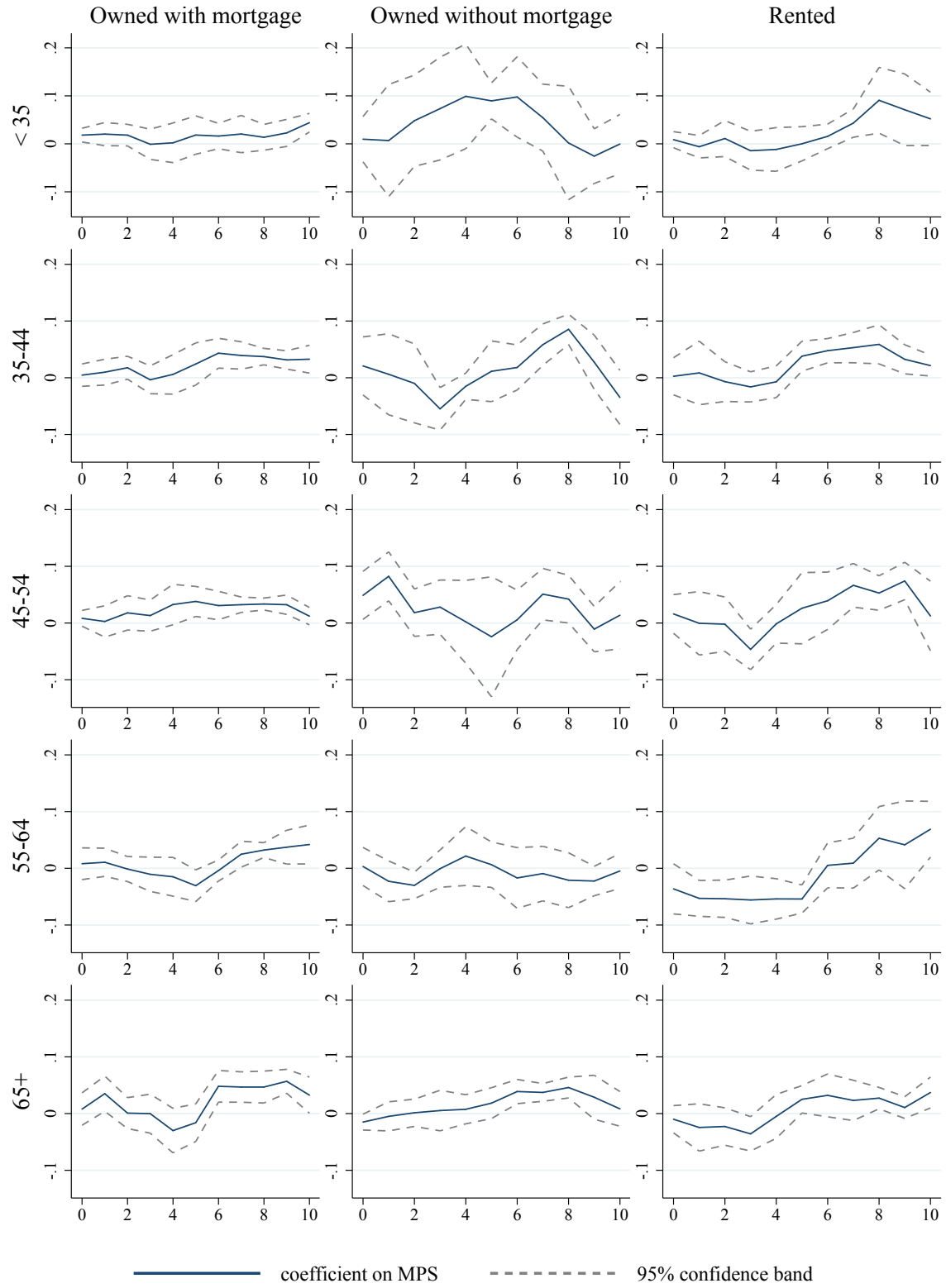


Figure 11: Impulse responses - financial activity groups with added lags

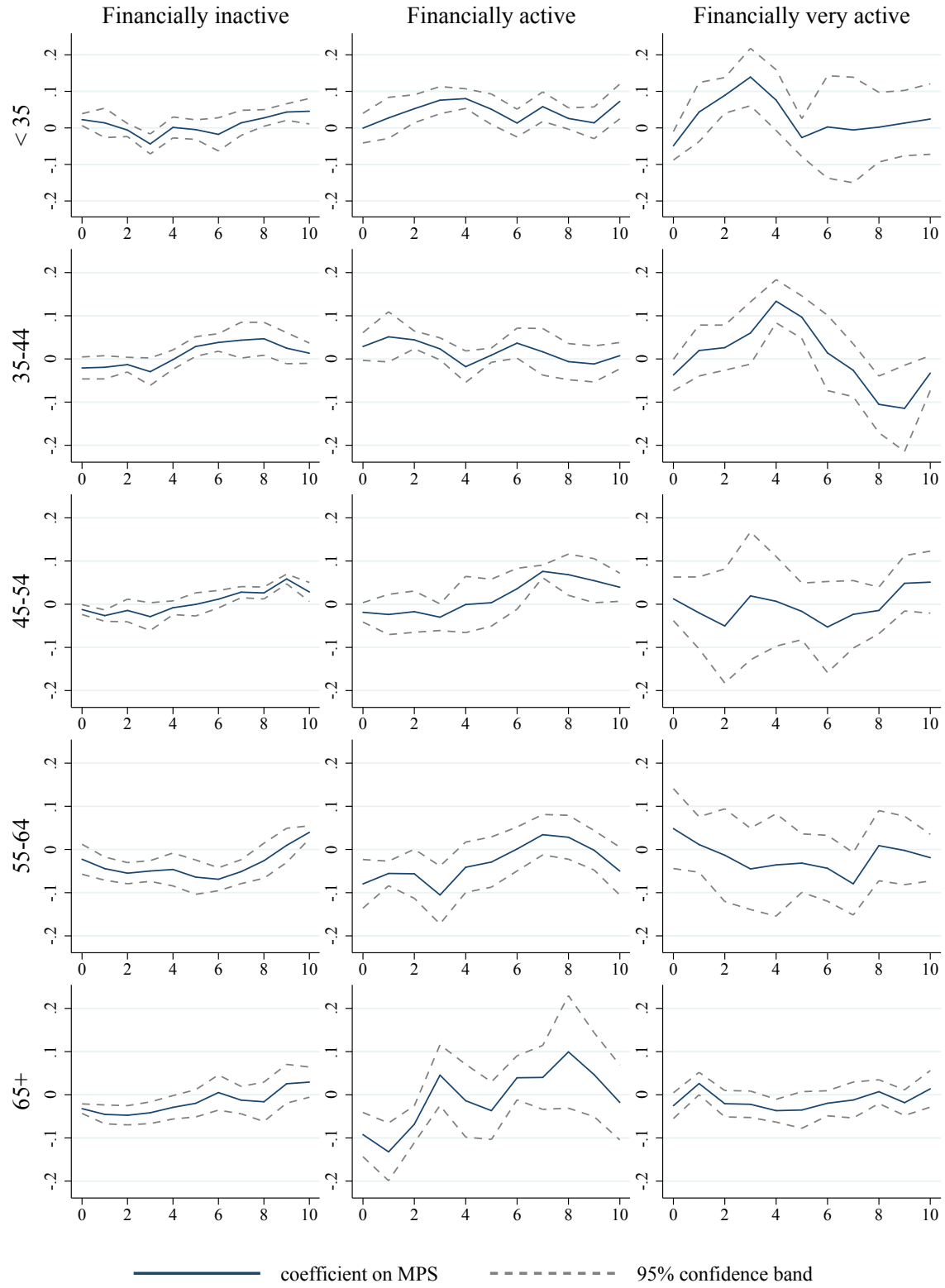


Figure 12: Impulse responses - age groups durable expenditure

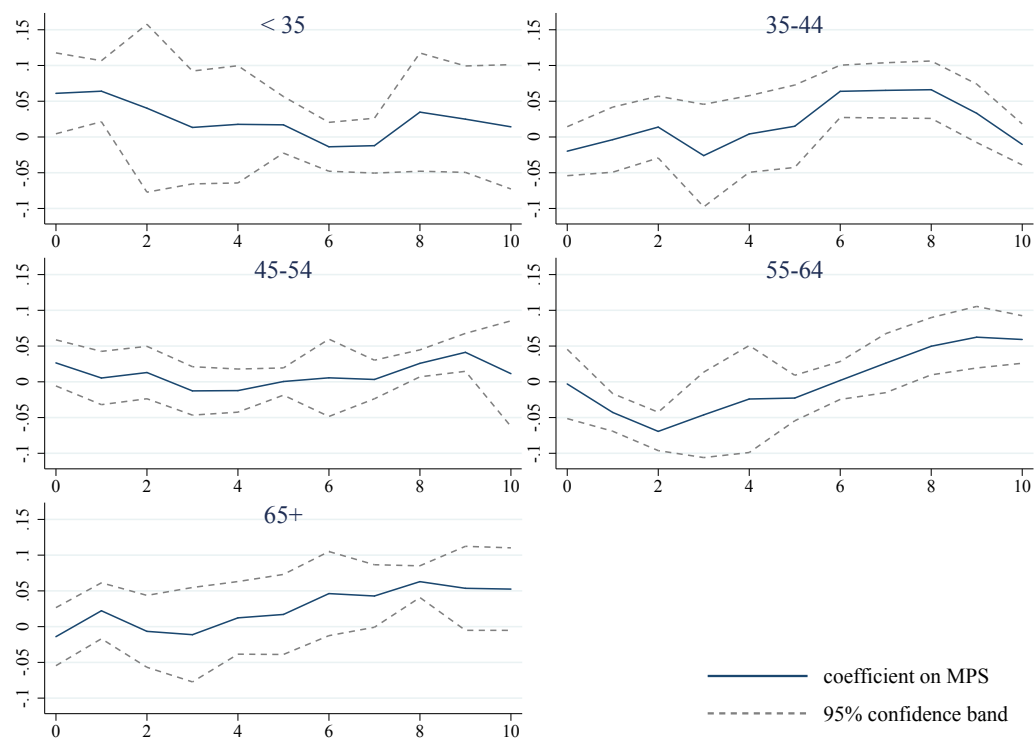


Figure 13: Impulse responses - housing tenure groups durable expenditure

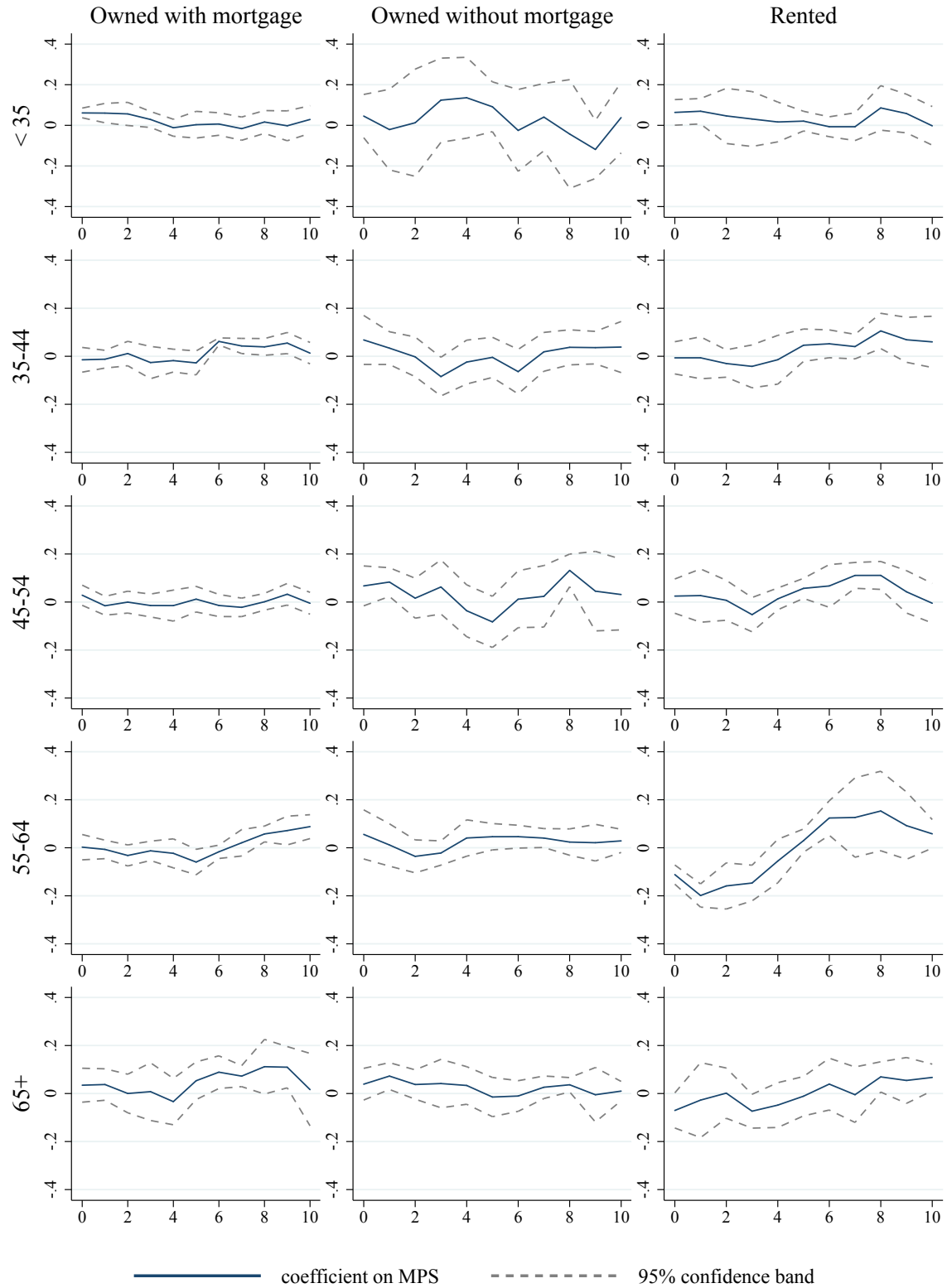


Figure 14: Impulse responses - financial activity groups durable expenditure

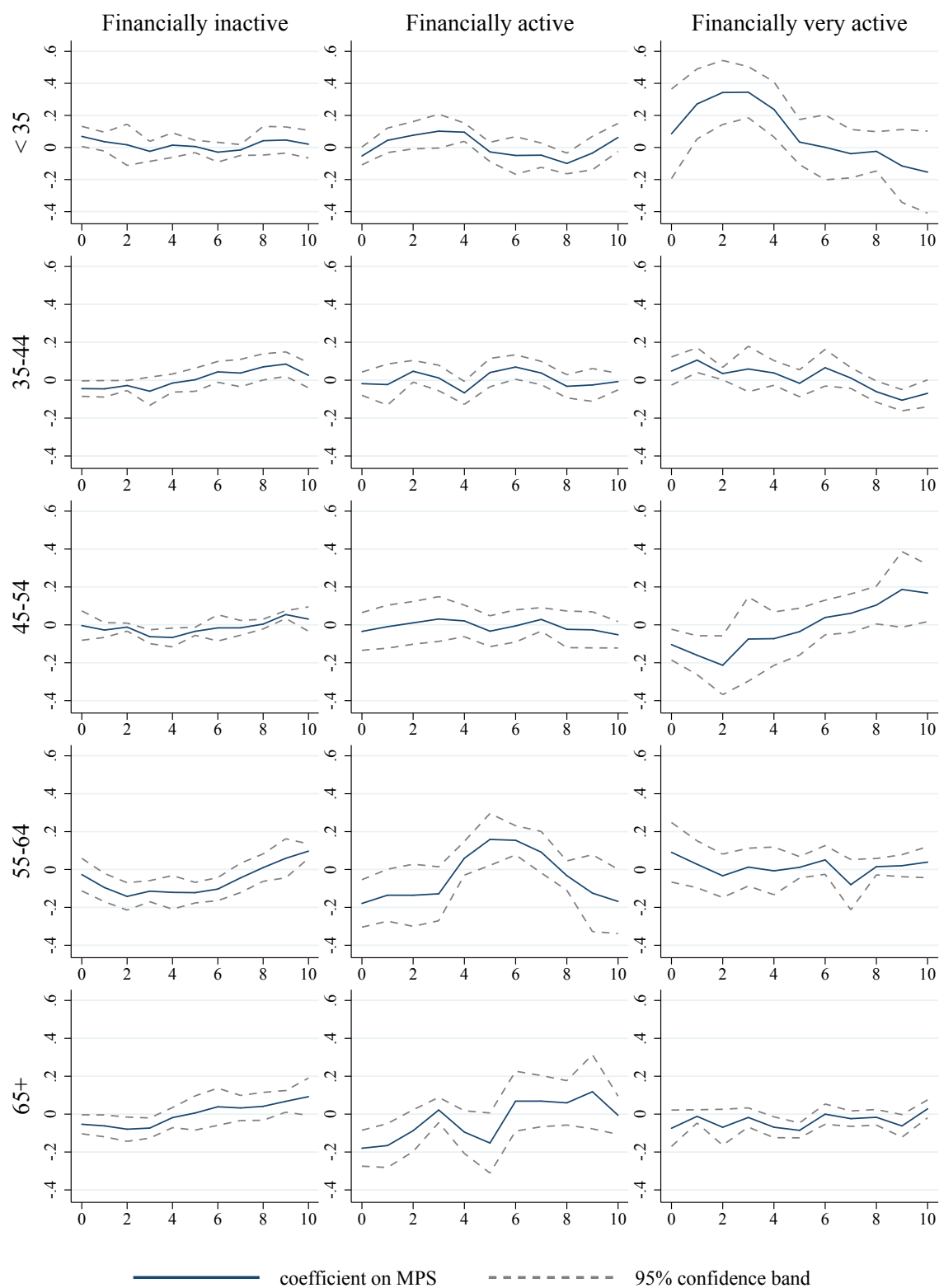


Figure 15: Impulse responses - securities groups

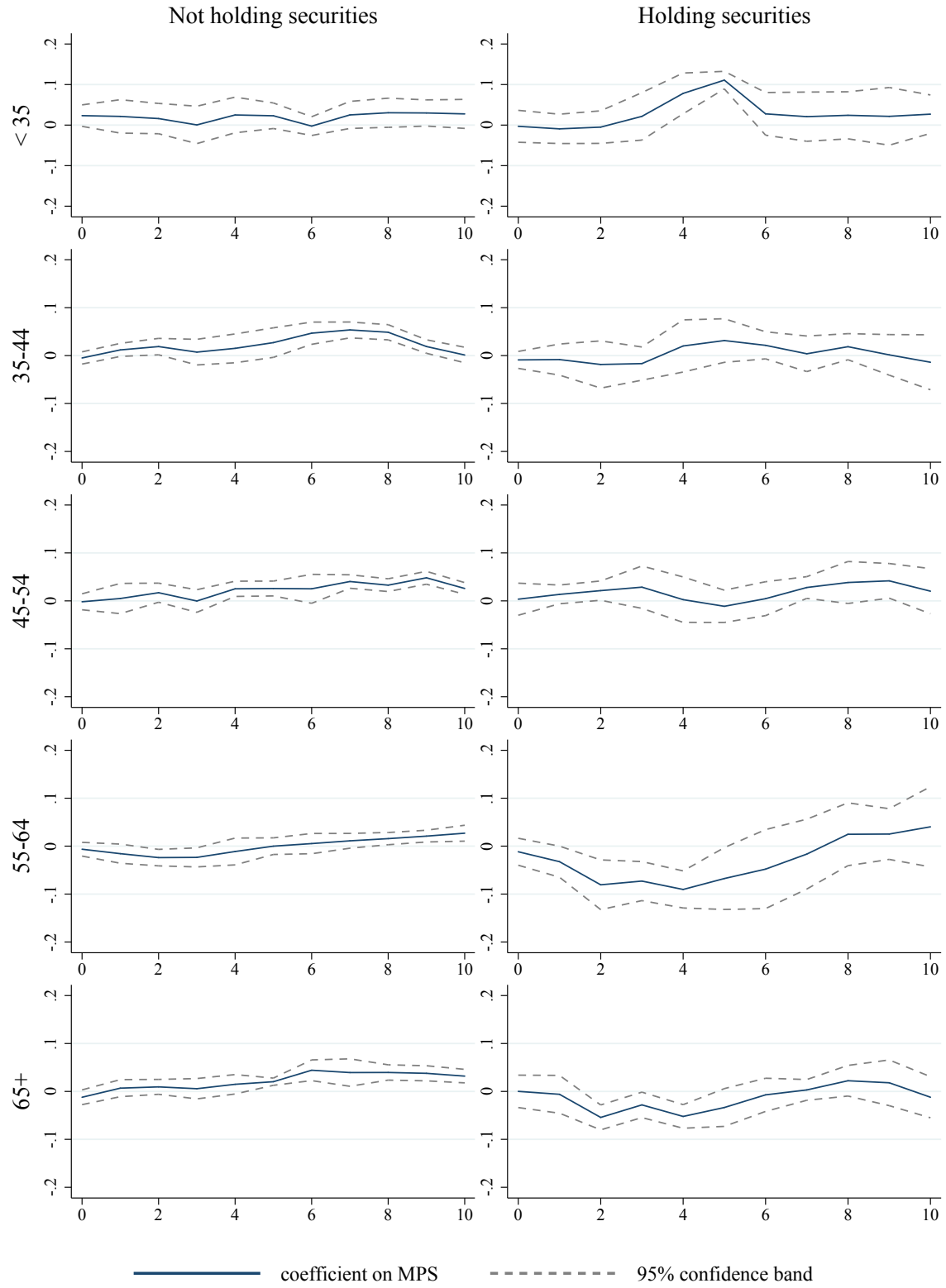


Figure 16: Shares of housing tenures, 1996-2007



Figure 17: Shares of financial activity, 1996-2007

