

HOUSING DEBT AND THE TRANSMISSION OF MONETARY POLICY*

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Abstract

In response to an unanticipated change in interest rates, households with mortgage debt adjust markedly their expenditure, especially on durable goods, renters react to a lesser extent and outright home-owners do not react at all. All housing tenure groups experience a significant change in disposable income (over and above the direct impact on mortgage repayments). The response of house prices is sizable, driving a significant adjustment in loan-to-income ratios but little change in loan-to-value ratios. A simple collateral constraint model augmented with durable goods and renters generates predictions consistent with these novel empirical findings and suggests that heterogeneity in housing debt positions plays an important role in the transmission of monetary policy.

JEL CLASSIFICATION: E21, D91, H31, E62.

KEY WORDS: mortgage debt, household expenditure, monetary transmission.

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1 Introduction

The recent financial crisis has brought household debt and the mortgage market to the center stage of modern business cycle analysis. Understanding the way economic policies, and monetary policy in particular, can stabilize macroeconomic fluctuations through the direct and indirect effects on the housing market is therefore of paramount importance for policymakers and academics alike. By affecting interest rates and access to credit, monetary policy inherently alters the incentives between borrowers and savers to smooth consumption over time, thereby making mortgage debt a potentially key element of the transmission mechanism.

Whilst these issues are much debated in policy and academic circles, little is known empirically about the specific channel(s) through which monetary policy affects different households and whether any heterogeneous response is related to housing debt. Exploring the impact of macroeconomic shocks across groups with diverse exposure to the credit market requires high quality micro-data over a sufficiently long period of time. To this end, we use a novel grouping strategy based on housing tenure in repeated cross sections of the UK Family Expenditure Survey (FES). This is then combined with a time series of monetary policy shocks derived for the U.K. by [Cloyne and Huertgen \(2014\)](#) in the spirit of [Romer and Romer \(2004\)](#).

The focus on the U.K. is motivated by two considerations. First, the prevalence of variable rate mortgage products, together with the availability of data on mortgage repayments, makes it a natural laboratory to evaluate the effects of an unanticipated change in interest rates (over and above the mechanical impact on mortgage repayments). Second, the availability of a unique dataset on mortgage originations from 1975 to the recent financial crisis will allow us to explore at an unprecedentedly detailed level the response of house prices, loan-to-value and loan-to-income ratios to a monetary policy shock. These seem important dimensions along which to evaluate the ability of any theoretical framework to rationalize the effects of a change in the

central bank policy rate.

A considerable challenge in analyzing the impact of monetary policy across agents with different mortgage debt positions is the lack of detailed information on households' wealth and balance sheets in surveys that also feature high quality expenditure and income data. While we are not aware of any data source that contains this information consistently and over a sufficiently long period of time, most widely used surveys, such as the UK's Living Cost and Food Survey, do allow us to proxy a household's debt position using housing tenure. Our analysis builds on a long standing tradition in microeconometrics which emphasizes demographics (especially birth cohorts) and educational attainments as significant predictors of the presence of liquidity constraints at the household level. We contribute to this important literature by arguing that housing tenure — and in particular the distinction between households with mortgage debt, outright home-owners and renters — can provide novel insights into the transmission of macroeconomic shocks to the real economy.

Our empirical analysis produces five main findings. First, the expenditure response of mortgagors to an unanticipated movement in interest rates is large and significant, the response of outright owners is not statistically different from zero and the renters' is in between the other two groups. Second, this heterogeneity is far more pronounced for durable goods. Monetary contractions therefore have a much larger negative effect on mortgagors' expenditure. Third, the income responses for all tenure cohorts are significantly positive but statistically indistinguishable from one other, even after netting-out the direct impact of the interest rate change on mortgage repayments. Fourth, the monetary policy intervention triggers variations in house prices and loan sizes of a similar magnitude. Fifth, in contrast to the movement in loan-to-value ratios, the effect on loan-to-income ratios begins in the first quarter and persists for up to four years after the shock.

Motivated by these findings, we then explore the extent to which a financial accelerator mechanism (which generates heterogeneous affects on different households)

can account for our results and the transmission of monetary policy. Specifically, we extend the collateral constraint framework proposed by [Kiyotaki and Moore \(1997\)](#) and applied to housing by [Iacoviello \(2005\)](#) to incorporate durable goods and renters. The model is kept deliberately simple, allowing us to elicit the role played by housing debt and mortgage market-related credit constraints. We show that heterogeneity in the discount factor coupled with the presence of a housing collateral constraint can generate heterogeneous responses in household expenditure, income and mortgage debt to a monetary policy shock which are qualitatively and quantitatively consistent with our empirical evidence.

Related Literature. This work relates to at least three strands of the existing literature. First, we contribute to the large body of results on the relationship between housing finance and real activity. This includes the earlier work by [Kiyotaki and Moore \(1997\)](#) and [Iacoviello \(2005\)](#) as well the more recent studies by [Mian et al. \(2013\)](#), [Mian and Sufi \(2014\)](#), [Calza et al. \(2013a\)](#), [Guerrieri and Iacoviello \(2013\)](#), [Justiniano et al. \(2014\)](#) and [Aladangady \(2014\)](#). We share an emphasis on developments in the mortgage market but, unlike these studies, we use survey data to evaluate the role played by housing debt and heterogeneity in the monetary transmission mechanism.

Our results also provide empirical support for the notion of debt-constrained agents that has been put forward by a (mostly theoretical) literature exemplified by [Eggertsson and Krugman \(2012\)](#), [Ragot \(2014\)](#), [Kaplan and Violante \(2014\)](#) and [Cloyne and Surico \(2013\)](#). Those studies consider the household response to fiscal policy whereas the present analysis focuses on monetary policy.

Finally, the findings in this paper complements the evidence from an increasing number of studies, including [Coibion et al. \(2012\)](#), [Gornemann, Kuester and Nakajima \(2012\)](#), [Sterk and Tenreyro \(2014\)](#), [Wong \(2014\)](#) and [Auclert \(2014\)](#), which analyze the redistributive effects of monetary policy focusing on differences across

demographics (rather than household debt positions as we do here).

Structure of the Paper. The rest of the paper is structured as follows. Section 2 presents the datasets used in the empirical analysis while Section 3 discusses the identification of monetary policy shocks and the grouping strategy for households with heterogeneous debt positions. The baseline estimates are reported in Section 4. Further empirical results are presented in Section 5, where we evaluate some potential interpretations of our findings. In Section 6, we examine the extent to which the predictions of a collateral constraint model, modified to confront key features of our data, are consistent with our novel empirical findings.

2 Data

2.1 Household Expenditure and Income

In order to measure how different households respond to monetary policy, we use individual household data from the UK Living Costs and Food Survey (LCFS), previously known as the Family Expenditure Survey (FES).¹

As noted in [Cloyne and Surico \(2013\)](#), there are few datasets that *both* (i) contain information about the balance sheet position of households and (ii) which have detailed consumption and income micro data over a sufficiently long period of time. One significant advantage of the LCFS is that it has detailed expenditure and income data that, among other things, forms the basis for National Accounts as well as information on the households' housing tenure positions. We make use of detailed information on weekly non-durable and durable consumption expenditures separately (excluding housing and rental-related costs), as well as on disposable income. The latter is composed of labor income (wages and salaries) and non-labor income (income

¹From 1957 to 2001, the FES together with the National Food Survey (NFS) where the surveys providing information on household food consumption and expenditure patterns in the UK. In April 2001, these two surveys were combined into one single survey, the Expenditure and Food Survey (EFS). The EFS then, in 2008, became known as the LCFS module of the Integrated Household Survey (IHS) of the UK.

from investments and social security payments), net of taxes paid.² In addition, the survey provides information on other two sets of variables which will be useful for our main empirical estimation: (i) several demographic variables, including the year of birth of the head of the household and education attainment and (ii) housing tenure as well as information of mortgage repayments for households with outstanding mortgage debt. These latter data will allow us to examine to what degree direct interest payment effects can explain our results. A more detailed description of the variables is provided in the Appendix.

We convert weekly data into a quarterly time series using the date of interview, as is common in the micro-econometrics literature. The resulting series is then scaled by the Retail Prices Index to convert the data into real series. Our sample covers 1975 to 2007. The key variables of interest are available in the FES from the mid-1970s and we deliberately stop just prior to the financial crisis, excluding the period of “unconventional” monetary policy in the UK.

2.2 Grouping into Cohorts

Unfortunately the LCFS only features repeated cross-sections rather than a genuine panel of households followed through time.³ In keeping with the tradition of [Browning et al. \(1985\)](#), we employ a grouping estimator to aggregate individual observations into pseudo-cohorts.

The LCFS, while having excellent micro data on consumption and income, does not — in common with other surveys — have detailed information about household

²As it has been recently documented in the household consumption literature (such as [Aguilar and Hurst \(2005\)](#) and [Attanasio et al. \(2006\)](#) using the Consumer Expenditure Survey (CEX) for the US; [Crossley et al. \(2012\)](#) and [Brewer and O’Dea \(2012\)](#) using the LCFS for the UK.), the non-durable and durable expenditures reported by households fall short, when aggregated appropriately, from the aggregate figures in the United Kingdom Economic Accounts (UKEA). Following this literature, we adjust the household data in the following way: in each quarter and *for each* household, we gross-up the reported expenditure categories using the inverse of the ratio of the aggregate expenditure implied by the LCFS to the aggregate expenditure in the UKEA.

³Panel datasets such as the British Household Panel Survey, in contrast, have the well-known issue of lacking detailed and broader expenditure data.

balance sheets. We do, however, observe whether the household has mortgage debt or not. Specifically, we observe whether the household owns their home outright or with a mortgage. We therefore group households according to their housing tenure status. To illustrate why this distinction is appealing, Table 1 presents some key statistics from the distribution of households’ net liquid and housing assets in one wave of the British Household Panel Survey.⁴ The mortgagor group tends to have few liquid assets. In contrast, the owner group tends to have sizable net savings.

The housing tenure groups — essentially borrowers with housing debt and net savers — have a close parallel in a range of theoretical models. For example, these groups emerge in *equilibrium* in a (by now) standard class of models, such as [Iacoviello \(2005\)](#). These papers have followed [Kiyotaki and Moore \(1997\)](#) in constructing heterogeneous agent frameworks which feature patient and impatient households. Differences in discount factors lead, in equilibrium, some agents to be borrowers and some to be savers. Impatient households are credit constrained but can increase their borrowing capacity by exploiting the collateral value of their housing assets. In addition, recent work by [Kaplan and Violante \(2014\)](#), using a different mechanism, has argued that many households could still be ‘wealthy hand to mouth’ in the sense that they own illiquid assets but are still liquidity constrained. Since it is hard to identify credit constrained households in the data, our mortgagor group has a close, and very useful, mapping to the constrained households in these models.

We also have information on the final group of households in the sample, renters. These are a relatively heterogeneous group comprising of social renters (those renting from local authorities and housing associations) and private renters (who are only around 10 % of the population). We therefore do not focus on this group of house-

⁴The BHPS collected information on wealth and asset positions of households only in the years 1995, 2000 and 2005. However, and as the case of other household panel surveys such as the SCF in the US or the EFF in Spain, these do not collect detailed information on different consumption items. As in Table 2 of [Cloyne and Surico \(2013\)](#), net financial (liquid) wealth is defined as the value of savings and investments net of outstanding non-mortgage debt, while net housing wealth is defined as the household’s estimate of the property value net of any outstanding mortgage.

holds, although the balance sheet information presented in table 1 suggests that the social renters are likely to be an interesting proxy for the traditionally liquidity constrained households.

One potential drawback of grouping by housing tenure is the selection effect associated with the possible transition from one tenure status to another over time. As it can be seen in figure 1, however, the very gradual rate at which home ownership has risen in the United Kingdom suggests this may be less of a concern. In addition, using estimates from the empirical specification described in the next section, Figure 5 shows that monetary policy does not significantly affect the share of different housing tenure groups.⁵

2.3 House Prices and Mortgage Market Data

To investigate the various channels explaining the heterogeneous response of different households to monetary policy shocks, we use a range of housing market variables, including mortgage payments, house prices, loan to value and loan to income ratios.

House Price Indices. Two sets of house price indices are available in the UK which provide information for the period we are interested in. These are compiled by the mortgage providers Halifax and Nationwide. Both provide national as well as regional indices at a monthly and quarterly frequency. These series track a “representative” house price derived from a monthly sample of its mortgage transactions (at the approval stage, rather than at completion) and are constructed using similar statistical techniques.⁶ Although Halifax has a larger market share for approved mortgages, and therefore a potentially broader coverage of prices, both indices follow a similar pattern across time. Figure 2 plots Halifax and Nationwide indices at the national level

⁵Furthermore, as in Cloyne and Surico (2013), we will verify the robustness of our estimates to using the grouping strategy proposed by Attanasio et al. (2002), which directly addresses the possibility of compositional changes.

⁶For a more detail description of the indices construction, see [Nationwide House Price Index](#) and [Halifax House Price Index](#).

for a representative transaction, as well as the Halifax indices for first-time-buyers (FTB) and non-FTB transactions. Both the 1986-1992 and the 2001-2008 boom in the housing market are apparent. The former coincided with an explosion in the availability of interest-only mortgages⁷, and the latter with a steep increase in the loan-to-income ratios.

In our benchmark estimations, we use the UK “All Properties” (old and new) index constructed by Nationwide at quarterly frequency, since allows us to go a bit further back in time.⁸ The series we use are not seasonally adjusted, and we deflate them using the Retail Prices Index in order to construct real values in 2005 pounds sterling.

Loan-to-Value and Loan-to-Income Ratios. Understanding the relative response of mortgagors to a monetary policy shock requires detailed data on the impact on mortgage debt, mortgage repayments and on households’ balance sheets. As discussed above, we don’t have individual household level balance sheet information. But we can make use of a different, novel, micro dataset to explore the response of mortgage debt.

We exploit data on *individual* loan-to-value (LTV) and loan-to-income (LTI) ratios at origination. These data come from the UK Council of Mortgage Lenders (CML) until 2005 and then the UK Financial Conduct Authority’s Product Sales Database from 2005 to 2007. Up to 2005, we have access to a representative sample comprising 10% of all mortgages originated; after 2005, we have access to the whole population of originations.⁹ The two dataset have information on *first-time-buyers*, i.e. households that get a mortgage for the first time, and *non-first-time-buyers*. As with mortgage

⁷The increase in the share of such mortgagors is also apparent from the LCFS data, as explained below.

⁸ Nationwide has been publishing quarterly property price reports since 1952, while Halifax House Price index starts in 1983. Another advantage is that Nationwide definition of the ‘typical’ house is revised every year, and the building society revises its regional weighting in accordance with rolling averages from HM Land Registry, Department of Communities and Local Government.

⁹To do, we first merge the pre- and post-2005 datasets using the *growth rates* from the latter one to extrapolate forward the former one.

repayment data from LCFS, we can analyze the evolution of different moments of the distribution, as well as the response of such moments to an exogenous monetary policy shock. Figures 3 and 4 present the evolution of the mean and 90th percentile of the LTV and LTI distributions, for all buyers as well as for both for first-time buyers and non-first-time buyers. It is interesting that average LTV ratios have not moved all that much over the sample, while there has been a sharp rise in LTI ratios, particularly in more recent decades.

As documented by Calza et al. (2013a), almost 75% of mortgages in the U.K. are of adjustable-rate type, meaning that the monthly mortgage payments faced by the majority of mortgagors can rapidly change when there is a change in the Bank Rate. One variable we do observe in the LCFS is household-level information on the last (monthly) mortgage repayment, and identifies mortgagors according to whether they have an interest-only or interest-plus-capital mortgage. In terms of repayments relative to income, the median is around 20 %, with a gentle upward trend over time, mirroring the rise in LTI ratios.

3 Identification and Empirical Strategy

As discussed above, we examine the effect of monetary policy on the consumption and income of different *groups* of households and on aggregate variables such as mortgage debt and house prices. We therefore face the usual macroeconomic identification problem that monetary policy responds countercyclically but also affects the economy. To identify movements in monetary policy we need a monetary policy shock series which can be used for estimation.

There is a vast literature on the identification of monetary policy changes, although the majority of research has focused on the United States. Older approaches relied on timing restrictions and a Choleski decomposition of the variance-covariance matrix of a Vector Autoregression, such as Christiano et al. (1996, 1999). But when applied to the U.K. this method produces a large rise in inflation following a monetary

contraction, the so-called price puzzle, as shown by [Cloyne and Huertgen \(2014\)](#).¹⁰ Another, very popular, approach for the U.S. was introduced by [Romer and Romer \(2004\)](#). This method first constructs a measure of the target policy rate (since the effective Federal Funds Rate is moved around by other factors than just policy decisions) and then regresses the change in the target rate around the policy decision on a proxy for the information set available to the policymaker just prior to that decision. This information set includes a range of real time indicators (such as GDP) and forecasts to reflect the forward-looking nature of monetary policy. [Cloyne and Huertgen \(2014\)](#) construct a measure for the U.K. employing this methodology and show that it improves on conventional VAR methods. Rather than constructing a new measure of monetary policy changes, we therefore use the [Cloyne and Huertgen \(2014\)](#) shock series directly.

The shock series matches our micro-data sample. This means we use shocks from 1975 to 2007. The shock series deliberately stop just prior to the recent financial crisis when the policy rate hit the zero lower bound. The original shock series is monthly but our micro-data are quarterly. Following [Romer and Romer \(2004\)](#) and [Coibion \(2012\)](#) we sum up the monthly innovations to get a quarterly shock to the target rate. The construction of the series also allows for a break in regime in 1993 when the U.K. adopted inflation targeting. The monetary policy series from [Cloyne and Huertgen \(2014\)](#) is shown in Figure 6.

Armed with a series of monetary policy shocks, the most natural empirical specification is to follow [Romer and Romer \(2004\)](#). We therefore regress the variable of interest on a distributed lag of the monetary policy shocks. As in [Romer and Romer \(2004\)](#) we also control for the lagged endogenous variable as is common in exercises with relatively small samples. Specifically we estimate for the following:

$$X_{i,t} = \alpha_0^i + \alpha_1^i t + B^i(L)X_{i,t-1} + C^i(L)S_{t-1} + D^i(L)Z_{i,t-1} + u_{i,t} \quad (1)$$

¹⁰This is true even after controlling for variables shown to ameliorate this issue for the U.S.

where X is real non-durable consumption, durable consumption or income¹¹, S are the monetary policy shocks, Z is vector of additional controls, including quarterly dummies, the α terms are constants and time trends, with breaks in 1993. $i \in \text{Mortgagors, Outright owners, Renters}$. The order of the lag polynomials are chosen using optimal lag length criteria.¹² Standard errors are bootstrapped using a recursive wild bootstrap to account for errors that are not i.i.d.

4 Empirical Results

In this section, we present the results from estimating our benchmark specification (1) with both aggregate and cohort level data. In order to make results comparable with the previous literature, all the impulse response functions (IRFs) are computed by simulating a 25 basis points (bp) *increase* in the policy rate. Finally, all the figures present point estimates together with bootstrapped 90% confidence bands generated from 5000 resamples.

4.1 Aggregate Variables from National Accounts

Before exploring the response of different household groups, it is useful to examine the aggregate response of non-durable consumption, durable consumption and household income from the UK National Accounts. These results are presented in Figure 7. We find that a contractionary increase in the policy rate lowers durable consumption, non-durable consumption and disposable income.¹³ Concretely, a 25 basis point monetary policy contraction lead to a persistent fall in non-durable consumption, which peaks at -0.36% after 10 quarters; a larger *percentage* fall in durable consumption peaking

¹¹When estimating (1) with cohort level data from the LCFS, in order to eliminate some of the noise inherent in survey data, $X_{i,t}$ is smoothed with a backward-looking (current and previous three quarters) moving average filter.

¹²Specifically, the corrected AIC. We have also explored a generalised specification where X is a vector, but with similar results. In addition, we have experimented with including and excluding the contemporaneous value of the shock and with the type of trend assumed. In all cases our results are robust.

¹³US results are shown in the appendix Figure 21.

at -1.6% after 10 quarters; and fall in household income that peaks at -0.4% after 12 quarters. Two points are worth mentioning: (i) these magnitudes are very similar to the overall effects found in [Romer and Romer \(2004\)](#) and [Cloyne and Huertgen \(2014\)](#).¹⁴; and (ii) the relative response of durable and non-durable expenditure is in line with the recent macro literature, such as [Barsky et al. \(2007\)](#), [Monacelli \(2009\)](#) and [Sterk and Tenreyro \(2014\)](#).

4.2 Household Variables from Survey Responses

We next explore the heterogeneous response by housing tenure status.¹⁵ The results comparing mortgagors and outright owners can be seen in Figures 8 to 10, while Figure 11 presents responses for the renters group.

Two main results stand out. First, we find that consumption expenditures (non-durable and durable) fall significantly after a shock *only* for the mortgagor group. For outright owners, the consumption responses are not significantly different from zero (with slightly positive point estimates for non-durable expenditure). Second, the heterogeneity is much more stark for the fall in durable expenditure. For mortgagors the peak effect on durable consumption is at -1.6% from trend 10 quarters after the shock and the response is fast and persistent. The corresponding peak effect for non-durable expenditure is -0.35%, although with a similar persistence. Given these numbers, and that durables expenditures represent around 15% of mortgagors' total quarterly expenditure, the *share* of durable expenditure falls to approximately 15% after 10 quarters. This relative response of durable and non durable expenditure is in line with the results we obtained using aggregate data. As far as we are aware of, although the results using aggregate data had been documented in the literature,

¹⁴For a discussion of these magnitudes relative to the VAR literature, see [Coibion \(2012\)](#) and [Cloyne and Huertgen \(2014\)](#).

¹⁵Before proceeding, we confirm that these aggregate results are broadly consistent with those obtained using aggregated micro data from the Living Cost and Food Survey (LCFS), formerly the Family Expenditure Survey, for the UK. We estimate equation (1) using *aggregate* variables constructed from the LCFS household level data and find results in line with the ones using aggregate data from national accounts. Results are available upon request.

there has been no comparable study using expenditure data at the *household level*.

As seen in Figures 10 and 11, we find that household disposable income (net of taxes¹⁶) tends to fall for *all three groups*, i.e. mortgagors, outright owners and renters, although the income of mortgagors responds a bit more strongly and we discuss this further below. The income fall across all groups is consistent with a general-equilibrium response of labor earnings following a monetary contraction. However, it is also important to take into account the heterogeneous composition of income for the three housing-tenure cohorts. On average, quarterly real earnings (labor income) represents 82%, 50% and 30% for mortgagors, renters and outright owners respectively. Even though the outright owners have a higher proportion of non-labor income, it is still noteworthy that their income still declines overall.

Consumption Relative to Income. One possibility is that the expenditure responses of mortgages can be explained by differential movements in income across groups. To evaluate this hypothesis, Table 2 computes the impact on the level of consumption (cumulated over the impulse response horizon) relative to the movement in income. It is tempting to think of this as a marginal propensity to consume, although it is a mere descriptive statistic rather than a structural parameter. That said, the proportions for mortgagors are high and significant, while those for the owners are insignificant and much lower. The expenditure response of mortgagors is large, even relative to the movement in income. Our findings thus do not simply reflect heterogeneity in the cyclical sensitivity of mortgagors, for example if their income were more responsive or if monetary contractions cause a larger number of mortgagors to become unemployed. While these mechanisms could still be at work in producing the fall in mortgagor income, that expenditure responds so much more than income suggests something else must explain the responses of the mortgagor group. The much larger response of mortgagors' consumption, even relative to income, suggests

¹⁶If we assume that identified monetary policy shocks are exogenous to fiscal policy changes, then whether we look at gross or net income should not affect the results.

some form of constraint could be at work. We now examine this in detail in the next two sections.

5 Interpreting the Housing Tenure Heterogeneity

In the previous section we showed that mortgagor households, on average, alter their expenditure far more than any other group to changes in monetary policy. One possibility is that mortgagors face constraints specifically related to their debt and mortgage market positions. But one may be concerned that our housing tenure distinction is simply picking up another characteristic and that the ultimate explanation for our results is not driven by mortgage related constraints. In this section we explore the issue further, showing that a collateral constraint facing mortgagors seems the most plausible explanation. In the next section we explore this further using a theoretical model.

5.1 Demographics

It could be that our housing tenure distinction is simply picking-up life cycle effects and our results simply reflect differences in age. For example, mortgagors are often younger and owners older. To explore this issue we follow the micro-econometrics literature and group our micro data according to birth cohort. One might be tempted to group households by age directly but, as discussed extensively in the micro-econometrics literature, this would be incorrect. The grouping estimator relies on constructing a sample for a representative household whose characteristics are predictable over time. If we were to construct a time series for someone who was, for example 25, we would end up with the change in consumption over time for a household who was always that age. As the composition of this group naturally changes over time, this is problematic.¹⁷ Instead, we consider older households

¹⁷While housing tenure also has some of these issues, the slow movement in housing tenure shares over time makes this far more exogenous. In addition, as noted above, we can confirm that the share of mortgagors is unaffected by changes in monetary policy. For a more extensive discussion of these

born before 1930, middle-aged households born between 1930 and 1955 and younger households born after 1955. Figure 12 shows the breakdown of our tenure groups by birth cohort. As expected, younger households tend to be dominated by mortgagors and older households by owners but, importantly, not all younger households are mortgagors.

If age or life cycle considerations are driving our results, rather than mortgage debt per se, it should be the case that younger mortgagors respond differently to older mortgagors. Unfortunately there are not enough mortgagors in the older birth cohort but we can explore this issue for the two younger cohorts. Interestingly, Figure 14 shows that younger and middle-aged mortgagors respond in a very similar way. This is true of the non-durable, durable and income responses. Life cycle considerations therefore do not seem to explain our heterogeneity.

5.2 Cash Flows and Redistributive Effects

A monetary contraction should lead to an increase in interest payments for borrowers and a rise in interest income for savers. It is therefore possible that mortgagors' expenditure is more sensitive because their mortgage payments are directly affected by higher interest rates, lowering their disposable income. This 'cash-flow' channel would also imply a redistributive effect with an increase in interest income for the owner group. Any aggregate effect of this transfer, however, still requires that the borrowers (our mortgagor group) are credit constrained, such that the effects do not net-out in the aggregate. But it is still instructive to ask whether the mechanical change in mortgage payments can explain the larger response of mortgagors. This is particularly important as, historically, most UK mortgages have been on a variable rate.

As discussed earlier, we construct household mortgage payments from the LCFS. Figure 15 shows the impulse response function for mortgage payments following an

issues in relation to housing tenure see [Cloyne and Surico \(2013\)](#).

increase in policy rate. As can be seen in the figure, mortgage payments rise following a monetary contraction, as expected. But the question is whether this is large enough to explain our empirical findings for mortgagors' expenditure. The response of mortgage payments is not particularly large, especially relative to the overall fall in income. So while there may be an effect from the direct movement in repayments, this channel cannot explain the large responses found in the previous section. To see this, Table 2 recomputes the response of expenditure relative to income net of mortgage payments. If the movement in mortgage payments is sufficient to explain the expenditure response, we should see considerable differences between the last two columns. Instead, we see the results are again significant, not that different from the previous results using overall income, and, once again, remain much larger than owners.

5.3 House Prices and the Collateral Channel

Given the role of mortgagors in explaining the aggregate effects of monetary policy, the response of the housing market is likely to play a crucial role in the transmission mechanism. To explore this we first show that a 25 basis point increase in interest rates lowers house prices, shown in Figure 16. The effect on house prices is significant and sizable, and the dynamics look very much like the dynamics of consumption and income presented earlier.

Next we consider the response of debt. For the UK we have detailed information on mortgage debt from two novel datasets of mortgage originations. While we are unable to study the response of debt at a household level we can still, therefore, study the response of key debt variables for the mortgagor group as a whole (and moments of the distribution). Specifically we now consider how loan to income ratios and loan to value ratios respond, two key measures of household leverage.

We find that loan to income ratios fall quickly and significantly, as shown in Figure 17. This means that monetary contractions *reduce* household leverage. In contrast,

over the first few years the response of loan to value ratios is not statistically different from zero (and even start rising later on), as shown in Figure 18. House prices therefore fall by more than loan values, but loan values fall by more income over the contractionary period. Secured debt and leverage therefore clearly responds to monetary policy contractions.

Interestingly, these qualitative findings — both on the housing market and the differential reaction of owners and mortgagors — appear consistent with the theoretical predictions of models with housing collateral constraints, such as [Iacoviello \(2005\)](#). Constraints in the housing market are therefore likely to play a key role in amplifying monetary policy shocks and the mortgagors’ responses in particular. In the next section we therefore explore whether a simple heterogeneous agent model featuring a collateral constraint can replicate all of our empirical findings.

6 Insights from a Financial Accelerator Model

Our empirical results appear consistent with mortgagors facing constraints that produce larger consumption responses than for other groups, even relative to income. In the previous section we also showed that monetary policy affects mortgage debt and that house prices fall significantly after a monetary contraction. In this section we interpret these findings using a relatively simple heterogeneous agent housing market model with mortgagors, owners and renters. Specifically, we investigate how well a simple model featuring a collateral constraint — in the spirit of [Iacoviello \(2005\)](#), [Guerrieri and Iacoviello \(2013\)](#) and [Calza et al. \(2013b\)](#) — can account for the empirical evidence presented in the previous section. Our goal is to examine how well this particular mechanism can, on it’s own, rationalize our empirical results. In doing so, we explore further the transmission mechanisms at work and how much the heterogeneous behavior mortgagors contributes to the aggregate impact of monetary policy.

6.1 Theoretical Framework

The full details of the model are provided in the appendix but in this section we set out the main features. The model is a simple heterogeneous agent New Keynesian model in the spirit of [Iacoviello \(2005\)](#). As in [Iacoviello \(2005\)](#) the model features patient and impatient households. Both own housing, consume non-durable goods and accumulate durable goods, but the impatient households have a lower discount factor and this leads them to borrow in equilibrium. In contrast, the patient households are net savers. The borrowing capacity of the impatient households is limited by a collateral constraint linked to the value their housing assets. As such, the impatient group can be thought of as mortgagors and we view the patient householders as outright owners. This seems a reasonable distinction in light of the evidence on the distribution of wealth across groups shown in [Table \(1\)](#).

In order to match our empirical analysis, we also include two additional features which have not been considered jointly in the macro literature: a third group of households, which we denote as “renters”, and *long-lived* durable goods. Since, in the data, the renter group is dominated by those renting from local authorities and housing associations, and given that they have no wealth (liquid or illiquid), we treat these as traditional hand to mouth consumers, following the setup in [Gali et al. \(2007\)](#). Unlike [Iacoviello \(2005\)](#), to simplify the set-up, we do not include entrepreneur households.

We specify durable goods in a similar way to [Barsky et al. \(2007\)](#) and [Mertens and Ravn \(2011\)](#) where consumers derive utility from the *stock* of durable goods and non-durable goods, weighted together using a Cobb-Douglas aggregator. Households then make choices about new durable purchases each period although. Importantly, and unlike in [Monacelli \(2009\)](#) or [Stern \(2010\)](#), durable goods *cannot* be used as collateral for borrowing. In other words, we distinguish durable goods from housing; we think about the former as capturing goods that are used less often as collateral for borrowing to fund other consumption, such as furniture and electronic/electrical

appliances.¹⁸

We cover the detailed setup in the appendix but, to make things concrete, it is useful to briefly consider the balance sheets of the three household groups. For mortgagors, their real budget constraint (in terms of the price of non-durable goods) features real non-durables C , real durable *expenditures* D (where q^d is the relative price of durables investment goods) and the accumulation of housing h (where q^h is the relative price of housing) which is in fixed supply (aggregate H is fixed). Mortgagors also borrow b from the owners and pay interest on the loans R . These households earn a real wage w and supply L hours of work. The labor market is competitive and the real wage w will be the same across all households.

$$C_t + q_t^d D_t + q_t^h \Delta h_t + \frac{R_{t-1}}{\pi_{c,t}} b_{t-1} = w_t L_t + b_t \quad (2)$$

The mortgagors also face a collateral constraint where the amount repayable in period $t + 1$ ($R_t b_t$) is constrained by the expected value of housing assets in $t + 1$.

$$b_t \leq m^{LTV} E_t \left(\frac{q_{t+1}^h h_t \pi_{c,t+1}}{R_t} \right) \quad (3)$$

Given the calibration of the discount factors, this collateral constraint binds which, following [Iacoviello \(2005\)](#), allows us to solve the model by linearizing first order conditions and applying conventional solution techniques.

The outright owners also consume and accumulate housing (the owners' variables are denoted with a $'$) but have positive net assets b' in equilibrium.

$$C'_t + q_t^d D'_t + q_t^h \Delta h'_t + \frac{R_{t-1}}{\pi_{c,t}} b'_{t-1} = w_t L'_t + b'_t + \frac{\Pi_{C,t}}{\omega_{PH}} + \frac{\Pi_{D,t}}{\omega_{PH}} \quad (4)$$

This means the owners are the net savers in the economy. $\Pi_{j,t}$ are the profits from monopolistically competitive intermediate goods firms (j refers to durable or non-durable producers) and ω^{PH} is the number of outright owners (patient households)

¹⁸While it is common for households to acquire furniture and cars on hire-purchase or secured credit, the same good is used as collateral for that particular transaction. It is much less common to use such goods as collateral for *other* purchases/contracts.

in the population. The owners, in addition to labor income, therefore also earn income from savings (at rate R) and receive dividends from firms.

Finally, as noted above, we model renters as as rule of thumb consumers. These households make labor supply and consumption choices but have no access to credit. As a result, their budget constraint is as follows:

$$C_t'' + q_t^d D_t'' = w_t L_t''. \quad (5)$$

The total population is normalised to one, which means the shares of each household are also the number of households in each group. ω^{PH} , ω^{IH} , $(1 - \omega^{PH} - \omega^{IH})$ refer to the shares of mortgagors, owners and renters and are calibrated using our LCFS microdata.

The production side of the economy is relatively standard in the New Keynesian literature. There are monopolistically competitive intermediate goods firms producing different varieties of intermediate inputs using labor supplied by each of the three household groups. Housing is not used in production. These firms are subject to price adjustment costs. The labor market is competitive so the real wage w is the same across households and firms. Final goods firms then package-up the intermediate goods and sell them in a competitive market to consumers.

The main difference with the typical New Keynesian set-up is that we have two types of producers and final goods firms. Specifically we have intermediate and final durable and non-durable goods firms. In principle this leads to a different evolution of prices between durable and non-durable goods and the model features two price Phillips Curves leading to movements in the relative price of durables q_t^d , as in [Monacelli \(2009\)](#).

Monetary policy follows a conventional Taylor rule where the policy rate responds to annual inflation, the output gap and is subject to shocks. The response of the economy and the household groups to these monetary policy shocks will be compared with our empirical results from the previous sections.

6.2 Main Findings

The model is linearized around a deterministic steady state and solved using conventional first order perturbation methods. The model’s deep parameters are calibrated to be in line with common parameter values found in the literature. The precise calibration can be found in Table (3). The elasticity of substitution between durables and non-durables is in line with the calibration used in [Mertens and Ravn \(2011\)](#). Discount factors are chosen as in [Iacoviello \(2005\)](#). Estimates of the degree of habit persistence vary in the literature from relatively low (for example around 0.3), to high (such as 0.7). We therefore choose 0.5 for the baseline case. The adjustment costs and mark-up parameters map into an average reset price reset time of around a year. In our baseline case, steady state debt is calibrated so that the steady state loan to value ratio is 65 %. The shares of the different groups comes from the Living Cost and Food Survey and the coefficients on the Taylor Rule are taken from [Iacoviello \(2005\)](#).

We now consider a 25 basis point shock to the policy rate in the model, to be consistent with our empirical results presented earlier. We consider the effect on non-durable and durable consumption across the three groups of households. The impulse response functions are shown in Figure (19). The responses are shown for real variables deflated using the aggregate price index to match our empirical specification.

In a representative agent model with durable and non-durable goods monetary policy would have real effects on both types of consumption (and GDP) via the usual New Keynesian transmission channels. Monetary policy induces households to alter their consumption decisions over time and, in the face of sticky prices, real outcomes respond. For representative agent New Keynesian models with durable purchases see [Monacelli \(2009\)](#), [Barsky et al. \(2007\)](#) and [Sterk \(2010\)](#).

The heterogeneity in the housing market in our model adds a key financial accelerator to the standard framework.¹⁹ A rise in the interest rate lowers inflation

¹⁹See [Calza et al. \(2013b\)](#) for a fuller discussion.

increasing the real service cost of debt. The second channel works via the collateral constraint where a rise in the interest rate increases the shadow value of borrowing which induces a fall in consumption. Finally, movements in asset prices alter the collateral value of housing which changes the tightness of the collateral constraint itself.

As can be seen in Figure (19) both types of consumption move considerably more for the constrained mortgagor households. The response of durables is also much larger (in percentage deviations from steady state) than for non-durable, as we find empirically. One interesting feature of the effect on owners is that the overall general equilibrium effects dominate (as must be the case in our empirical results). While owners may benefit directly from higher interest payments on their savings and lower inflation raising the real value of their assets, overall their total income falls (both labor and non-labor income), as does their consumption. Savers are therefore also adversely affected by an increase in interest rates, although less so than borrowers.

Figure (19) shows that the model, despite being simple and stylized does a remarkably good job replicating the heterogeneity we find in the data. The model lacks some of the extra amplification mechanisms found in larger scale DSGE models, so the responses lack some of the persistence found in our empirical section, but this is a well-known issue with DSGE models in general. What is striking is the significant heterogeneity and that the empirical magnitudes mirrors our empirical IRFs for consumption across owners and mortgagors. The model is also able to replicate the fall in house prices and loan to income ratios. Defined in terms of expected house value, loan to value ratios rise slightly, although the m parameter is clearly constant by construction. The model therefore matches all the salient features of our empirical results, suggesting that a even a simple collateral constraint story is highly consistent with our findings.

6.3 Aggregate Impact of Monetary Policy

If monetary policy were purely re-distributive between borrowers and savers any differential impact of policy on the two groups would be irrelevant for the macro impact of policy changes.²⁰ Our results, however, suggest that mortgagors respond considerably more than owners and this has a first-order effect on magnitude of the effect of monetary policy.

One advantage of setting up a theoretical model is that it allows us to quantify how important this heterogeneity is in driving the aggregate impact of policy. Specifically we conduct counter-factual simulations where the role of the collateral constraint is lessened. When the loan to value parameter (m) is high, changes in monetary policy can significantly affect the borrowing capacity of mortgagors through the channels discussed above. When the loan to value parameter is low, mortgagors in the model are unable to satisfy their higher demand for consumption (and borrowing) relative to owners, the financial accelerator is muted, and the model behaves more like the representative agent model. In short, the higher the steady state loan to value ratio (and hence steady state indebtedness) the greater the effect of consumer heterogeneity on the aggregate impact of monetary policy.

Figure (20) shows the effects of the same monetary policy shock on non-durable and durable consumption for different calibrations of m . In the lower cases, the model behaves more like the representative agent model and the aggregate impact of policy is much smaller. In contrast, for higher LTV ratios the effect of monetary policy is considerably amplified. Monetary policy therefore appears more potent as a result of the heterogeneous behavior of mortgagors and the constraints in the mortgage market. Furthermore, monetary policy is more potent the higher the steady state loan to value ratio.

²⁰For example, in partial equilibrium set-ups it is common to argue that borrowers might have a higher ‘marginal propensity to consume’ and so the cash-flow effect from higher interest payments and a high real debt burden would lead them to reduce consumption, whereas savers would *increase* consumption but by less.

7 Conclusions

This paper has explored empirically the interactions between monetary policy, household indebtedness and the housing market. Many have argued that household debt and the housing market played a key role in the recent financial crisis, and understanding how monetary policy affects different groups, as well as whether this matters for the aggregate effects, remains a key issue facing academics and policymakers. But, as we have argued, little is known empirically about whether monetary policy has heterogeneous effects according to a household's debt position, and whether this heterogeneity has first-order implications.

To overcome a number of empirical challenges, we have exploited a series of novel UK datasets and proxied the household's balance sheet position using housing tenure. Specifically, we have examined whether homeowners with mortgage debt respond differently to monetary policy than outright home-owners. Since these grouping have natural counterparts in many housing market models, this is a novel way to explore whether indebted households react disproportionately more than savers following monetary policy changes.

We find that monetary policy has sizable heterogeneous effects across household groups. Most importantly, we showed that this heterogeneity is highly correlated with mortgage debt and the household's housing market position. Mortgagors change their consumption significantly whereas outright owners do not. And this heterogeneity is much more stark for durable expenditure. Furthermore, income falls for all groups following a monetary contraction but we showed that the response of consumption for mortgagors remains significantly larger, even relative to their change in income. We also showed that our results do not seem to be simply driven by demographics or due to the direct interest 'cash-flow' effects associated with higher policy rates.

Our results are consistent with a housing collateral constraint story and we showed that house prices and — in exploiting a unique UK dataset on mortgage originations

— we found that mortgage debt responds significantly, with leverage (loan to income ratios) falling following a monetary contraction. Loan to value ratios, in contrast, do not move, at least in the short term.

A relatively simple housing market model, in the spirit of [Iacoviello \(2005\)](#), does a remarkably good job, both qualitatively and quantitatively, in accounting for our empirical results. An interesting implication from the model is that higher steady state indebtedness increases the effect of monetary policy both on mortgagors and in the aggregate. This suggests that heterogeneity in housing debt positions play an important role in the transmission of monetary policy.

Figures

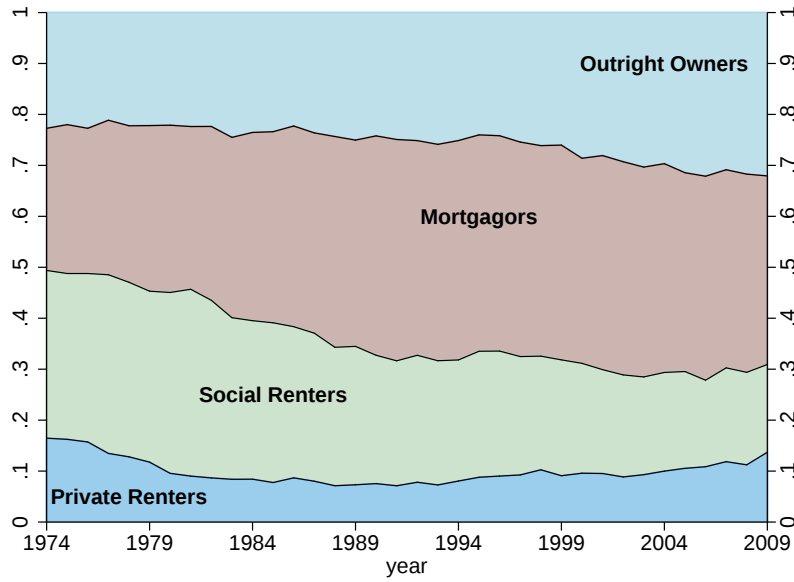


Figure 1: Evolution of Housing Tenure Shares

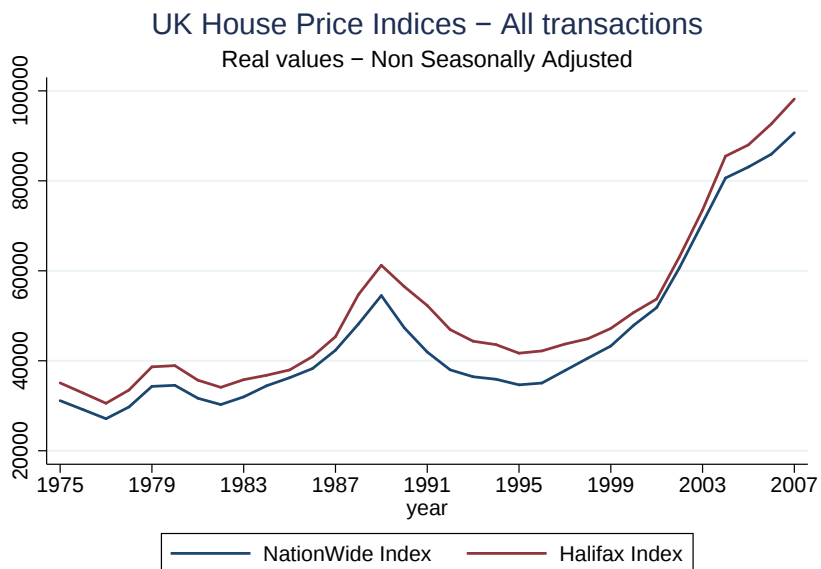


Figure 2: House Price Indexes for the UK. The 1975-1983 data for the Halifax is constructed by backward-extrapolation, using the growth rates from the NationWide Index.

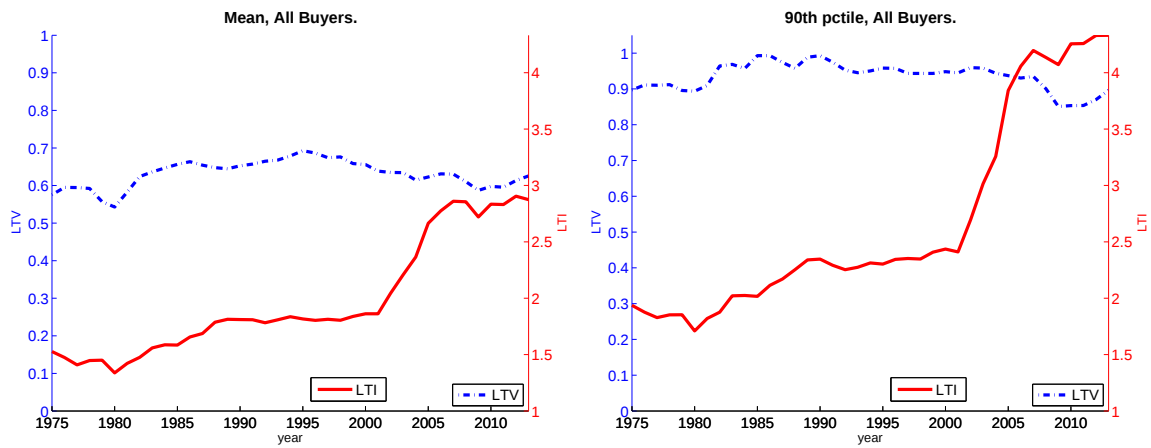


Figure 3: LTV ratios over time (using CML data up to 2005)

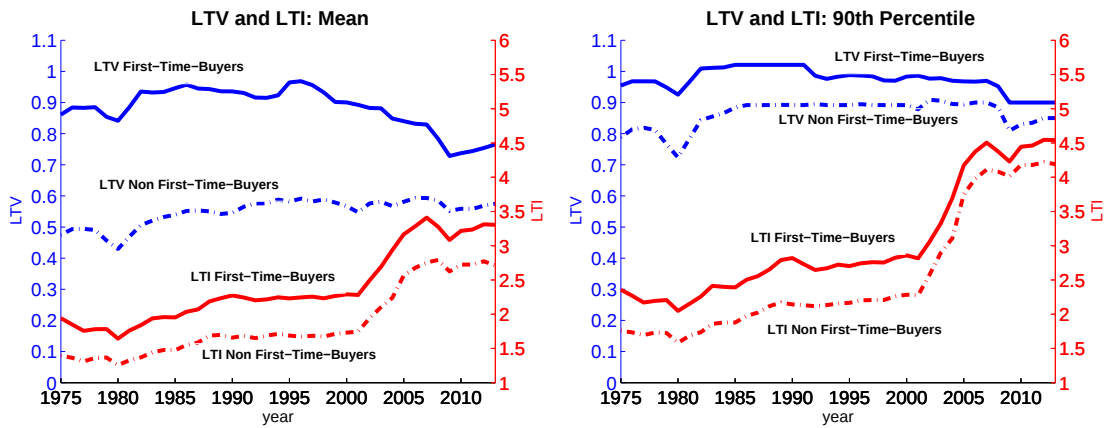


Figure 4: Loan-to-Value (LTV) and Loan-to-Income (LTI): mean (left) and 90th percentile (right)

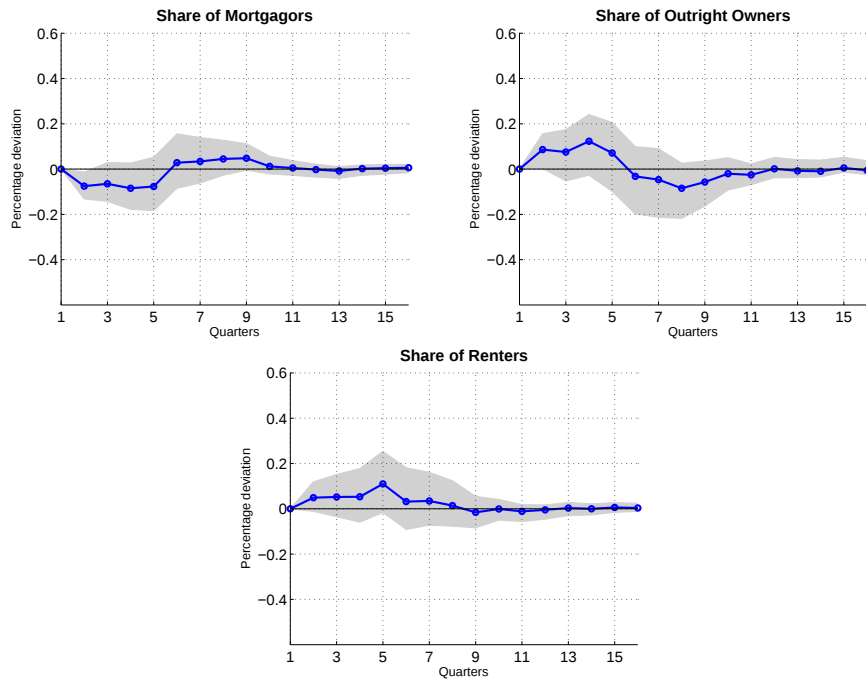


Figure 5: Response of the group shares

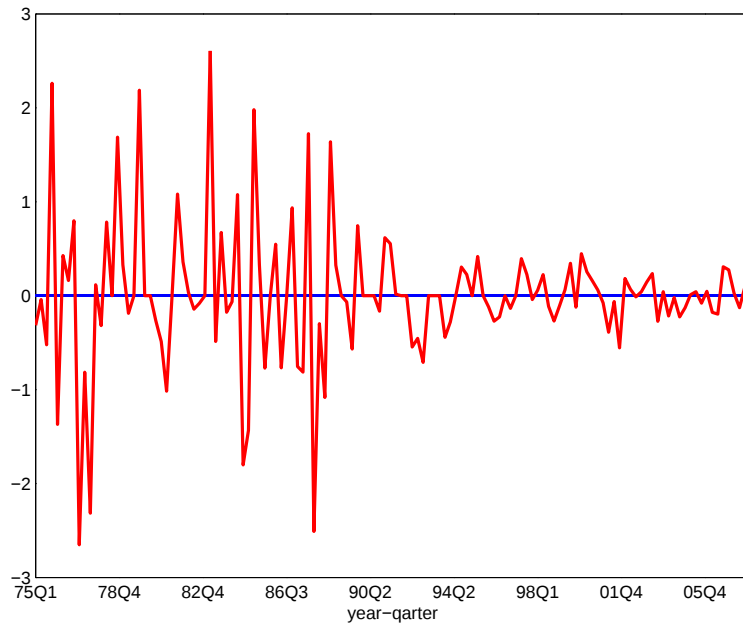


Figure 6: UK monetary policy shocks: [Cloyne and Huertgen \(2014\)](#)

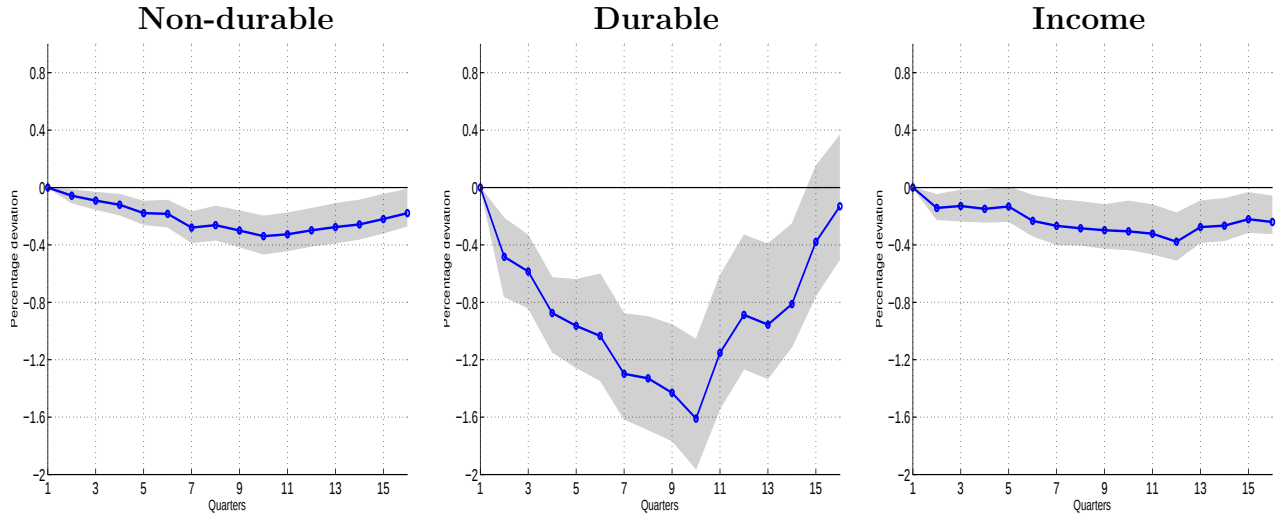


Figure 7: Response of consumption and income using aggregate ONS data.
Grey areas are 90% confidence intervals.

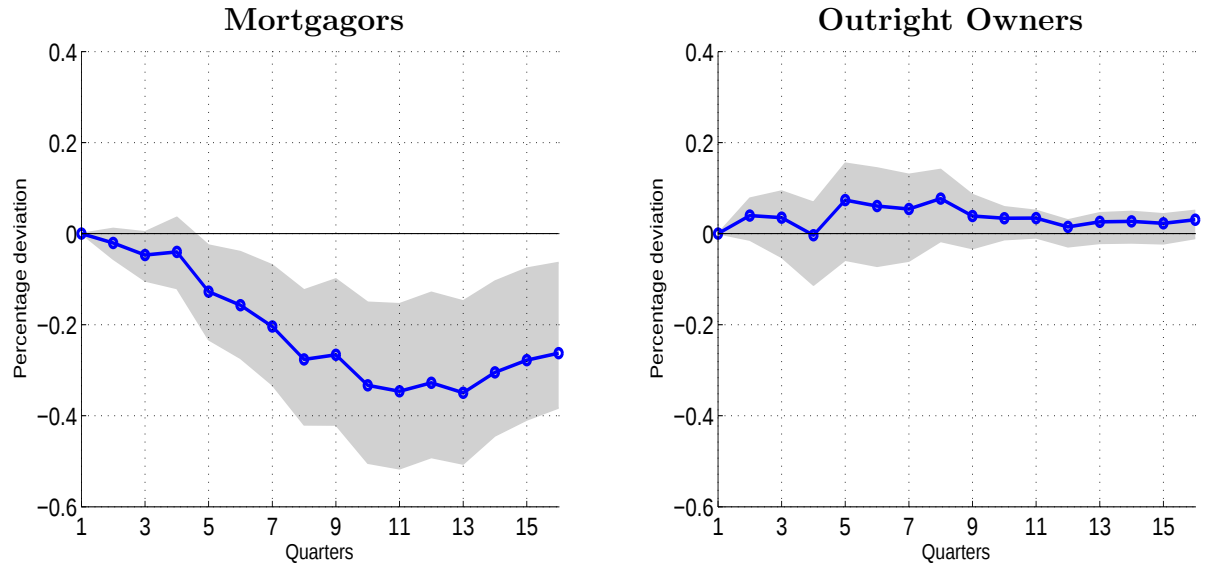


Figure 8: Response of non-durable consumption by housing tenure.

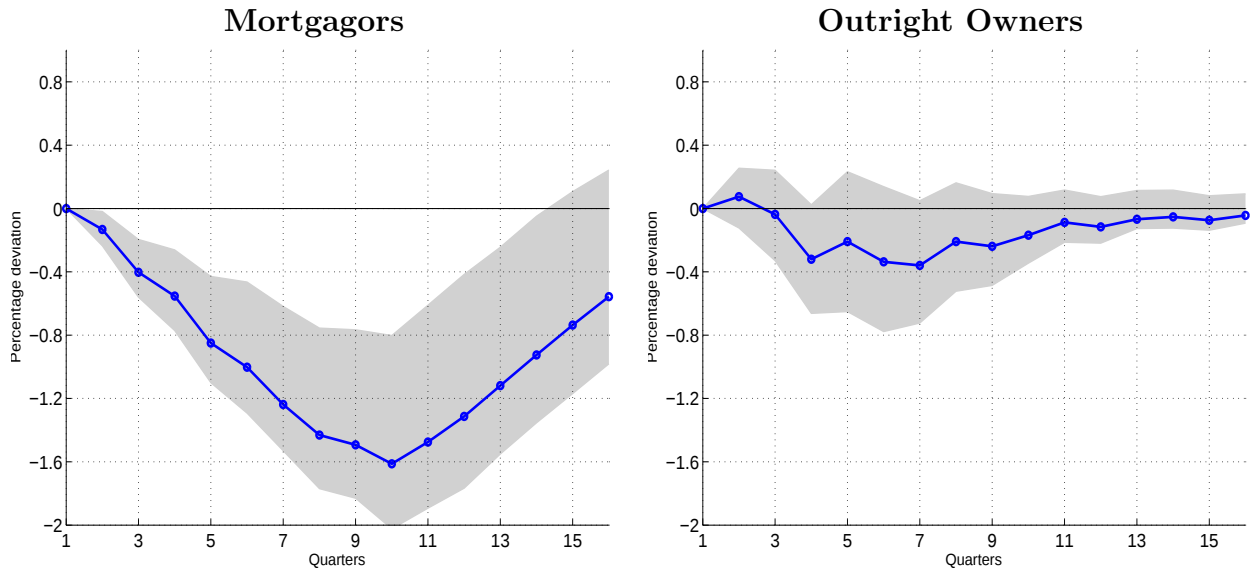


Figure 9: Response of durable consumption by housing tenure.

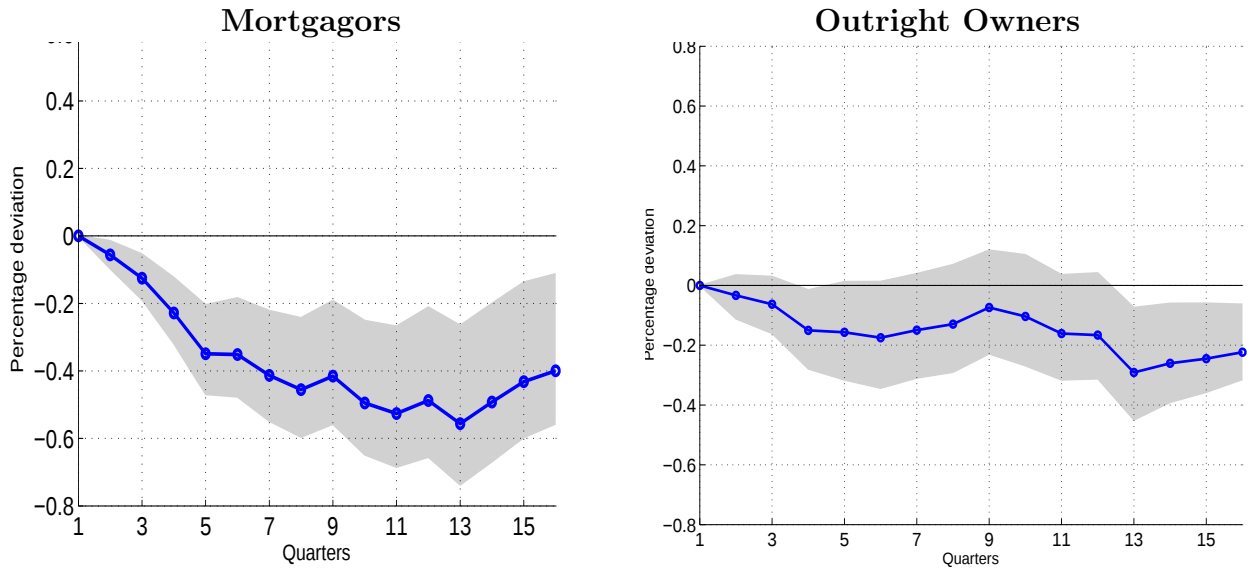


Figure 10: Response of net income by housing tenure.

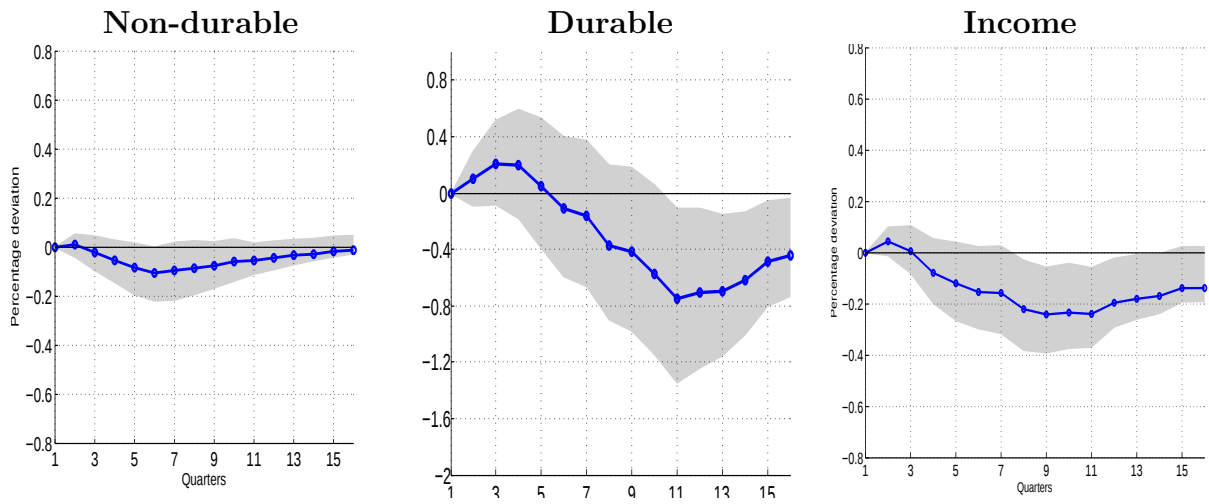


Figure 11: Response of consumption and income for renters

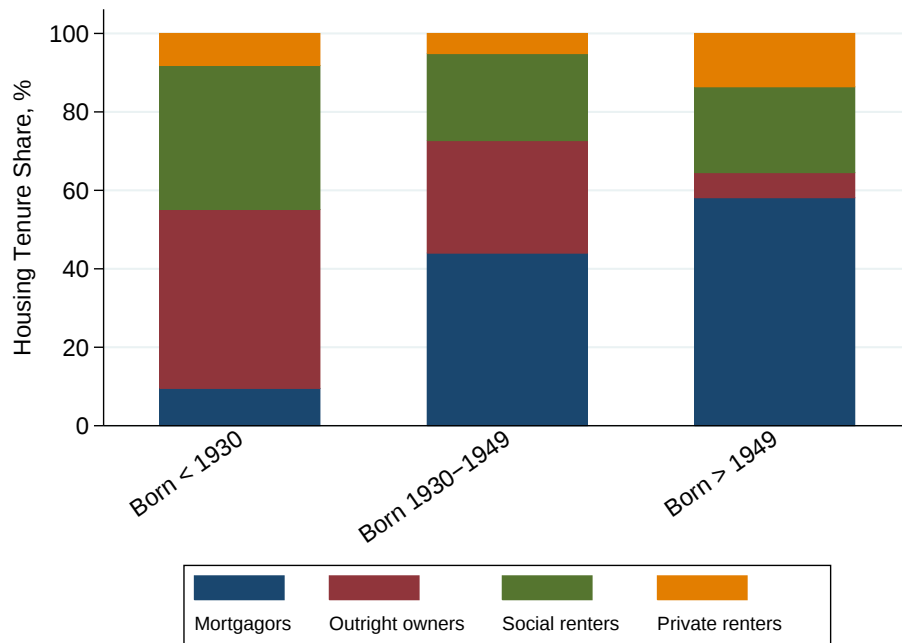
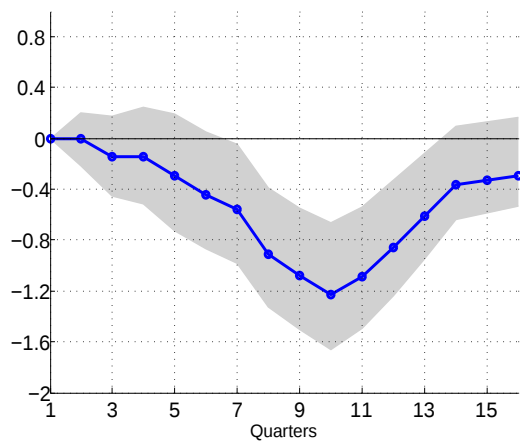


Figure 12: Housing tenure by birth cohort.

Middle-Aged Mortgagors



Middle-Aged Owners

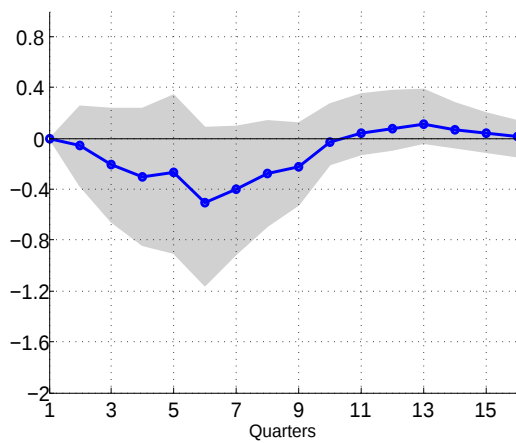


Figure 13: Response of durable expenditure for middle aged mortgagors and owners

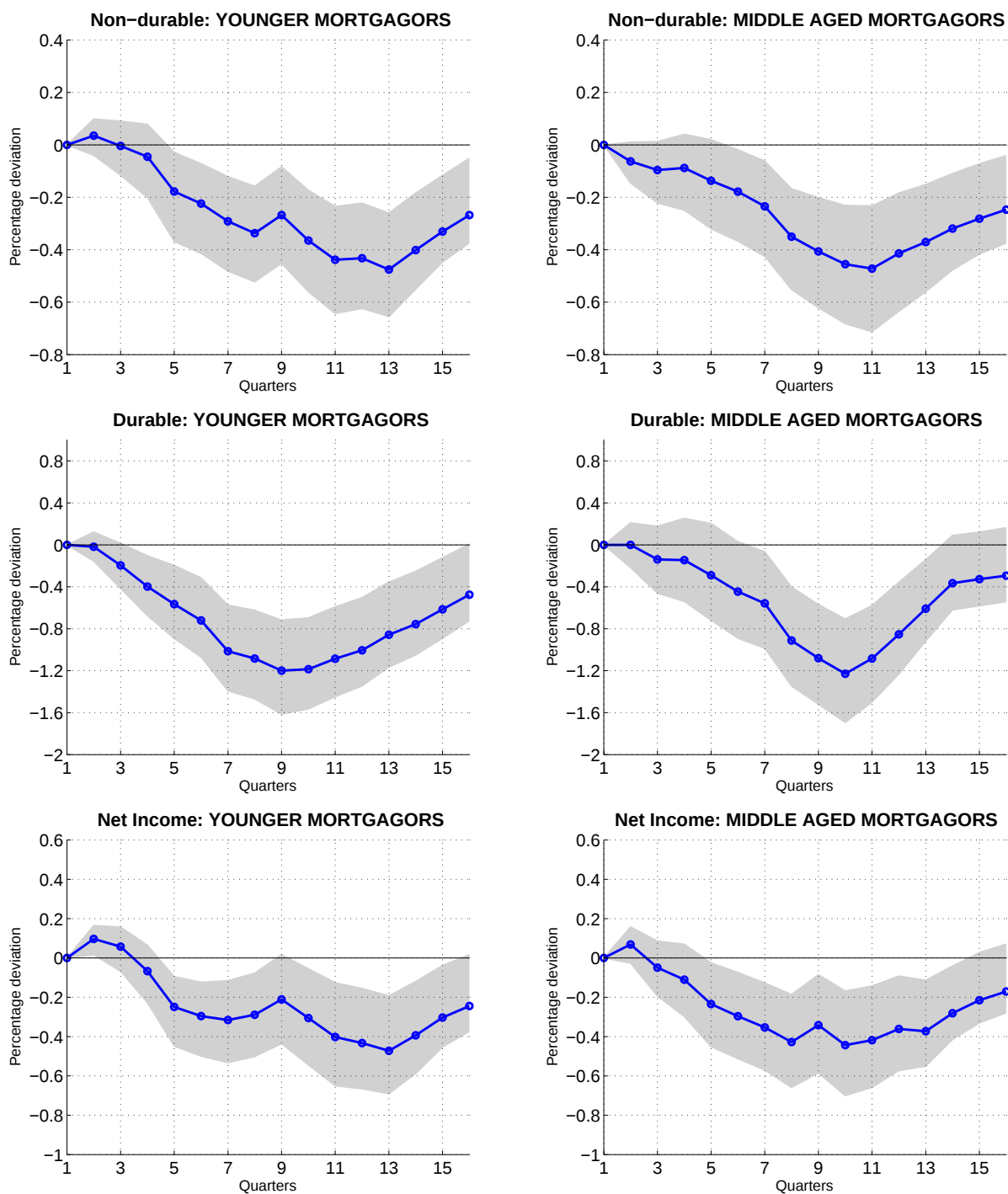


Figure 14: Response of different tenure groups by birth cohort. Left column: mortgagors born after 1949; right column: mortgagors born between 1930-1949.

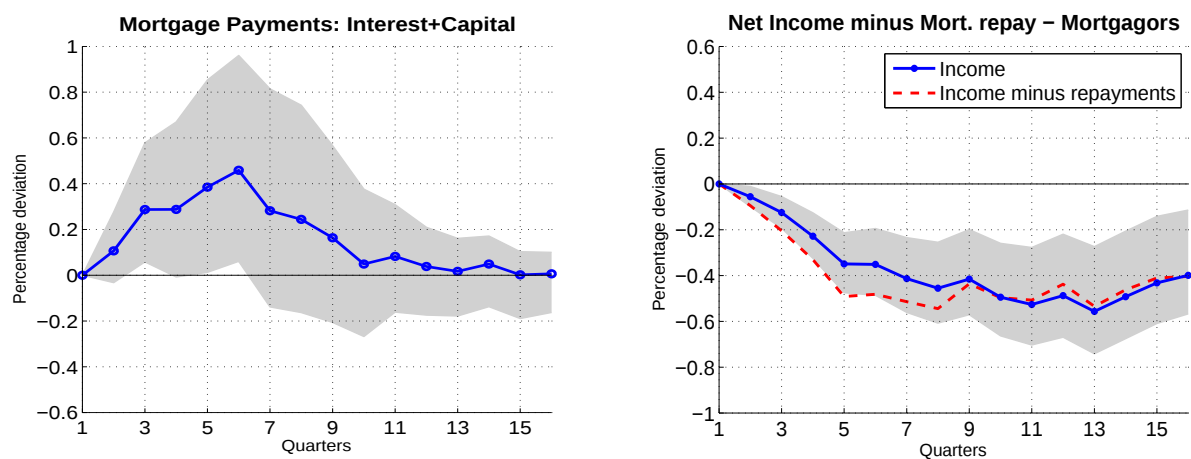


Figure 15: Impulse responses of the level of the average level of mortgage repayment (left) and the disposable income net of mortgage repayments (right). Computed using data from the Living Costs and Food Survey (LCFS).

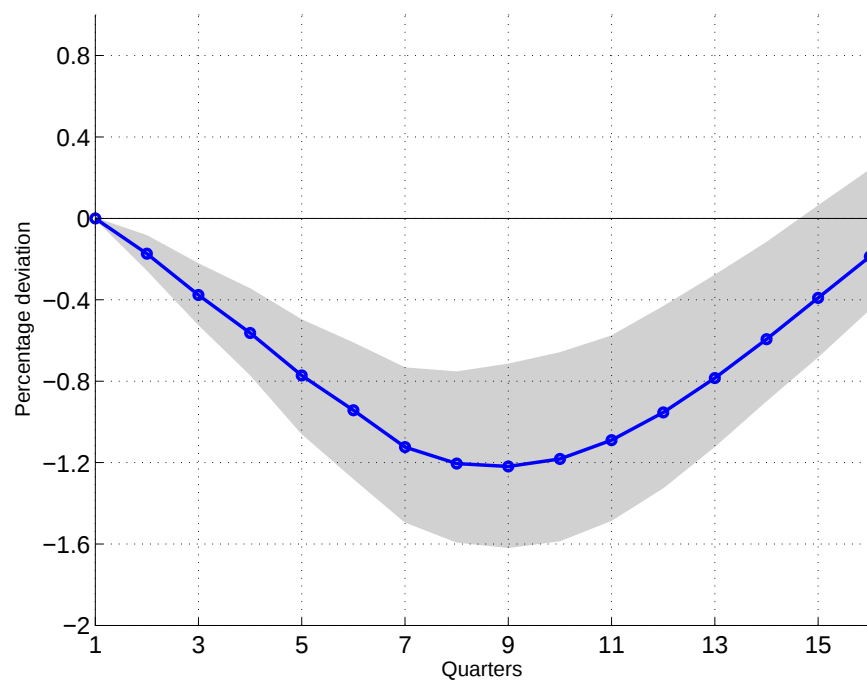


Figure 16: Response of real house prices

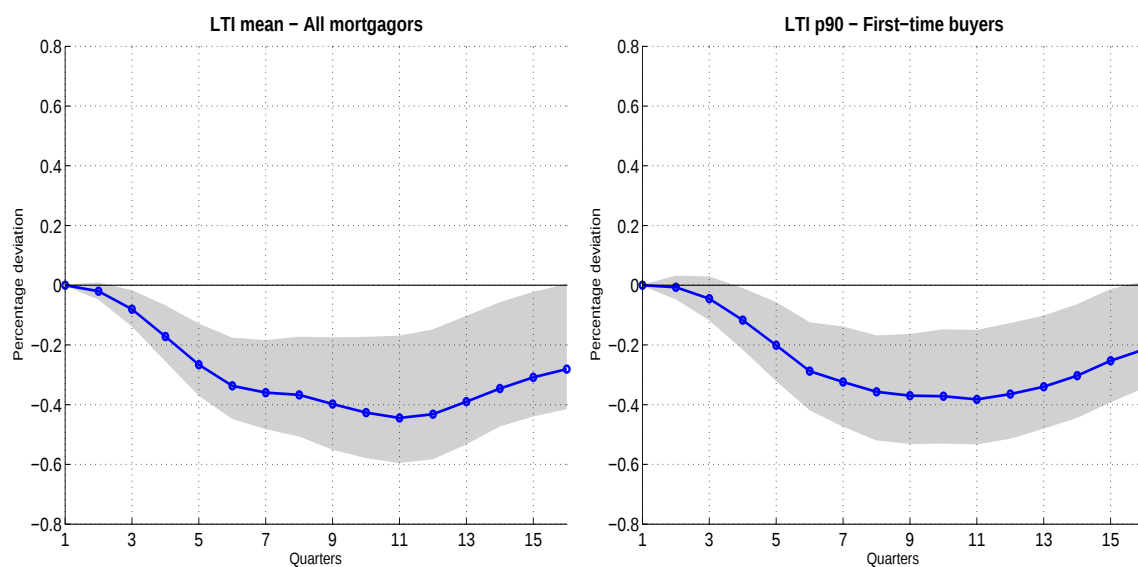


Figure 17: Response of loan to income ratios (mean, left; p90, right).

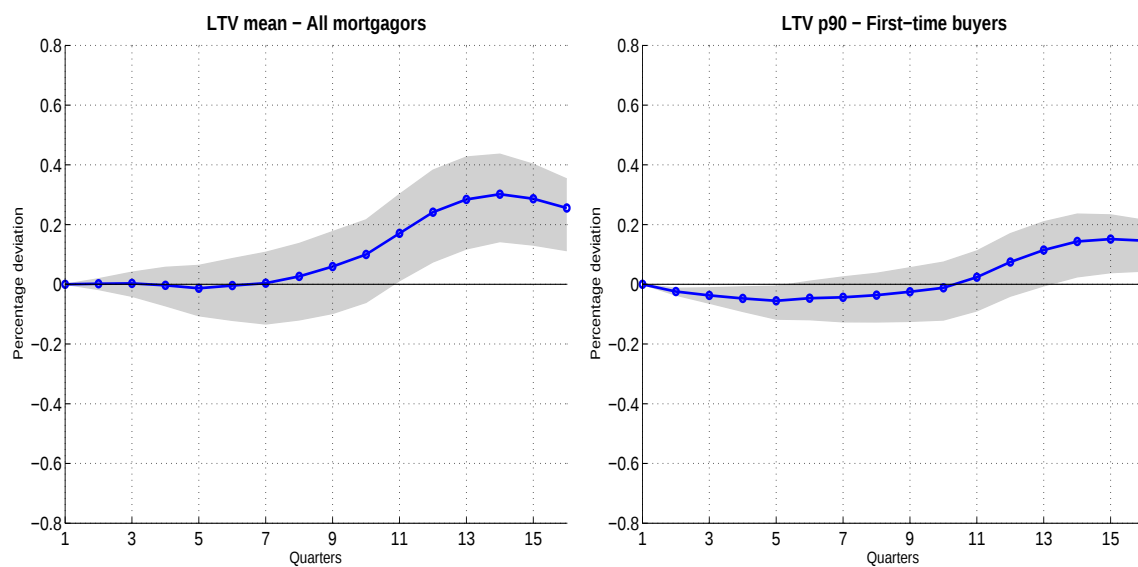


Figure 18: Response of loan to value ratios (mean, left; p90, right).

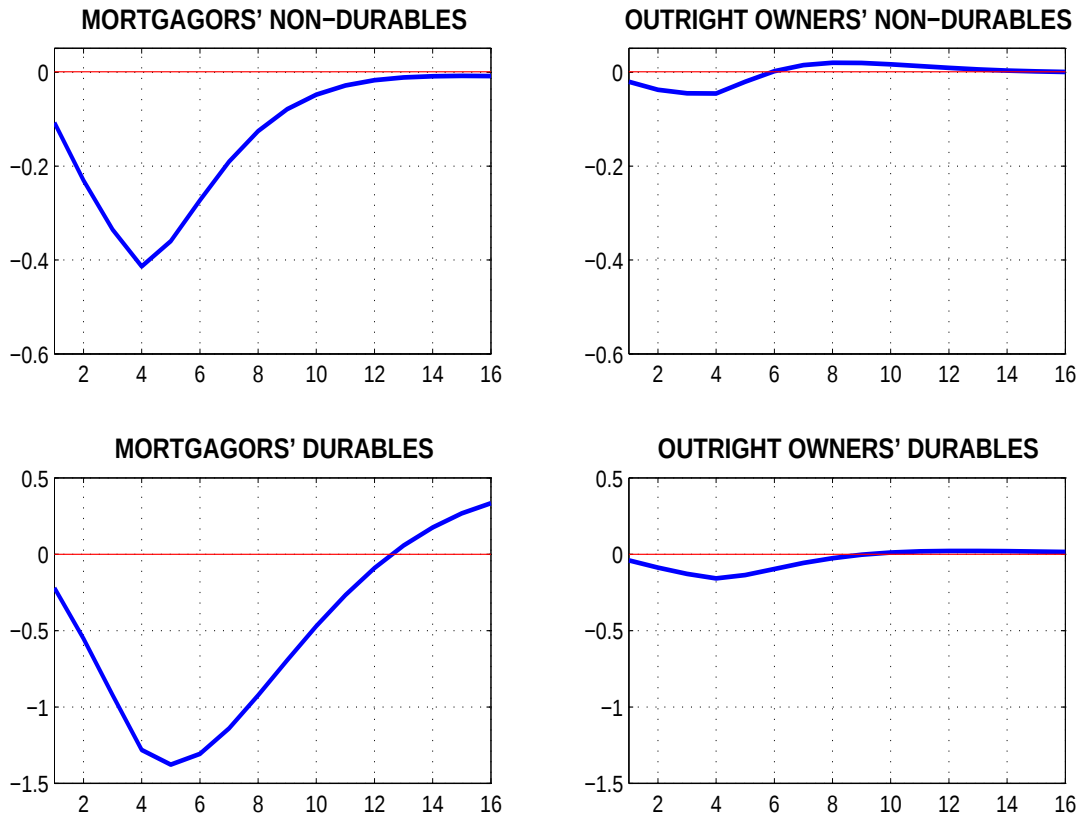


Figure 19: Response of consumption variables across the three groups.

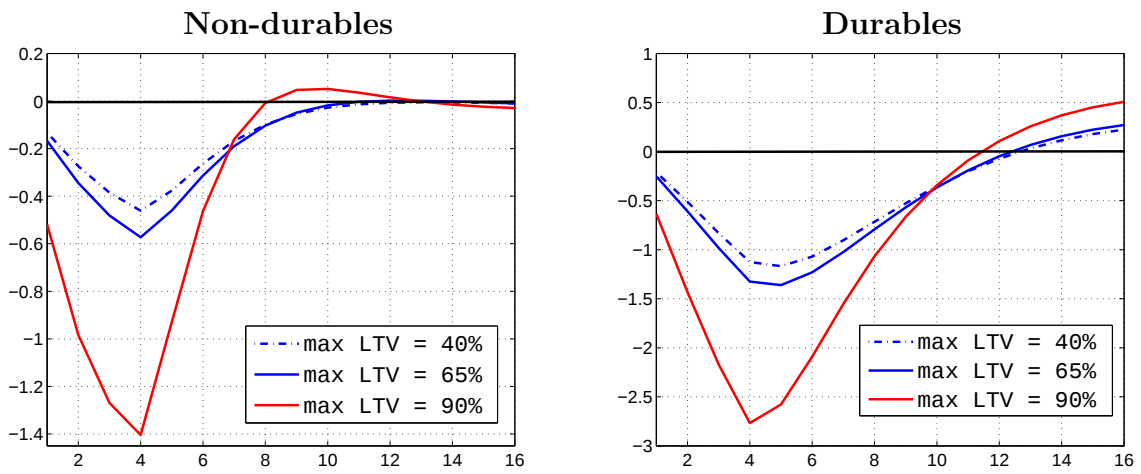


Figure 20: Varying the degree of steady state indebtedness.

Table 1: Some moments from the wealth distribution in 2005

	Net financial wealth ¹			Net housing wealth ²			<i>Obs.</i>
	<i>p25</i>	<i>Median</i>	<i>p75</i>	<i>p25</i>	<i>Median</i>	<i>p75</i>	
Renters	-400	0	150	0	0	0	1,337
Mortgagors	-3,250	0	4,600	55,000	95,000	150,000	3,179
Outright owners	0	3,000	21,100	100,000	150,000	230,000	2,385

Note: Computed from the 2005 wave of the British Household Panel Survey (BHPS). Values in 2005 £. ¹**Net financial wealth** is defined as the value of savings and investments net of outstanding non-mortgage debt. ²**Net housing wealth** is defined as the household's estimate of the property value net of any outstanding mortgage.

Table 2: Expenditures Relative to Income.

	Outright Owners	Mortgagors	
		Inc gross of repay	Inc net of repay
ND consum	0.143	0.568	0.435
D consum	0.168	0.483	0.346

Note: **Bold** figures represent statistical significance using 90% confidence intervals constructed from a non-parametric bootstrap with 5000 repetitions. Numbers are computed by cumulating the impulse response functions for 15 periods post shock. For details, see formula in the main text.

Parameter	Description	Value
$\theta/(1 - \theta)$	elasticity of substitution between ND and D stock	4
σ	elasticity of intertemporal substitution	1
β, β'	discount factor: mortgagors, outright owners	0.95, 0.99
$1/(\eta - 1)$	Frisch elasticity of labor supply	2
μ	habits parameter	0.5
$\varepsilon_{C,D}$	elasticity varieties	11, 7.7
$\vartheta_{C,D}$	price adjustment cost	116
m	max LTV (baseline)	0.65
ω_{IH}	share of mortgagors	40%
ω_{PH}	share outright owners	30%
r_π, r_Y, r_R	Taylor rule: CPI, output, smoothing	1.5, .125, .8

Table 3: Calibration of the model.

Appendices

Details of the model

The model can be seen as a stripped down version of [Iacoviello \(2005\)](#) but including durables as in [Mertens and Ravn \(2011\)](#) and including rule of thumb consumers as in [Gali et al. \(2007\)](#). Unlike in [Monacelli \(2009\)](#) households do not face a collateral constraint on their purchase of durables but instead face a collateral constraint according to their housing assets (as in [Iacoviello \(2005\)](#)). These extra features are important as they allow us to investigate key aspects of our empirical findings. There is a continuum of households, measure one, with each of the population shares calibrated to match our microdata.

Mortgagors: Impatient Households

There are ω^{IH} impatient households who consume durable and non-durable goods, accumulate housing and supply labor. They have a lower discount factor than the patient households which makes them net borrowers. We therefore refer to this group of households as mortgagors. The household's problem is to maximize utility:

$$\max_{\{C_t, D_t, V_{t+1}, h_t, L_t, b_t\}} E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{x_t^{1-\sigma}}{1-\sigma} + j_t \log(h_t) - \frac{L_t^\eta}{\eta} \right) \quad (6)$$

where

$$x_t \equiv C_t^\theta V_t^{1-\theta} - \mu C_{t-1}^\theta V_{t-1}^{1-\theta} \quad (7)$$

subject to

$$C_t + q_t^d D_t + q_t^h \Delta h_t + \frac{R_{t-1}}{\pi_{c,t}} b_{t-1} + \xi_{h,t} = w_t L_t + b_t + T_t \quad (8)$$

$$V_{t+1} = \left(1 - \Phi \left(\frac{D_t}{D_{t-1}} \right) \right) D_t + (1 - \delta) V_t \quad (9)$$

and a collateral constraint

$$b_t \leq m^{LTV} E \left(\frac{q_{t+1}^h h_t \pi_{c,t+1}}{R_t} \right) \quad (10)$$

Owners: Patient Households

Patient households are the savers in this economy and have measure ω^{PH} . They also own housing but without debt. We therefore refer to these households as outright owners. These households maximise utility:

$$\max_{\{C_t, D_t, V_{t+1}, h_t, L_t, b_t\}} E_0 \sum_{t=0}^{\infty} \beta'^t \left(\frac{x_t'^{(1-\sigma)}}{1-\sigma} + j_t \log(h_t') - \frac{L_t'^{\eta}}{\eta} \right) \quad (11)$$

where

$$x_t' \equiv C_t'^{\theta} V_t'^{(1-\theta)} - \mu C_{t-1}'^{\theta} V_{t-1}'^{(1-\theta)} \quad (12)$$

subject to

$$C_t' + q_t^d D_t' + q_t^h \Delta h_t' + \frac{R_{t-1}}{\pi_{c,t}} b_{t-1}' + \xi_{h,t} = w_t L_t' + b_t' + \frac{\Pi_{C,t}}{\omega_{PH}} + \frac{\Pi_{D,t}}{\omega_{PH}} + T_t' \quad (13)$$

$$V_{t+1}' = \left(1 - \Phi \left(\frac{D_t'}{D_{t-1}'} \right) \right) D_t' + (1 - \delta) V_t' \quad (14)$$

Renters: rule of thumb consumers

To proxy for (social) renters, we simply model our final group of households as rule of thumb consumers as in [Gali et al. \(2007\)](#). The size of this group is therefore $1 - \omega^{PH} - \omega^{IH}$. Renters maximise:

$$\max_{\{C_t, D_t, V_{t+1}, h_t, L_t, b_t\}} E_0 \sum_{t=0}^{\infty} \beta''^t \left(\frac{x_t''^{1-\sigma}}{1-\sigma} - \frac{L_t''^{\eta_r}}{\eta_r} \right) \quad (15)$$

where

$$x_t'' \equiv C_t''^{\theta} V_t''^{(1-\theta)} - \mu C_{t-1}''^{\theta} V_{t-1}''^{(1-\theta)} \quad (16)$$

subject to

$$C_t'' + q_t^d D_t'' = w_t L_t'' \quad (17)$$

$$V_{t+1}'' = \left(1 - \Phi \left(\frac{D_t''}{D_{t-1}''} \right) \right) D_t'' + (1 - \delta) V_t'' \quad (18)$$

Intermediate Firms

On the production side there are two types of intermediate goods firms producing a distinct durable or non-durable intermediate good. These firms face price adjustment costs as in [Monacelli \(2009\)](#) and this leads to movements in the relative price of durable goods relative to non-durables. In keeping with the standard New Keynesian set-up, these firms are monopolistically competitive and produce output using labor:

$$Y_{j,t}(i) = L_{j,t}(i) \quad (19)$$

Subject to price adjustment costs:

$$AC_{j,t}(i) = \frac{\vartheta_j}{2} \left(\frac{P_{j,t}(i)}{P_{j,t-1}(i)} - 1 \right)^2 Y_{j,t} \quad (20)$$

$\vartheta_j \geq 0$ measures price-stickiness.

Final goods firms

Competitive final good producers combined intermediate goods to produce a durable and non-durable final consumption good ($j = C, D$):

$$Y_{j,t} = \left(\int_0^1 Y_{j,t}(i)^{\frac{\epsilon_j-1}{\epsilon_j}} di \right)^{\frac{\epsilon_j}{\epsilon_j-1}} \quad (21)$$

Profit maximization imply a demand for variety i

$$Y_{j,t}^*(i) = \left(\frac{P_{j,t}(i)}{P_{j,t}} \right)^{-\epsilon_j} Y_{j,t} \quad (22)$$

and the sector-price index then is:

$$P_{j,t} \equiv \left(\int_0^1 P_{j,t}(i)^{1-\epsilon_j} di \right)^{\frac{1}{1-\epsilon_j}} \quad (23)$$

Price dynamics

Standard linearization of the intermediate goods firms' equilibrium conditions lead to two sectoral Phillips curves describing the evolution of durable and non-durable

goods prices.

$$\hat{\pi}_{D,t} = \tilde{\beta} E_t (\hat{\pi}_{D,t+1}) + \left(\frac{\epsilon_D - 1}{\vartheta_D} \right) \hat{m} c_{D,t} \quad (24)$$

$$\hat{\pi}_{C,t} = \tilde{\beta} E_t (\hat{\pi}_{C,t+1}) + \left(\frac{\epsilon_C - 1}{\vartheta_C} \right) \hat{m} c_{C,t} \quad (25)$$

Monetary policy

Monetary policy is conducted by means of a simple Taylor rule,

$$R_t = (R_{t-1})^{r_R} \left(\pi_{t-1}^{A(1+r_\pi)} \left(\frac{Y_{t-1}}{Y} \right)^{r_Y} \right)^{1-r_R} \epsilon_{R,t} \quad (26)$$

Market clearing

$$\begin{aligned} Y_{C,t} &= \omega_{IH} (C_t + \xi_{h,t}) + \omega_{PH} (C'_t + \xi'_{h,t}) \\ &+ (1 - \omega_{IH} - \omega_{PH}) C''_t + \frac{\vartheta_C}{2} (\pi_{C,t} - 1)^2 Y_{Ct} \\ Y_{D,t} &= \omega_{IH} D_t + \omega_{PH} D'_t + (1 - \omega_{IH} - \omega_{PH}) D''_t \\ &+ \frac{\vartheta_D}{2} (\pi_{D,t} - 1)^2 Y_{Dt} \end{aligned}$$

$$0 = \omega_{IH} b_t + \omega_{PH} b'_t$$

$$H = \omega_{IH} h_t + \omega_{PH} h'_t$$

$$L_{C,t} + L_{D,t} = \omega_{IH} L_t + \omega_{PH} L'_t + (1 - \omega_{IH} - \omega_{PH}) L''_t$$

Aggregate US results

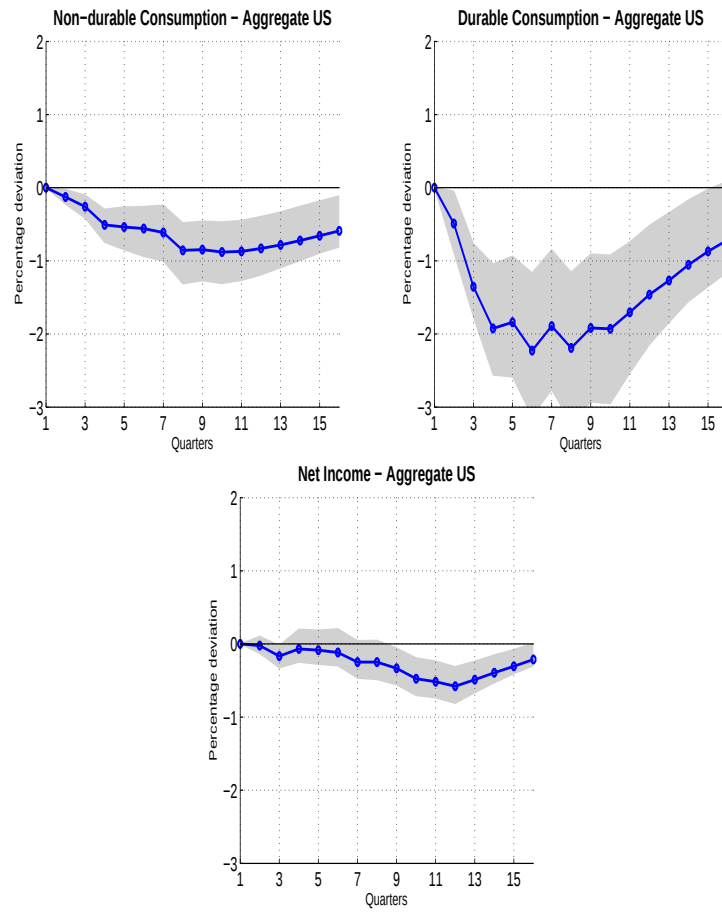


Figure 21: Response of aggregate consumption and income for the US using [Romer and Romer \(2004\)](#) shocks.

Descriptive statistics

Table 4: Descriptive Statistics for Birth Cohorts, 1975q1 - 2007q4

	Older¹	Middle Aged²	Younger³	Mortgagors	Owners
Educated	0.28	0.39	0.49	0.51	0.41
Employed	0.17	0.63	0.79	0.87	0.34
Earnings	170.51	675.23	944.98	1107.62	365.62
Net Income	967.17	1184.50	1183.91	1387.53	1167.25
Soc. Renters	0.32	0.21	0.21	-	-
Priv. Renters	0.06	0.05	0.16	-	-
Mortgagors	0.07	0.40	0.52	-	-
O. Owners	0.48	0.28	0.05	-	-

¹ **Older:** born before 1930. ² **Middle Aged:** born bewteen 1930 and 1949.

³ **Younger:** born after 1949.

Table 5: Descriptive Statistics for Housing Tenure Cohorts, 1975q1 - 2007q4

	Social Renters			
	Mean	St. Dev.	Min	Max
Educated	0.20	0.04	0.11	0.35
Employed	0.37	0.12	0.24	0.67
Earnings	322.60	79.18	169.73	511.98
Net Income	762.44	94.44	625.47	972.14
	Private Renters			
	Mean	St. Dev.	Min	Max
Educated	0.49	0.09	0.28	0.74
Employed	0.57	0.08	0.41	0.76
Earnings	710.22	210.01	375.15	1240.06
Net Income	1091.87	234.15	721.32	1591.83
	Mortgagors			
	Mean	St. Dev.	Min	Max
Educated	0.51	0.03	0.45	0.58
Employed	0.87	0.03	0.81	0.94
Earnings	1107.62	233.57	719.40	1512.60
Net Income	1387.53	325.78	851.86	1948.60
	Outright Owners			
	Mean	St. Dev.	Min	Max
Educated	0.41	0.06	0.27	0.55
Employed	0.34	0.07	0.23	0.54
Earnings	365.62	70.17	247.10	588.54
Net Income	1167.25	262.99	726.94	1663.21

References

- Aguiar, M. and E. Hurst (2005, October). Consumption versus Expenditure. *Journal of Political Economy* 113(5), 919–948.
- Aladangady, A. (2014). Homeowner balance sheets and monetary policy. Technical report, Divisions of Research & Statistics and Monetary Affairs, Federal Reserve Board.
- Attanasio, O., J. Banks, and S. Tanner (2002). Asset holding and consumption volatility. *Journal of Political Economy* 110, 771–792.
- Attanasio, O. P., E. Battistin, and A. Leicester (2006). From micro to macro, from poor to rich: Consumption and income in the uk and the us. Technical report. University of Michigan.
- Auclert, A. (2014). Monetary policy and the redistribution channel. *Job Market Paper, MIT*.
- Barsky, R., C. House, and M. Kimball (2007). Sticky-price models and durable goods. *American Economic Review* 97(3), 984–998.
- Brewer, M. and C. O’Dea (2012, Jul). Measuring living standards with income and consumption: evidence from the uk. Technical report.
- Browning, M., A. Deaton, and M. Irish (1985). A profitable approach to labour supply and commodity demands over the life-cycle. *Econometrica* 53(3), 503–44.
- Calza, A., T. Monacelli, and L. Stracca (2013a). Housing finance and monetary policy. *Journal of the European Economic Association* 11, 101–122.
- Calza, A., T. Monacelli, and L. Stracca (2013b). Housing finance and monetary policy. *Journal of the European Economic Association* 11, 101–122.

- Christiano, L. J., M. Eichenbaum, and C. Evans (1996, February). The effects of monetary policy shocks: Evidence from the flow of funds. *The Review of Economics and Statistics* 78(1), 16–34.
- Christiano, L. J., M. Eichenbaum, and C. L. Evans (1999). Monetary policy shocks: What have we learned and to what end? In J. B. Taylor and M. Woodford (Eds.), *Handbook of Macroeconomics*, Volume 1A, Chapter 2, pp. 65–148. Amsterdam: North-Holland.
- Cloyne, J. and P. Huertgen (2014). The macroeconomic effects of monetary policy: a new measure for the united kingdom. *Bank of England Working Paper* 493.
- Cloyne, J. and P. Surico (2013). Household debt and the dynamic effects of income tax changes. *CEPR Discussion Paper* 9649.
- Coibion, O. (2012). Are the effects of monetary policy shocks big or small? *American Economic Journal: Macroeconomics* 4(2).
- Coibion, O., Y. Gorodnichenko, L. Kueng, and J. Silvia (2012). Innocent Bystanders? Monetary Policy and Inequality in the U.S. *NBER Working Papers* 1817.
- Crossley, T., H. Low, and C. O’Dea (2012). Household consumption through recent recessions. Technical report.
- Eggertsson, G. and P. Krugman (2012). Debt, deleveraging, and the liquidity trap: A Fisher-Minsky-Koo approach. *Quarterly Journal of Economics* 127, 1469–513.
- Gali, J., J. Valles, and D. Lopez-Salido (2007). Understanding the effects of government spending on consumption. *Journal of the European Economic Association* 5(1).
- Guerrieri, L. and M. Iacoviello (2013). Collateral constraints and macroeconomic asymmetries. *International Finance Discussion Papers* 1082, Board of Governors of the Federal Reserve System.

- Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American Economic Review* vol. 95(3).
- Justiniano, A., G. Primiceri, and A. Tambalotti (2014). Credit supply and the housing boom. *Manuscript*.
- Kaplan, G. and G. L. Violante (2014). A model of the consumption response to fiscal stimulus payments. *Econometrica* forthcoming.
- Kiyotaki, N. and J. Moore (1997). Credit cycles. *Journal of Political Economy* 105(2).
- Mertens, K. and M. O. Ravn (2011). Understanding the aggregate effects of anticipated and unanticipated tax policy shocks. *Review of Economic Dynamics* 14(1), 27–54.
- Mian, A., K. Rao, and A. Sufi (2013). Household balance sheets, consumption, and the economic slump*. *The Quarterly Journal of Economics* 128(4), 1687–1726.
- Mian, A. and A. Sufi (2014, May). House price gains and u.s. household spending from 2002 to 2006. Working Paper 20152, National Bureau of Economic Research.
- Monacelli, T. (2009). New keynesian models, durable goods and collateral constraints. *Journal of Monetary Economics* 56, 242–254.
- Ragot, X. (2014). The case for a financial approach to money demand. *Journal of Monetary Economics* 62(0), 94 – 107.
- Romer, C. D. and D. H. Romer (2004). A new measure of monetary shocks: Derivation and implications. *American Economic Review* 94(4), 1055–84.
- Sterk, V. (2010). Credit frictions and the comovement between durable and non-durable consumption. *Journal of Monetary Economics* 57, 217–225.

Sterk, V. and S. Tenreyro (2014). The transmission of monetary policy operations through redistributions and durable purchases. *Centre for Macroeconomics Discussion Paper DP2013-5*.

Wong, A. (2014). Population aging and the aggregate effects of monetary policy.