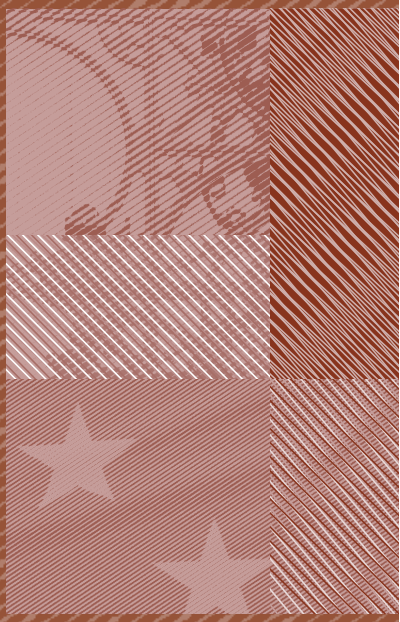
MONETARY POLICY WHEN HOUSEHOLDS HAVE DEBT: NEW EVIDENCE ON THE TRANSMISSION MECHANISM

2018

James Cloyne, Clodomiro Ferreira
and Paolo Surico

Documentos de Trabajo
N.º 1813

BANCO DE ESPAÑA
Eurosistema



MONETARY POLICY WHEN HOUSEHOLDS HAVE DEBT: NEW EVIDENCE ON THE TRANSMISSION MECHANISM

MONETARY POLICY WHEN HOUSEHOLDS HAVE DEBT: NEW EVIDENCE ON THE TRANSMISSION MECHANISM (*)

James Cloyne

UNIVERSITY OF CALIFORNIA DAVIS, NBER AND CEPR

Clodomiro Ferreira

BANCO DE ESPAÑA

Paolo Surico

LONDON BUSINESS SCHOOL AND CEPR

(*) We appreciate comments and suggestions from Antonio Ciccone, Joao Cocco, Mark Gertler, Sebastian Hohmann, Matteo Iacoviello, Michael McMahon, Tommaso Monacelli, Xavier Ragot, Ricardo Reis, David Romer, Ryland Thomas, Gianluca Violante, Garry Young and participants at many seminars and conferences. The views in this paper are those of the authors and do not necessarily reflect the views of the Bank of Spain, Bank of England, the Monetary Policy Committee, the Financial Policy Committee or the PRA. The graphs in this paper are best viewed in color. Surico gratefully acknowledges financial support from the European Research Council (Starting Grant 263429 and Consolidator Grant 647049) and the British Academy (Mid-career fellowship 130093).
Address for correspondence: James Cloyne (University of California Davis, NBER and CEPR) jcloyne@ucdavis.edu; Clodomiro Ferreira (Bank of Spain) clodomiro.ferreira@bde.es; Paolo Surico (London Business School and CEPR) psurico@london.edu.

Documentos de Trabajo. N.º 1813

2018

ISSN: 1579-8666 (on line)

Abstract

How do changes in monetary policy affect consumption? Using household data for the US and the UK, we show that most of the aggregate response of consumption to interest rates is driven by households with a mortgage. Outright home owners do not adjust expenditure at all and renters change their spending but by less than mortgagors. Income rises for all households as interest rate cuts directly affect firm investment and household consumption, boosting aggregate demand. A key difference between these housing tenure groups is the composition of their balance sheets: mortgagors hold sizable illiquid assets but little liquid wealth, consistent with a higher marginal propensity to consume.

Keywords: monetary policy, household balance sheets, liquidity constraints.

JEL classification: E21, E32, E52.

Resumen

¿Qué efecto tiene la política monetaria sobre el consumo? Mediante el uso de información a nivel de hogar en el Reino Unido y Estados Unidos, este trabajo muestra que la mayor parte de la dinámica del consumo agregado después de un cambio en los tipos de interés a corto plazo, viene explicada por el comportamiento de los gastos de consumo de familias que son propietarias de una vivienda financiada por hipoteca. Por el contrario, aquellas familias propietarias de vivienda pero sin hipoteca, no cambian sus gastos de consumo, mientras que el consumo de aquellas familias que alquilan una vivienda responde a los cambios en tipos pero de forma más atenuada que para las familias hipotecadas. Una diferencia crucial entre estos tres modelos de familia es la composición de sus balances: las familias hipotecadas poseen, de media, una cantidad significativa de activos ilíquidos pero muy poca riqueza líquida, lo cual es congruente con una mayor propensión marginal a consumir. Una reducción en los tipos de interés genera, además de un incremento en el consumo, una expansión en la inversión en capital fijo por parte de empresas, lo cual contribuye a un impacto positivo sobre la demanda agregada en la economía.

Palabras clave: política monetaria, restricciones de liquidez, balance financiero de las familias.

Códigos JEL: E21, E32, E52.

1 Introduction

How monetary policy affects the real economy is one of the oldest and most intensively investigated topics in macroeconomics. In many standard macroeconomic theories, interest rate changes primarily affect household consumption through intertemporal substitution. The recent financial crisis, however, has sparked a lively debate about whether other mechanisms could be equally, or even more, important for the transmission of monetary policy.

A key part of this debate has focused on the financial positions of households. Mortgages make-up the vast majority of household debt in the US and the UK, and nearly half the population has a mortgage. As a result, there has been renewed interest in debt, household balance sheets and the mortgage market — popularized by an influential set of papers highlighting the role of household debt in the amplification of macroeconomic shocks (Mian et al. (2013), Mian and Sufi (2014)). A growing body of theoretical work has been exploring how balance sheet differences across households may amplify the transmission of monetary policy (e.g. Iacoviello (2005), Kaplan et al. (2018), Mitman et al. (2016) and Bilbiie (2017)). In these models, some households exhibit a high marginal propensity to consume out of temporary income shocks and this may vary with a household's financial position.

Despite the renewed interest in these issues, the literature is lacking a systematic empirical investigation of whether differences in household balance sheets affect the transmission mechanism of interest rate changes. We use household survey data for the U.S. and the U.K. to fill this gap. Our contribution is to provide a novel set of empirical stylized facts about the heterogeneous effects of monetary policy and use these results to assess different channels of monetary transmission.

Few, if any, datasets contain information on household expenditure and income, together with assets and liabilities over a long period of time. This poses a significant challenge for studying the effects of monetary policy on households with different balance sheet positions. Instead, we use household survey data from the U.K. Living Costs and Food Survey and the U.S. Consumer Expenditure Survey, which have extensive expenditure and income coverage and have been run for many decades. These surveys are mostly cross-sectional and lack detailed balance sheet information, but our innovation is to use a household's housing tenure status — specifically whether they rent, own their home with a mortgage or own without a mortgage — as a predictor of their debt and asset positions, a fact that we document using lower frequency surveys. We construct pseudo-cohorts based on the three housing tenure groups and tackle the endogeneity of policy interest rates using identified monetary policy shocks for each country (Romer and Romer (2004), Cloyne and Huertgen (2016)). This strategy allows us to study the heterogeneous effects on consumption, explore the dynamics and consider the general equilibrium effects on household income.

In the first part of the paper, we show that the vast majority of the aggregate consumption response to a temporary unanticipated interest rate change is driven by households with a mortgage. When interest rates fall, households with a mortgage increase their spending considerably, while outright home-owners without mortgage debt do not change their expenditure at all. This heterogeneity exists over and above any heterogeneity coming from demographic factors. Renters also increase their spending, although by less than mortgagors.

In the second part of the paper, we ask: what theoretical mechanism is most consistent with these results? We show that expansionary monetary policy leads to a significant increase in income for all groups as lower interest rates directly affect firm investment and household expenditure, boosting aggregate demand. But higher income only seems to translate into higher consumption for mortgagors and renters. To explore this, we use lower-frequency US and UK wealth survey data and show that the three housing tenure groups differ markedly in their holdings of liquid and illiquid assets. Renters have little wealth and, being younger and poorer, fit the typical description of liquidity constrained households. Mortgagors tend to have little liquidity, despite owning sizable illiquid assets. Indeed, between 40 and 50% of households with mortgage debt have net liquid wealth that is less than half of their monthly income, consistent with a significant proportion of 'wealthy' hand-to-mouth consumers (Kaplan and Violante (2014))).[1] In contrast, outright home-owners have ample amounts of liquid and illiquid assets. Our housing tenure proxy is therefore capturing *two*, very different, types of hand-to-mouth households. While our empirical strategy is not suited to establishing a causal link between consumption and income, the heterogeneity in the response of expenditure (relative to income) is consistent with theories where the marginal propensity to consume varies with the composition of household balance sheets. Since mortgagors are a large share of the population, our findings provide a new perspective on what drives the aggregate effects of monetary policy.

We also examine a range of other possible explanations for heterogeneity in the expenditure responses and show these struggle to explain all our results. In particular, we show that the differences across groups are not driven by heterogeneous changes in resources. The fall in mortgage payments is significantly larger in the U.K. than in the U.S. — as might be expected given the prevalence of variable rate mortgages in the U.K. — but the magnitudes are, on their own, too small to account for the magnitude of the increase in mortgagors' expenditure in either country. Rental payments also go up and, therefore, cannot explain the increase in renters' expenditure. Furthermore, since household income increases significantly for all groups, heterogeneity in the expenditure response

[1] The notion that debtors are liquidity constrained and exhibit high marginal propensities to consume can also be found in Eggertsson and Krugman (2012) and Iacoviello (2005).

does not seem to be explained by any heterogeneity in the response of income. We also show that our results cannot be explained easily, qualitatively or quantitatively, by differences across households in the elasticity of intertemporal substitution, the revaluation of nominal assets and liabilities via inflation and other financial wealth effects. Of course, this does not mean that these channels are necessarily insignificant; rather, a large expenditure response of mortgagors — who hold sizable illiquid assets but little liquid wealth — seems to be of first-order importance in understanding the transmission of monetary policy.

Two empirical issues are worth noting. First, households are not randomly assigned to be mortgagors, outright owners or renters. Mortgagors may respond more than outright owners not because of their balance sheet position, but because some other trait makes them more responsive to interest rate changes. At the very minimum, our balance sheet proxy (i.e. housing tenure) is still a strong predictor of the households most affected by monetary policy. But we also show that the heterogeneity we uncover exists over and above any effect from demographics. Furthermore, we show that other household characteristics are unlikely to explain our evidence. A second concern is the possibility of endogenous transitions from one tenure status to another over time. In addition to grouping by actual housing tenure, we therefore use a variant of the Attanasio et al. (2002) propensity score approach which explicitly addresses the issue of compositional change.

Related literature. This paper relates to four strands of the recent literature. First, we provide empirical support for theories that highlight the role of household balance sheet channels, credit constraints and market incompleteness in the transmission of monetary and fiscal policies. These include Iacoviello (2005), Eggertsson and Krugman (2012), Kaplan et al. (2018), Mitman et al. (2016), Luetticke (2015), Auclert (2015), Greenwald (2016), Mitman (2016), Werning (2015), McKay et al. (2016) and Bilbiie (2017).

Second, our paper relates to a large empirical literature, surveyed by Jappelli and Pistaferri (2010), estimating the response of consumption to exogenous income changes.[2] Examples include Johnson and Parker (2006), Parker et al. (2013), Misra and Surico (2014), Jappelli and Pistaferri (2014), Baker (2017) and Cloyne and Surico (2017). Unlike this literature, we focus on the dynamic effects of changes in monetary policy in the US and the UK and explore what we can learn about the monetary transmission mechanism.

Third, a growing literature has studied how the structure of the mortgage market affects the transmission of monetary policy. Using aggregate data for selected OECD economies, Calza et al. (2013) show that countries with a higher debt to GDP ratio, an ability to extract housing equity

[2] Campbell and Mankiw (1989) and Attanasio and Weber (1993) are early seminal contributions to this literature.

and a higher share of adjustable rate mortgages tend to exhibit a larger average consumption response, although their empirical approach does not identify the marginal contribution of each of these features separately. Di Maggio et al. (2017) for the U.S., La Cava et al. (2016) for Australia, Jappelli and Scognamiglio (2017) for Italy and Floden et al. (2016) for Sweden, find evidence that the cash-flow channel via lower repayments on adjustable rate mortgages is active in these countries, although they do not evaluate other channels in the transmission mechanism. The theoretical model in Garriga et al. (2013) predicts that under adjustable mortgage rates the change in consumption is only slightly larger than under fixed rates when the monetary policy shock is temporary (as in this paper). They show, however, that the difference can become much larger if the policy shock is very persistent (as in Di Maggio et al. (2017)).

Fourth, our findings complement evidence from an increasing number of studies that explore heterogeneity in the effects of monetary policy and income shocks. These include, Coibion et al. (2016), Wong (2016), Fagereng et al. (2016) and, on the more theoretical side, Gornemann et al. (2012) and Sterk and Tenreyro (2015).

While we also share an interest in mortgage debt, repayments and heterogeneity, relative to these studies, we focus on a broader set of household-level variables, including durable expenditure, mortgage and rental payments and gross and net income. Furthermore, we compare the evidence for the United States — a mortgage market in which access to housing equity is frequent *and* fixed rate deals are prevalent — with the results for the United Kingdom — a mortgage market in which access to housing equity is also frequent *but* fixed rate deals are less common. We show that considering all these dimensions of heterogeneity together, and across countries, is important for evaluating and disentangling different theoretical channels of monetary transmission.

Structure of the paper. The rest of the paper is structured as follows. Section 2 presents the datasets, discusses the identification of the monetary policy shocks and sets out the empirical specification. The baseline estimates are reported in Section 3, together with two extensions that control for demographic factors and endogenous compositional changes. In Section 4, we assess which theoretical channels are most consistent with all our results. Section 5 briefly discusses what components of demand account for the increase in household income. Section 6 concludes. The Appendix contains some further results and robustness exercises.

2 Data and empirical framework

In this section, we describe our main sources of household survey data and the variables we use. We then lay out the strategy to group individual observations into pseudo-cohorts using housing tenure status to proxy a household's debt and asset position. We also discuss the identification of the monetary policy shocks. Finally, we present our empirical specification.

2.1 Household survey data

In order to investigate how different types of consumers change their expenditure in response to changes in monetary policy, we use household survey data with a rich coverage of expenditure variables. For the U.K., we use the Living Costs and Food Survey (LCFS).[3] For the U.S. we use the Consumer Expenditure Survey (CEX). Both surveys contain detailed information on weekly expenditures on non-durable goods and services, durable goods (excluding housing and rental-related costs) and household income. The latter is defined as labor income (wages and salaries) plus non-labor income (income from investments and social security payments), net of taxes paid by each household. In the appendix, we provide a more detailed description of the variable definitions and the sample restrictions.

In addition, the survey provides information on two additional useful sets of variables (i) demographics, in particular household size and the year of birth of the household head, (ii) mortgage payments for households with outstanding debt and rental payments for renters. The information on birth years will be used to verify that the heterogeneity we uncover across housing tenure groups does not reflect (omitted) differences in life-cycle positions (as opposed to genuine differences in debt positions over and above differences in demographics). The information on household size will allow us to conduct the analysis at the per capita level. The mortgage and rental payments data will be used to quantify the extent to which changes in cash flows can account for movements in expenditure.

We convert the data into a quarterly time series using the date of interview. The resulting series is then deflated by the Retail Prices Index (excluding mortgage interest payments) for the U.K.

[3] This survey was previously known as the Expenditure and Food Survey (EFS) and the Family Expenditure Survey (FES).

and the Consumer Price Index for the U.S. to convert the data into real series.[4] Our sample covers 1975 to 2007 for the U.K. and 1981 to 2007 for the U.S.. The key variables of interest are available in the FES from the mid-1970s whereas the CEX begins in 1981. Our focus is on the effects of interest rate changes, so we deliberately stop just prior to the financial crisis, excluding the period of unconventional monetary policy.

2.2 Grouping households into pseudo-cohorts

The first empirical challenge we face is that, to our knowledge, no U.S. and U.K. datasets contain disaggregated information on *both* (i) wealth and household balance sheets and (ii) a rich array of expenditure categories at the household level over a sufficiently long period of time. Unfortunately, the LCFS and the CEX are no exceptions but they do record detailed expenditure and income data as well as information on housing tenure status, namely whether a household lives in rented accommodation, is an owner-occupier with a mortgage or owns the property outright without a mortgage.

Housing tenure is a useful proxy for the balance sheet positions of households in both the U.S. and the U.K.. Mortgagors, by definition, have sizable debt but also sizable wealth (which is typically tied-up in their house). Outright owners have sizable housing and other financial wealth. In contrast, renters tend to have low wealth. The housing tenure distinction therefore makes it possible to bypass the lack of household balance sheet information in surveys that feature rich expenditure and income data.[5] Accordingly, and in keeping with the tradition of Browning et al. (1985), we employ a grouping estimator to aggregate individual observations into pseudo-cohorts by housing tenure.

It is worth discussing two potential concerns about grouping households. The first concern is about endogenous changes in group composition. Specifically, a household may change housing tenure status in response to a monetary policy shock. The second concern is about selection. The assignments into the housing tenure groups are not random and some other characteristics may, potentially, be responsible for the heterogeneous responses we find.

[4] Previous research finds evidence consistent with possible trends in the under-reporting of expenditure for more affluent households. This can lead to a divergence between expenditure measures aggregated in the CEX and those from national statistics over time (Aguiar and Bils (2015)). To ensure consistency between the survey data and the national statistics, while allowing for different trends in under-reporting (and other characteristics) across groups, we do two things. First, we rescale expenditure for each cohort in the survey data by the ratio of the national statistics series to the corresponding series aggregated from the CEX/LCFS. The adjusted expenditure series for each cohort are reported in Appendix Figure C.2. Second, our cohort-specific regressions feature cohort-specific time trends. These time trends are meant to absorb low-frequency variation in both under-reporting and other characteristics that are specific to each group.

[5] In Section 4.2, we examine the balance sheet composition of each of these housing tenure groups.

In terms of compositional changes, the time series of the tenure shares in Figure 1 are clearly slow-moving. The variation in monetary policy we exploit, however, occurs at a much higher frequency (as can be seen from Figure 2). In Section 3, we provide formal evidence that compositional change is unlikely to be driving our results. Specifically, we show that the monetary policy shocks do not significantly affect the shares of households in each housing tenure group. Furthermore, we show that our findings are not affected by using the propensity score method of Attanasio et al. (2002), which deals with possible endogenous compositional change.

Turning to the issue of selection, three factors seem to make this less severe in our context. First, we explicitly consider demographic and life cycle factors. In Section 3, we divide each housing tenure cohort into further sub-groups using the age of the household-head. We show that the expenditure response of middle-aged mortgagors is still significantly different from the response of middle-aged outright owners, despite the more stable age range. The heterogeneity we uncover based on housing tenure therefore exists over and above any possible heterogeneity purely due to demographic factors.[6] Second, in Section 4, we explicitly consider which other characteristics might be driving our results and show that alternative mechanisms struggle to explain our empirical findings. The composition of household balance sheets therefore seems most likely to account for why some households respond strongly to interest rate changes while others do not. Finally, grouping households by housing tenure can be motivated from various theoretical frameworks. For example, the distinction between consumers with and without mortgage debt fits well with the predictions of a range of theoretical models that would imply heterogeneous expenditure responses to a monetary policy shock, including Iacoviello (2005), Eggertsson and Krugman (2012), and Kaplan et al. (2018).

2.3 Identification of monetary policy shocks

Our goal is to examine the effect of monetary policy on the spending and income of different *groups* of households. As such, we face the usual macroeconomic reverse causation problem: the economy responds to movements in monetary policy, but monetary policy also responds to developments in the macroeconomy. To identify unanticipated changes in the short-term interest rate we need a monetary policy shock series that can be used for estimation.

There is a vast literature on the identification of monetary policy changes. Older approaches, mainly developed for the United States, relied on timing restrictions and a Choleski decomposition

[6] Selected descriptive statistics for all housing tenure groups are reported in Appendix A. There are some small differences across the distributions of per-capita income and across the shares of post-compulsory educational attainment between mortgagors and outright owners. While the age difference between these two groups seems larger, (i) the age distributions for mortgagors and outright owners still overlap significantly and (ii) as already noted, the heterogeneous responses across housing tenure groups are not overturned in the sensitivity analysis of Section 3.2 where we further control for demographics.

of the variance-covariance matrix of the residuals from a Vector Autoregression, such as Christiano et al. (1996, 1999). But when applied to the United Kingdom, this method produces a large rise in inflation following a monetary contraction, the so-called price puzzle, even after controlling for variables shown to ameliorate this issue for the U.S. (Cloyne and Huertgen (2016)).

Another 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 and forecasts to reflect the forward-looking nature of monetary policy. Cloyne and Huertgen (2016) construct a measure for the U.K. employing this methodology and show that it improves on conventional VAR methods. Hence, we use an updated version of the Romer and Romer (2004) shock series for the U.S. (whose original analysis ended in 1996) and the Cloyne and Huertgen (2016) shock series for the UK.[7] One particular advantage of using shocks based on the Romer and Romer (2004) method is that we have two comparable series across the two countries we study.

The shock series match the micro-data sample periods, which are from 1975 to 2007 for the U.K. and 1981 to 2007 for the U.S.. The shock series deliberately stop before the recent financial crisis, when the policy rate hit the zero bound in both countries.[8] To boost the number of household observations used to generate the pseudo-cohorts at each point in time, we aggregate household survey variables to a quarterly frequency. The original shock series are monthly but, following Romer and Romer (2004) and Coibion (2012), we sum up the monthly innovations to obtain a quarterly series. The construction of the U.K. series also allows for a break in 1993 reflecting the adoption of the inflation targeting framework. The monetary policy shock series for the two countries are shown in Figure 2.

Cohort-specific Granger causality. The shock series we use should already be regarded as monetary innovations from a macroeconomic perspective. But there is still a concern that the monetary policymakers might have been reacting to the conditions in particular groups. While some of this should be captured in the policymakers' forecasts, for example if they were concerned about

[7] Unfortunately, the length and frequency of the sample we consider prevents us from using a high frequency identification strategy as in Gertler and Karadi (2015).

[8] Results using the Romer and Romer (2004) shocks might be sensitive to the period in the early 1980s when monetary policy was conducted somewhat differently (Coibion (2012)). This is also the period where the share of floating rate mortgages was unusually high in the U.S. Accordingly, in Appendix F, we verify that our findings are not sensitive to starting the sample in 1985. This chimes with independent evidence from Wong (2016), who also provides support for a household balance sheet effect on non-durable consumption across U.S. households using the high-frequency identification in Gertler and Karadi (2015) over a shorter sample starting in 1993.

developments in the housing market, it is useful for our purposes to test whether the U.S. and U.K. shock series can be predicted by movements in cohort level consumption and income. Finding that these shocks are unpredictable on the basis of cohort level concerns would therefore be reassuring. Specifically, we conduct Granger causality tests based on a VAR which contains consumption, expenditure and income per capita for each household group. We cannot reject the hypothesis that the cohort-specific time-series from household survey data (as well as the aggregate time-series from national statistics) do not Granger cause the monetary policy shocks in each country.

2.4 Empirical specification

Using the two monetary policy shock series, our empirical specification closely resembles Romer and Romer (2004). Accordingly, we 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 short samples. Specifically, we estimate the following equation:

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

where $X_{i,t}$ is real non-durable consumption, durable expenditure or income recorded by households interviewed at time t.[9] The monetary policy shocks are denoted by S and Z is a vector of quarterly dummies. The α terms represent intercepts and coefficients on a time trend polynomial, with a break in 1993 for the U.K. (consistent with the time-series evidence in Benati (2006) and Nelson (2001)) and no break for the U.S.. Finally, $i \in Mortgagors, OutrightOwners, Renters$ refers to the relevant housing tenure group. The orders of the lag polynomials are chosen using an optimal lag length criteria, namely the corrected AIC.[10] Standard errors are bootstrapped using a recursive wild bootstrap following Mertens and Ravn (2013).[11]

[9] Households interviewed at time t are typically asked to report expenditure over the previous three months (with the exception of non-durable consumption in the LCFS which refers to the previous two weeks). 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. In Appendix **??**, we show that similar results are obtained without smoothing the data (although point estimates become more jagged and imprecise) or smoothing the impulse response function (in the spirit of Barnichon and Brownless (2017) and Tenreyro and Thwaites (2016)).

[10] We have also explored a more general specification where X is a vector of variables, but with similar results. In addition, we have experimented with including the contemporaneous value of the shock and with assuming different types of trend. In all cases, our results are robust.

[11] The wild bootstrap in Mertens and Ravn (2013) randomly multiplies draws of the residuals by -1 and 1 and is robust to heteroskedasticity.

3 The heterogeneous response of expenditure

This section reports strong heterogeneity across housing tenure groups in the response of expenditure to a monetary policy shock. Mortgagors respond the most, outright owners do not change expenditure at all, and the response of renters is closer to that of mortgagors. We first show results based on actual housing tenure status. We then consider a more sophisticated propensity score approach that tackles concerns about endogenous changes in group composition. Finally, we explore the role of demographics by restricting the age range within each housing tenure group. In all cases, we simulate the effects of a *temporary* 25 basis points (bp) cut in the policy rate. The gray areas on the charts show the 90% confidence intervals. For reference, in Appendix Figure C.1, we report the aggregate responses of expenditure to a monetary policy shock using national accounts data. We show that these are consistent with the disaggregated results using household survey micro-data.

3.1 Results based on housing tenure

In this section, we present the results from estimating our benchmark specification (1) using cohort-level data. Figures 3 and 4 present our baseline estimates for the response of non-durable consumption and durable expenditure across housing tenure groups. The left, middle and right-hand columns show the different responses for mortgagors, outright owners and renters respectively.

Beginning with the response of non-durable consumption in Figure 3, the response of mortgagors tends to be larger than the adjustment made by outright owners. Specifically, the response of households with mortgage debt in the U.K. peaks at 0.3% after about 10 quarters but the response of outright owners without debt is never statistically different from zero. The response of non-durable expenditure for renters is similar to that of mortgagors at around 0.2%. This suggests that the behavior of mortgagors and renters drives the aggregate results for non-durables in Appendix Figure C.1. For the U.S. the pattern is similar, with the peak effects for renters and mortgagors between 0.2% and 0.3%.

Clear evidence of heterogeneous effects across groups can also be seen in the response of durable expenditure in Figure 4. The heterogeneity between housing tenure groups is now starker. The response of U.K. mortgagors' expenditure peaks at around 1.2%, but the reaction of outright owners' durables is statistically indistinguishable from zero. The bottom row paints a similar picture for the U.S., with the significant and persistent response of households with debt peaking around 1.2%, and driving the aggregate durable response reported in Appendix Figure C.1. The results for renters' durable expenditures are, however, typically smaller (especially in the U.K.) and less precisely estimated than for the other cohorts, possibly reflecting the heterogeneous composition of the renter group. Still, the durable expenditure of renters tends to increase, especially in the U.S.

Given that there are differences in the average levels of expenditure and income across housing tenure groups, it is useful to consider what these IRFs imply in dollar terms. This will also be useful later when we quantify the contribution of different transmission mechanisms. In Table 1, we convert the IRFs into an equivalent dollar change in expenditure over the four year forecast period.[12] This can be seen as the overall dollar adjustment in the short-run as a result of the change in monetary policy.[13] The overall effects on non-durable and durable expenditure in the two countries are shown in the first two columns of Table 1. The other columns will be discussed in Section 4.

Table 1 shows that the total dollar change in mortgagors' expenditure (non-durables and durables) is very similar across the two countries, with U.K. mortgagors spending around 70 dollars (about 10%) more than those in the U.S. following a cut in interest rates of the same magnitude. The dollar changes for the other two housing tenure groups are also similar across countries and spending categories, with the possible exception of the response of durable expenditure for renters. Overall, mortgagors display the largest and most significant overall dollar adjustment whereas outright owners experience a small and insignificant change.[14] This difference is not only economically meaningful but also statistically significant.

In summary, in response to a cut in interest rates, the response of expenditure tends to be large and significant for mortgagors but small and insignificant for outright owners, with the heterogeneity being more pronounced for durable goods. The response of renters tends to be closer to the response of mortgagors than outright owners, especially for non-durable goods and services. Since mortgagors represent around 40-50% of the population, the response of mortgagors accounts for the vast majority of the aggregate effect of monetary policy on consumption.[15]

3.2 Controlling for demographics

One possible concern is that the housing tenure distinction may simply be picking up (omitted) life-cycle effects. Although we can include demographic controls in our regressions, given the grouping

[12] More detail on the calculation can be found in the notes to Table 1.

[13] The response of the policy rate to the monetary policy shock tends to be slightly more persistent in the U.S. than in the U.K., as can be seen in Coibion (2012) and Cloyne and Huertgen (2016). To make the magnitudes comparable, we rescale the U.K. numbers by the ratio of the cumulated response of the U.S. Federal Funds Rate and the cumulated response of the U.K. Bank Rate. This is like rescaling by the relative movement in the long-rate.

[14] The absolute magnitudes of the numbers in Table 1 may seem small but we are considering a small and *temporary* change in interest rates (i.e. a change of 25 basis points on impact, which then returns to zero after about four to eight quarters). The size of our monetary policy shock is therefore about twelve times smaller and more than six times less persistent than the shock analyzed in Keys et al. (2015) and Di Maggio et al. (2015).

[15] More specifically, based on the distributions of the expenditure responses for each group in Table 1, we calculate that the interquartile range of the share of the aggregate response accounted for by mortgagors is about 77-90% for the U.K. and 61-79% for the U.S..

strategy, this does not condition on demographics in the usual sense. Conditioning requires further splitting the groups by demographics. To explore this possibility, we follow the micro-econometric literature and construct birth cohorts.[16] We regard households as 'older' if the head was born before 1935, as 'middle-aged' if the head was born in the interval [1935, 1949] and as 'younger' if the head was born after 1949. This strategy therefore produces groups with a more stable age range than our baseline grouping strategy. For example, while the maximum possible age gap within the middle-aged group at each point in time is 14 years, it is important to note that the interquartile range is around 6 years.

Before reporting the results of this exercise, it is useful to consider the demographic composition of the housing tenure groups. As shown in Appendix Figure B.2, a greater share of mortgagors are younger and there is a prevalence of outright home-owners without mortgage debt among the older households. But, importantly, not all younger households are mortgagors and not all older households are outright home-owners. Furthermore, the middle-aged cohort is populated by even shares of all housing tenure groups.

Within each housing tenure group, we sub-divide households into birth cohorts. We then consider two separate experiments to explore whether age/life-cycle considerations could be driving our heterogeneous responses. First, we investigate whether the response of middle-aged mortgagors is similar to the response of middle-aged outright owners.[17] Second, we examine whether excluding households with a retired head makes any difference to our results.

Comparing the first and the second columns in Figures 7 and 8 reveals that the expenditure responses for middle-aged mortgagors are large and significant, while those for middle-aged outright owners are small and statistically indistinguishable from zero. This is true both in terms of the magnitude and in terms of the significance of the point estimates (both for non-durable consumption and durable expenditure). Consistent with the results in the previous section, middle-aged renters generally respond less than mortgagors but significantly more than outright owners. The heterogeneity across housing tenure groups therefore exists even for cohort groups with a more stable age range. In the Appendix Figures D.1 and D.2, we also consider restricted samples from the LCFS and the CEX where we exclude households with a retired head. The results are very similar to our baseline findings above.

[16] The objective in a pseudo-panel is to construct a group with relatively stable composition over time. Directly grouping by age does not satisfy this requirement as we would be constructing a representative household who never ages.

[17] Unfortunately, there are neither enough mortgagors in the older birth cohort nor enough outright owners in the younger birth cohort for us to look at these two other sub-groups. Furthermore, we find little heterogeneity within the renter group.

In summary, the estimates in the previous section are not overturned when considering the impact of demographics. In particular, the heterogeneous responses associated with housing tenures status appear to hold over and above any possible heterogeneity associated with age or birth cohort.

3.3 A propensity score approach

By classifying households into particular groups, we are implicitly assuming that group transitions are not a significant concern. In particular, to interpret our estimates as the causal effect of monetary policy on the expenditure of mortgagors, we need that the policy change does not cause households to move from one housing tenure status to another. Note that this is likely to be more problematic, if anything, for the U.K. survey data which consist of repeated cross-sections, than for the U.S. survey data where, given the short panel dimension, we already consider only those households who have not changed housing tenure status between interviews. The risk of group transitions seems limited given the slow-moving housing tenure shares that we report in Figure 1 and the small (25bps) monetary policy change we consider. But, in this section, we assess formally the empirical relevance of possible changes in group compositional.

One simple way to tackle this issue is to look at the response of the housing tenure group shares to an unanticipated cut in interest rates. In Appendix Figure E.1, we show that none of the group shares respond significantly, indicating that changes in monetary policy do not seem to trigger significant endogenous changes in the housing tenure status.[18]

A more formal approach is to apply the Attanasio et al. (2002) propensity score method. Rather than grouping households based on actual housing tenure, this approach groups households based on the probability of being a mortgagor using fully predictable household characteristics. Specifically, we run a probit regression over the full sample to generate individual predicted probabilities of having a mortgage based on a high order polynomial in age, education, a time trend and their interactions.[19] For households observed in quarter t, we compute the probability that they had a mortgage in the previous quarter. For these two periods, we classify households as 'likely' or 'unlikely mortgagors' if the probability in the first of the two periods is larger or smaller than the share of mortgagors in the sample.[20] We then take the growth in consumption across these two

[18] While it may be theoretically possible that the inflows into one group might be offset by its outflows, it would seem difficult to think that *at the same time*, for example, some renters become mortgagors and other households with debt become renters following a monetary policy shock.

[19] To maximize the number of households in each quarter and cohort, we place no restrictions on the birth year of the household head in this exercise but include age among the demographic variables in the probit regressions. To sharpen the comparison we do not include renters in the analysis in this section. While these restrictions do not affect the point estimates from the propensity score method significantly, they improve their accuracy.

[20] As time variation in the probability of being a mortgagor may induce changes in the group composition, we use a constant threshold for determining the group of 'likely' mortgagors.

quarters for each group, from which we can construct the implied consumption series for each of the groups that we then use for estimation.

The results of this exercise are shown in Figures 5 and 6. As can be seen, the main findings of our earlier analysis are not overturned. The likely mortgagor group still exhibits stronger expenditure responses than the unlikely mortgagors, with the difference being particularly pronounced for durables and in line with the results on actual housing tenure. Changes in group composition are therefore unlikely to drive the heterogeneous expenditure responses we found above.

4 Inspecting the transmission mechanism

In the previous section, we showed that there is significant heterogeneity in the response of expenditure to monetary policy shocks across housing tenure groups. Furthermore, this heterogeneity is not driven by heterogeneity in demographics. In this section, we explore which mechanism may be consistent with our results. To do so, we consider a rich set of household-specific variables in the micro-data as well as other, relevant, aggregate variables in the national statistics.

We show that our results are consistent with theories where the marginal propensity to consume varies with the composition of household balance sheets. In particular, some households may exhibit larger marginal propensities to consume if they have few liquid assets.[21] By directly affecting investment and consumption decisions, interest rate cuts raise GDP and household income. For hand-to-mouth households, the increase in income leads to additional expenditure, which may stimulate aggregate demand further.[22]

We explore this mechanism in two parts. First, we document a significant rise in income for all housing tenure groups and examine how expenditure responds relative to income — mortgagors exhibit the largest response of expenditure relative to income. Second, we analyse independent household survey data on wealth, and find that the balance sheets of the three housing tenure groups differ markedly in their composition of liquid and illiquid wealth. In particular, we show that our findings are consistent with *two*, very different, types of hand-to-mouth households: low wealth renters and wealthy mortgagors.

[21] To be precise: heterogeneous marginal propensities to consume could interact with a range of other mechanisms. Our point is that, without this, other mechanisms are unlikely to be able to explain all our findings.

[22] In theory, the mechanisms that generate heterogeneous MPCs — such as incomplete markets and credit constraints — may or may not amplify the effects of monetary policy on consumption. On the one hand, hand-to-mouth behaviour can attenuate the initial direct (partial equilibrium) effect of monetary policy on consumption (for example, by attenuating the degree of intertemporal substitution). On the other hand, these frictions can lead to a larger consumption response via general equilibrium effects: higher aggregate demand leads to more income, generating more consumption etc. Important contributions to this theoretical debate are Werning (2015), McKay et al. (2016), Bilbiie (2017) and Kaplan et al. (2018). In particular, Kaplan et al. (2018) show that the presence of "wealthy hand to mouth" agents can amplify the effects of monetary policy, and that the indirect general equilibrium effects dominate the direct partial equilibrium effects. Our results are supportive of the dominance of the general equilibrium effect.

We also explore other channels that might account for our findings. For instance, the heterogeneous response of expenditure may simply reflect heterogeneity in the response of disposable income — either because mortgage and rental payments fall, or because monetary expansions increase earnings only for mortgagors and renters. In addition, a higher sensitivity of consumption to interest rates for some groups could reflect a higher elasticity of inter-temporal substitution. Finally, the effects may represent wealth redistribution across households from movements in goods and asset prices. All these mechanisms are likely to play a role in the transmission mechanism but we illustrate why, on their own, these explanations would struggle to explain the heterogeneity we find in the data.

4.1 The response of income

Household expenditure may respond directly to interest rate changes, for example through substitution effects. But the overall response of expenditure may also be affected by the general equilibrium effects that monetary policy has on GDP and household income. This section explores how income responds across groups and document two key results. First, we show that income responds for all household groups, consistent with a general equilibrium effect of monetary policy. Second, we show that the heterogeneity documented in the previous section does not reflect heterogeneity in the response of income. If the income of some groups is more sensitive to macroeconomic conditions, then the heterogeneity in resource windfalls associated with a monetary expansion may be the driver of heterogeneity in the expenditure responses across groups (Gornemann et al. (2012)).

In Figure 9, we report the point estimates and confidence bands for the response of total household income net of taxes. We also report the point estimates for gross income.[23] Income net of taxes responds significantly for all three housing tenure groups and increases by a similar proportion across countries and cohorts. The peak effects are typically between 0.3 and 0.4%. It is useful to note that, despite the expenditure heterogeneity across groups, there is limited heterogeneity in the IRFs for income.[24] This is consistent with the notion that the increase in household resources triggered by the monetary policy shock is likely driven by an overall increase in aggregate demand. In other words, expenditure heterogeneity does not simply reflect earnings heterogeneity. To compare these income effects to the change in expenditure, it is useful to convert the IRFs into a 'windfall' in dollars. This is shown in the Table 1. Converting the percentage changes into dollar amounts reveals that the response of expenditure relative to income is still sizable for mortgagors and considerably smaller for outright owners. Furthermore, in both countries, the dollar increase

[23] We only report the point estimates for gross income purely for presentational convenience. The confidence bands for this measure largely overlap with those of net income.

[24] In Appendix G, we show that similar results are obtained using labour income rather than total income.

in mortgagors' income is of the same order of magnitude as the dollar change in mortgagors' total expenditure.[25]

Disposable income may also be affected by changes in taxes if fiscal policy responds to the fall in interest rates. This could be the case if, for instance, lower interest payments on government debt encourage tax cuts. But Figure 9 shows that the movements in gross and net income are very similar, with the difference being insignificant. The majority of the movement in net income is therefore driven by the response of gross income and not by movements in taxes.[26]

To summarize, the increase in aggregate income is shared across all housing tenure groups, consistent with a general equilibrium effect of monetary policy on aggregate demand. Heterogeneity in the response of income therefore does not explain our results for expenditure. Table 1 also implies that higher income for all groups is associated with higher expenditure only for mortgagors and renters.

4.2 Liquidity shortages for the poor and the 'wealthy'

In the previous section, we showed that income increases for all groups, but expenditure increases only for renters and mortgagors. Furthermore, the dollar change in expenditure for these two groups is of a similar order of magnitude to the dollar change in their income (Table 1). While renters seem to fit the traditional characterization of hand-to-mouth households, a strong sensitivity of consumption to income for mortgagors is hard to reconcile with traditional one-asset models. A number of recent theories, however, emphasize the role of debtors and balance sheets in the transmission of macroeconomic policy. For example, in Eggertsson and Krugman (2012) the presence of debt constraints facing borrowers generate heterogeneous MPCs, a mechanism that can vary over time if (as in Iacoviello (2005)) the credit limit is tied to the value of the asset used as collateral. In Kaplan et al. (2014, 2018), consumers can be wealthy but still behave in a constrained manner if most of their wealth is tied-up in an illiquid asset (such as housing). In other words, mortgagors may become hand to mouth by purchasing a large housing asset.

Prima facie evidence that both renters and mortgagors may face liquidity shortages is provided by Table 2. At the one end of the spectrum, renters have little 'cash on hand' and no housing wealth, consistent with the notion of poor hand to mouth consumers. At the other end, outright owners have sizable financial and housing wealth and seem unconstrained. In-between, mortgagors,

[25] While we focus on the response of consumption and income separately here, in independent work on fiscal policy Surico and Trezzi (2018) show that Italian mortgagors have a higher marginal propensity to consume out of temporary tax windfalls. This is also consistent with the MPC estimates in Misra and Surico (2014) for the U.S..

[26] Gross income responds slightly less than net income, consistent with Mountford and Uhlig (2009) who show that a monetary expansion is associated with a fall in net taxes receipts.

in both countries, have little liquid assets despite having significant housing equity. As such, they appear to fit well the definition of 'wealthy' hand-to-mouth (WHTM) households put forward by Kaplan and Violante (2014), and further explored empirically by Cloyne and Surico (2017) in the context of U.K. tax changes.

To explore this hypothesis in more detail, we draw on independent evidence on household wealth from the British Household Panel Survey (BHPS) and the U.S. Survey of Consumer Finance (SCF) for the (multi-year) waves that correspond to our baseline samples.[27] Following Kaplan and Violante (2014), we define a household as 'wealthy' hand-to-mouth if at any given point in time both (i) their net illiquid wealth is positive and (ii) their net liquid wealth is less than half of their total monthly labor income.[28] In Figure 11, we report the share of 'wealthy' hand-to-mouth mortgagors for pairs of temporally close waves in the BHPS and SCF. The message from this chart is that between 40% and 50% of households with debt hold a value of liquid assets below half of their monthly income and therefore are likely to face liquidity shortages. In the second panel of Figure 11, we also show that most WHTM agents in the sample do have a mortgage.

In summary, renters have low wealth and fit the typical description of liquidity constrained households. Their strong consumption response may not, therefore, be surprising. But, importantly, a significant share of mortgagors have low liquidity despite having high wealth. These balance sheet characteristics, coupled with the significant increase in after-tax income for all groups, suggest that heterogeneity in liquid asset holdings can account for the heterogeneity in expenditure documented earlier.[29] In Appendix I, we lay out a simple theoretical framework with collateral constraints, a renting/owning decision and durable expenditures that captures this idea. We show that this model can replicate our evidence on the heterogeneous responses of non-durable and durable expenditure across different households groups.

[27] These surveys do not contain wealth information at a sufficiently high frequency to be used for our main analysis and they lack rich consumption data over a long period of time. While there are more SCF waves than reported here, there are only three waves of the BHPS over our sample period (but we have confirmed that similar results emerge from the SCF waves that we have not reported).

[28] When constructing the relevant household income and wealth measures, we select variables to make the concepts of net liquid and illiquid wealth as consistent as possible across the two datasets. The BHPS only reports quantities for overall investment and debts whereas for specific assets it only records whether these are held or not. The SCF, in contrast, does provide quantities for particular assets and overall investment. Furthermore, the assets on which information is provided differ slightly between surveys. Accordingly, net liquid wealth in the U.K. is constructed as total amount of liquid savings and investments (National Savings Bank Accounts and Cash ISAs or TESSAs, Premium Bonds, Stocks and shares ISAs or PEPs) minus non-mortgage debt (Hire purchase agreements, Personal Loans, Credit and store cards, DWP Social Fund loans). Following Kaplan and Violante (2014), net liquid wealth in the U.S. is the value of checking, saving and MM accounts, directly held mutual funds, stocks, bonds and t-bills, net of outstanding unsecured debt. Net illiquid wealth in the U.K. is measured using a binary variable which takes value one if housing equity>0 or the household has positive investments in (relatively) illiquid instruments such as National Saving Certificates, NS/BS insurance bonds, private pensions, non-regular savings. Net illiquid wealth in the U.S. is the value of housing equity (housing value - mortgage debt) plus pension/retirement funds, life insurance, saving bonds and certificate of deposits.

[29] As emphasized by Tobin (1980) (p.10), this hand to mouth behaviour by mortgagors could be entirely rational and optimal if, for instance, this group of households expect future income growth but find it difficult to borrow against this.

4.3 Mortgage and rental payments

A fall in interest rates can also affect the resources available to households by affecting interest payments and rents. These windfalls from lower interest or rental payments might then be spent on durables and non-durables in a way that could potentially rationalize the expenditure heterogeneity we documented in the previous section.[30] In our survey data, we observe both variables and we therefore explore how mortgage and rental payments react to monetary policy changes.

In Figure 10, we report the percentage change in mortgage payments (top row) and rents following a temporary interest rate cut of 25 basis points. Mortgage payments fall significantly in both countries but the effect is considerably faster and larger in the U.K., peaking at around 0.7% versus 0.4% for the U.S.

As in the previous section, to compare these effects to the change in expenditure, it is useful to convert the IRFs into a 'windfall' in dollars. This is shown in the third column of Table 1. A few points are worth noting. First, the dollar benefit of this change for the average mortgagor is nearly three times larger in the U.K. than in the U.S. Interestingly, the absolute difference between the two point estimates is also consistent with the difference in total expenditure for mortgagors in the two countries (columns 1 and 2).[31] The relative size and speed of the adjustment in mortgage payments is intuitive given the historic prevalence of adjustable rate mortgages in the U.K. market (Besley et al. (2013)). Finally, and most importantly, the dollar fall associated with lower mortgage payments is considerably smaller than the dollar increase in total expenditure — the expenditure changes are four and nine times larger than the changes in mortgage payments in the U.K. and the U.S. respectively. This suggests that the windfall from lower mortgages payments is quantitatively too small to account for the magnitude of the rise in the expenditure of mortgagors.

The response of rental payments tells a similar story. On the one hand, a monetary expansion lowers the user cost of housing. On the other hand, a fall in interest rates could lead to a rise in house prices — as we document in Appendix Figure H.1 for both countries — and therefore encourage the demand for renting relative to buying. The bottom row of Figure 10 shows that, in the data, the latter effect dominates and rental payments increase. Yet, renters increase their expenditure on both non-durable and durable goods.

[30] Note that financial income is already included in our measure of household income. Any cash-flow effect on savers is therefore already captured in our income responses. Since outright owners do not alter their expenditure, this section focuses on cash flows for mortgagors and renters.

[31] The size of the dollar change in the average mortgage payments is consistent with a back-of-the-envelope calculation using an *effective* mortgage duration of ten years, an *effective* loan to value ratio on outstanding debt of 0.5 and, for the U.K., the average house value from the Land Registry since 1995 (and from Halifax before then) as well as a share of mortgages on adjustable rates of 45%. This yields an average change in U.K. mortgage payments of 168 US dollars. Replacing the UK share of mortgage contracts on adjustable rates with a share of 15% for the U.S., we obtain a value of 56 dollars. Note that our results are an average of the effect on loan rates for newly originated mortgages and the effect on existing adjustable and fixed rate loans.

In summary, mortgage payments move significantly more in the U.K. than in the U.S., but the magnitudes are much smaller than the overall dollar increase in expenditure. Furthermore, movements in rental payments do not free up extra resources because they actually increase following a monetary expansion. These cash flow effects are, *on their own*, unlikely to explain why mortgagors respond differently from outright owners.[32] These effects also cannot explain why renters respond differently from other households without mortgage debt. Interestingly, our findings are consistent with the theoretical predictions in Garriga et al. (2013), who show that the distinction between adjustable and fixed rate mortgages implies a small difference in the consumption responses to a *temporary* monetary policy shock (as we consider here) but a large difference to a *very persistent* monetary shock (as considered in empirical work Di Maggio et al. (2017))

4.4 Intertemporal substitution

Differences in the elasticity of intertemporal substitution (EIS) may also explain heterogeneity in the expenditure responses across housing tenure groups. There is a large literature estimating the EIS across households and several papers have argued that the EIS is likely to be increasing with wealth (see Guvenen (2006) and Attanasio and Weber (2010) for an overview). Blundell et al. (1994) report evidence that the EIS is larger for more affluent households and that wealth is a more important driver of EIS heterogeneity than demographics. More specifically, Attanasio et al. (2002) estimate that the EIS is around one for stock-holders — who are wealthier households — but only between 0.1 and 0.2 for households who do not participate in financial markets.

As shown in Table 2, outright owners tend to be richer than renters and have more financial assets than mortgagors. They also tend to be well-off households in general. Based on the empirical evidence above, one would therefore expect the outright owners to have a high EIS. But to explain our results, the outright owners would need to have a very low sensitivity of consumption to interest rates and thus a *very low* EIS. Similarly, mortgagors and renters would need to have a considerably higher EIS to be, even qualitatively, consistent with our results.[33] Since mortgagors do not, on average, have sizable net financial wealth (Table 2) and renters tend to be poorer, we conclude that heterogeneity in the intertemporal elasticity of substitution is unable to explain the heterogeneity in expenditure we find.

[32] Of course, in the presence of heterogeneity in marginal propensities to consume, this cash flow channel could lead to additional consumption, further boosting aggregate demand.

[33] Best et al. (2015) estimate a low EIS for mortgagors in the United Kingdom.

4.5 Fisher and other wealth effects

By raising inflation, expansionary monetary policy may revalue both sides of the household balance sheet, leading to a redistribution of wealth from net savers to net borrowers (see, for example, the large and permanent change in inflation considered in Doepke and Schneider (2006)). As shown in Table 2, our housing tenure grouping identifies mortgagors as net borrowers and outright owners as net savers.

There are at least two reasons why a Fisher effect does not easily explain the heterogeneous response of expenditure to small and temporary monetary policy shocks that we find. First, if this channel was driving the dynamics of expenditure, then the impulse responses for inflation would look broadly similar to the impulse responses for expenditure. Consistent with the wider macro literature (e.g. Romer and Romer (2004) and Christiano et al. (1999)), however, Figure 12 shows that the effect of an interest rate cut on inflation and one-year-ahead expected inflation build over time, with small and insignificant responses in the near-term and more significant effects only after the first seven quarters. In contrast, the adjustment in durable expenditure is already large and significant within the first two years for both countries. Second, if a Fisher effect is driving our results, we would expect the spending responses to be of a similar magnitude but with opposite signs for borrowers and savers (i.e. mortgagors and outright home-owners in our sample). Durable expenditure, however, moves in the same direction across all groups and, although outright owners' non-durable expenditure does fall slightly, the non-durable responses are never statistically different from zero.

Finally, a fall in interest rates is also likely to raise the price of financial assets, including housing, and this may lead to additional wealth effects. It seems unlikely, however, that these effects alone could explain the heterogeneity in expenditure we find. First, we consider a small (25 bps) and short-lived fall in the interest rate which is unwound within two years.[34] Furthermore, any effect on asset prices should be more beneficial for those with a larger amount of net financial assets. Since outright owners — the group holding the largest amount of net financial assets — do not adjust their expenditure at all, it is unlikely that these pure wealth effects could be, on their own, the main driver of our results.

[34] See Coibion (2012) and Cloyne and Huertgen (2016).

5 What is behind the movement in income?

In the previous sections, we have shown that heterogeneity in the access to liquidity combined with a sizable effect of monetary policy on household income can account for the evidence presented so far. Furthermore, in Table 1, we have also shown that the dollar changes in income are not only significant for all groups but are also larger than the dollar changes in expenditure. This implies that the overall increase in labor and capital income across the three housing tenure groups is larger than the overall household expenditure increase in the economy. In other words, the change in interest rates must trigger a response in the other components of aggregate expenditure. In this section, we therefore explore the response of government spending, private investment and net exports using aggregate data.

In the left column of Figure 13, we do not find evidence that government spending reacts to a monetary policy shock. In contrast, the middle column reveals that investment does respond strongly and significantly, which is consistent with the evidence in several empirical macro studies (e.g. Christiano et al. (1999)). This is important because it reveals that the extra demand driving the increase in household income comes from the private sector rather than from the government.

The extra demand also does not come from the rest of the world. In theory, the effect of monetary policy on net exports could be ambiguous, depending on whether the expenditure switching effect (from the exchange rate depreciation) increases exports *by more* than the rise in imports coming from increased household expenditure on both foreign and domestic goods. In the right column of Figure 13, we find that net exports fall in both countries, with the adjustment being slightly larger for the United States. While this is consistent with the United Kingdom being a more open economy, it suggests that the income effect (on expenditure) dominates the expenditure switching effect.

In summary, the boost to household income following a relaxation of monetary policy reflects increased demand from the domestic private sector rather than expenditure by the government or the rest of the world. Interestingly, this is consistent with the theoretical results in the supplementary note by Kaplan et al. (2016) where household liquidity is provided by the private sector rather than by the government, as in their original paper (Kaplan et al. (2018)).

6 Conclusion

What features of household balance sheets, if any, matter for the transmission of monetary policy? Our analysis suggests that households with a mortgage tend to hold little liquid wealth and therefore exhibit hand-to-mouth behaviour despite owning sizable illiquid assets. Outright owners, in contrast, hold sufficient liquid assets and therefore hardly change their spending at all. Renters — whose financial circumstances are closer to the traditional characterization of liquidity constrained households in one-asset models — also exhibit behavior consistent with a high marginal propensity to consume. We reach these conclusions by performing a detailed and extensive evaluation of the effects of temporary interest rate changes using household survey data for the U.S. and U.K..

While our empirical approach cannot shed light on the causal link between consumption and income, our evidence is consistent with the view that expansionary monetary policy has a direct effect on aggregate demand by stimulating firm investment and household expenditure. This, in turn, raises household income for all groups, but translates into higher consumption only for households with low liquid wealth. Our key contribution is to show that the response of mortgagors is consistent with a sizable share of this group having a high marginal propensity to consume. Given that mortgagors are the largest housing tenure group in the population, their behaviour drives the aggregate response and has first order implications for the transmission of monetary policy.

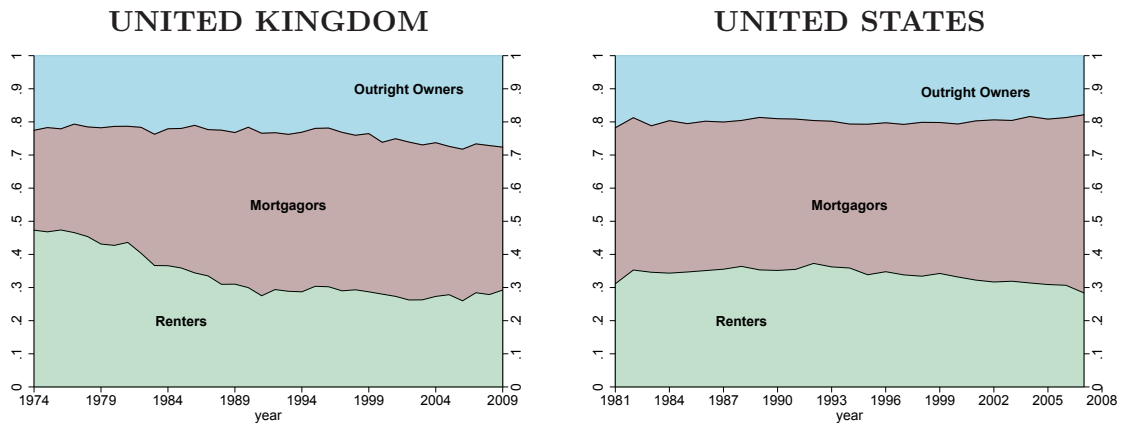


Figure 1: Share of mortgagors, outright home owners and renters in the U.K. (source: FES/LCFS, 1975-2009) and the U.S. (source: CEX, 1981-2009).

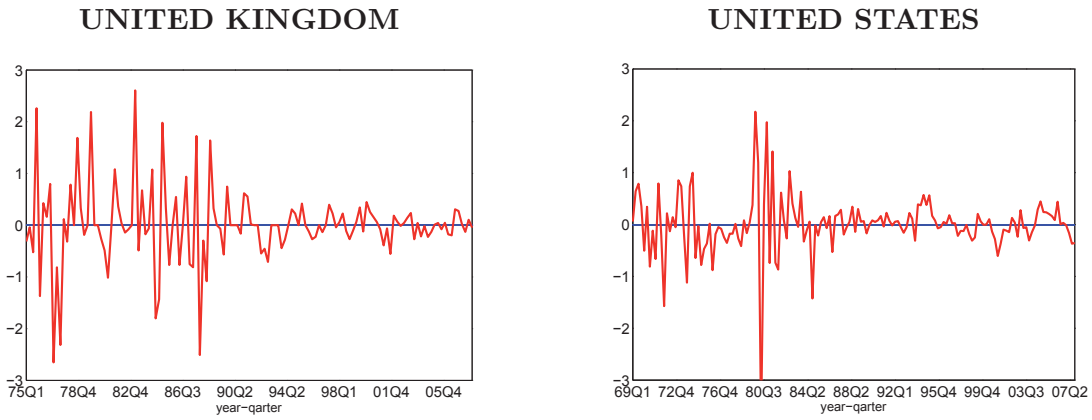


Figure 2: Monetary policy shocks series. United Kingdom: Cloyne and Huertgen (2016); United States: updated version of Romer and Romer (2004).

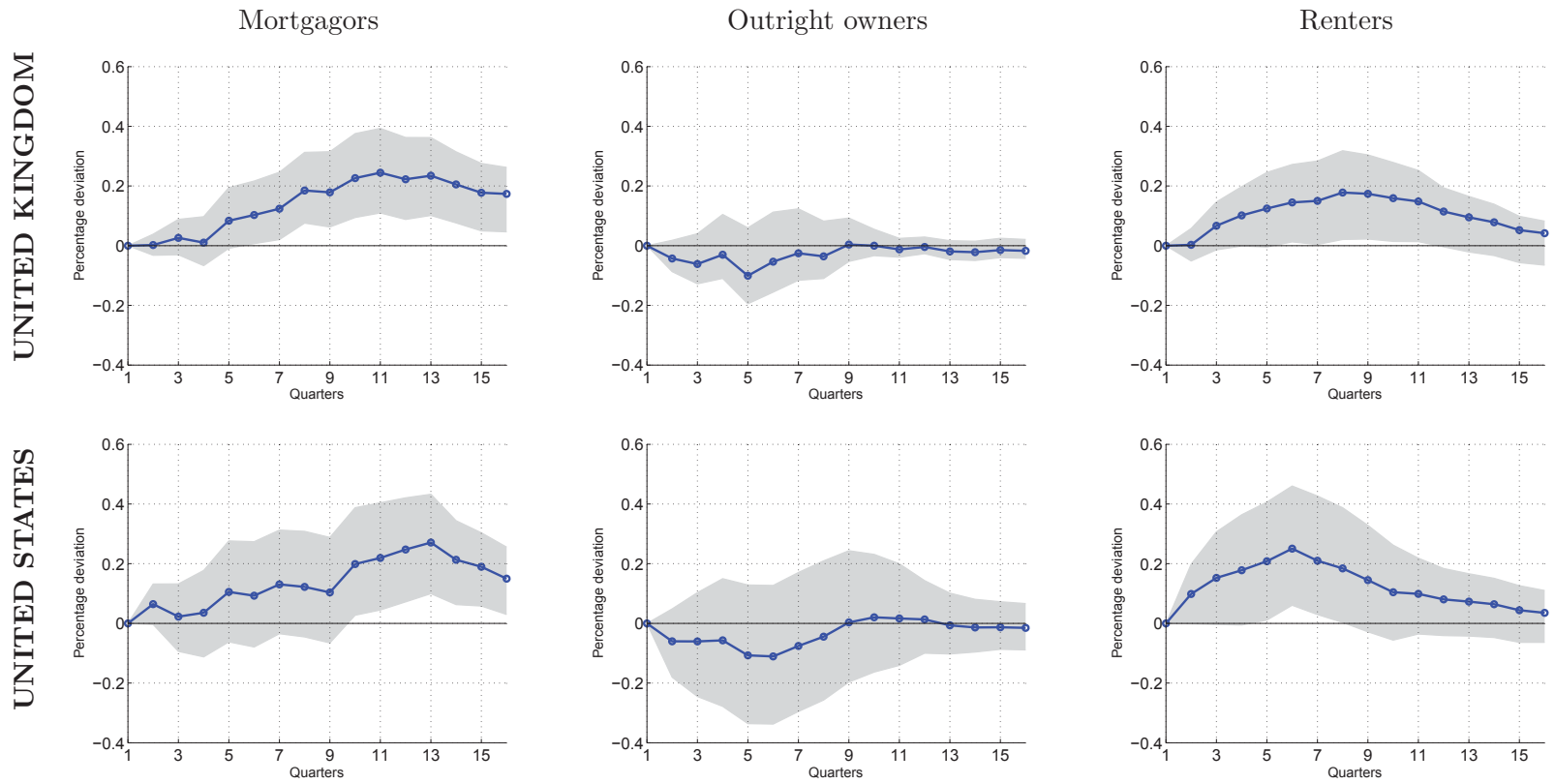


Figure 3: Dynamic effects of a 25 basis point unanticipated interest rate cut on the consumption of non-durable goods and services by housing tenure group. Grey areas are bootstrapped 90% confidence bands. Top row: UK (FES/LCFS data). Bottom row: US (CEX data).

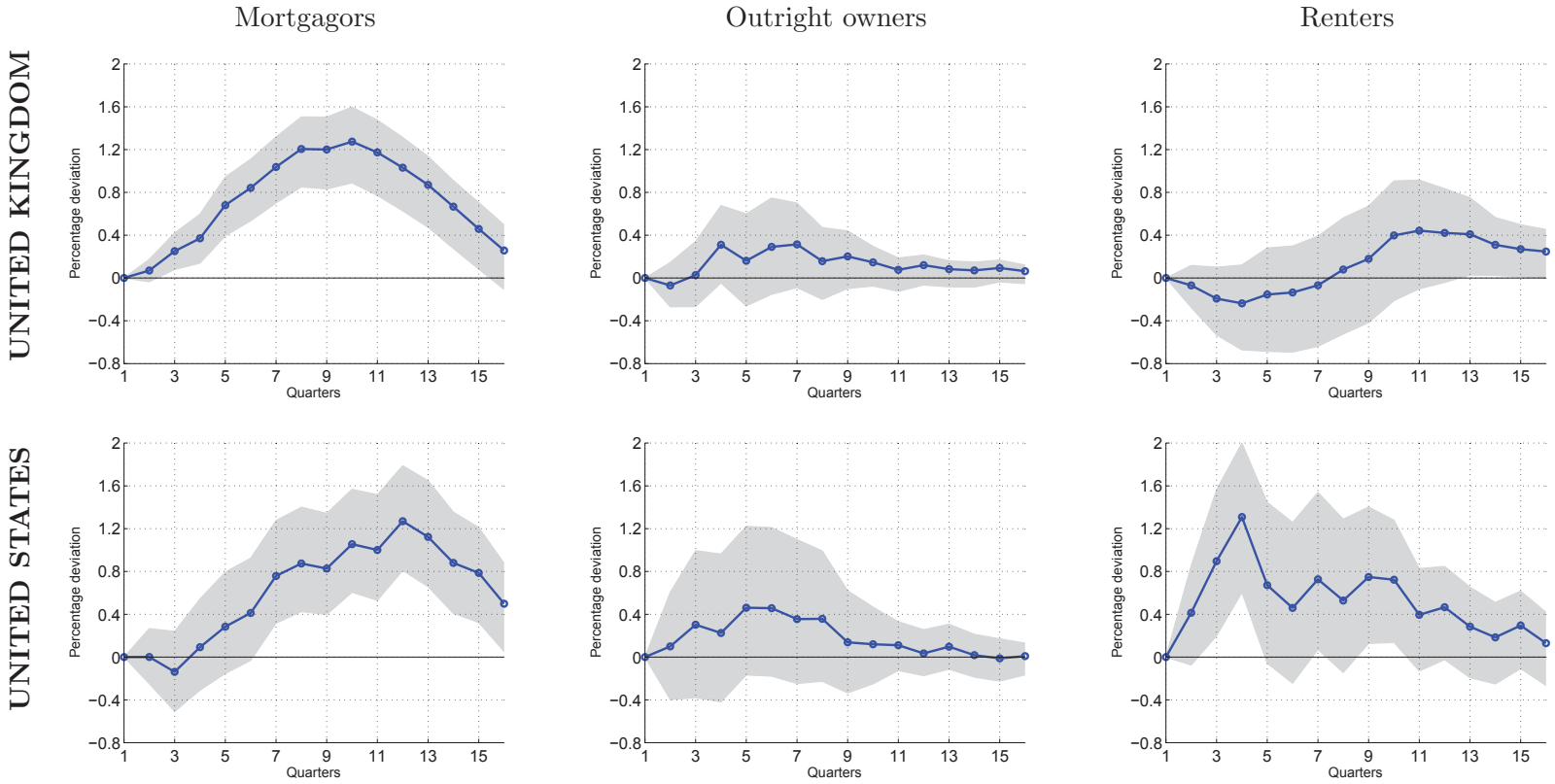


Figure 4: Dynamic effects of a 25 basis point unanticipated interest rate cut on the expenditure of durable goods by housing tenure group. Grey areas are bootstrapped 90% confidence bands. Top row: UK (FES/LCFS data). Bottom row: US (CEX data).

Figure 5: UK results for non-durable, durable and income net of taxes for "likely" and "unlikely" mortgagors, excluding renters. Groups computed following Attanasio et al (2002) propensity score approach using a fixed probability threshold. Grey areas are bootstrapped 90% confidence bands.

Figure 6: US results for non-durable, durable and income net of taxes for "likely" and "unlikely" mortgagors, excluding renters. Groups computed following Attanasio et al (2002) propensity score approach using a fixed probability threshold. Grey areas are bootstrapped 90% confidence bands.

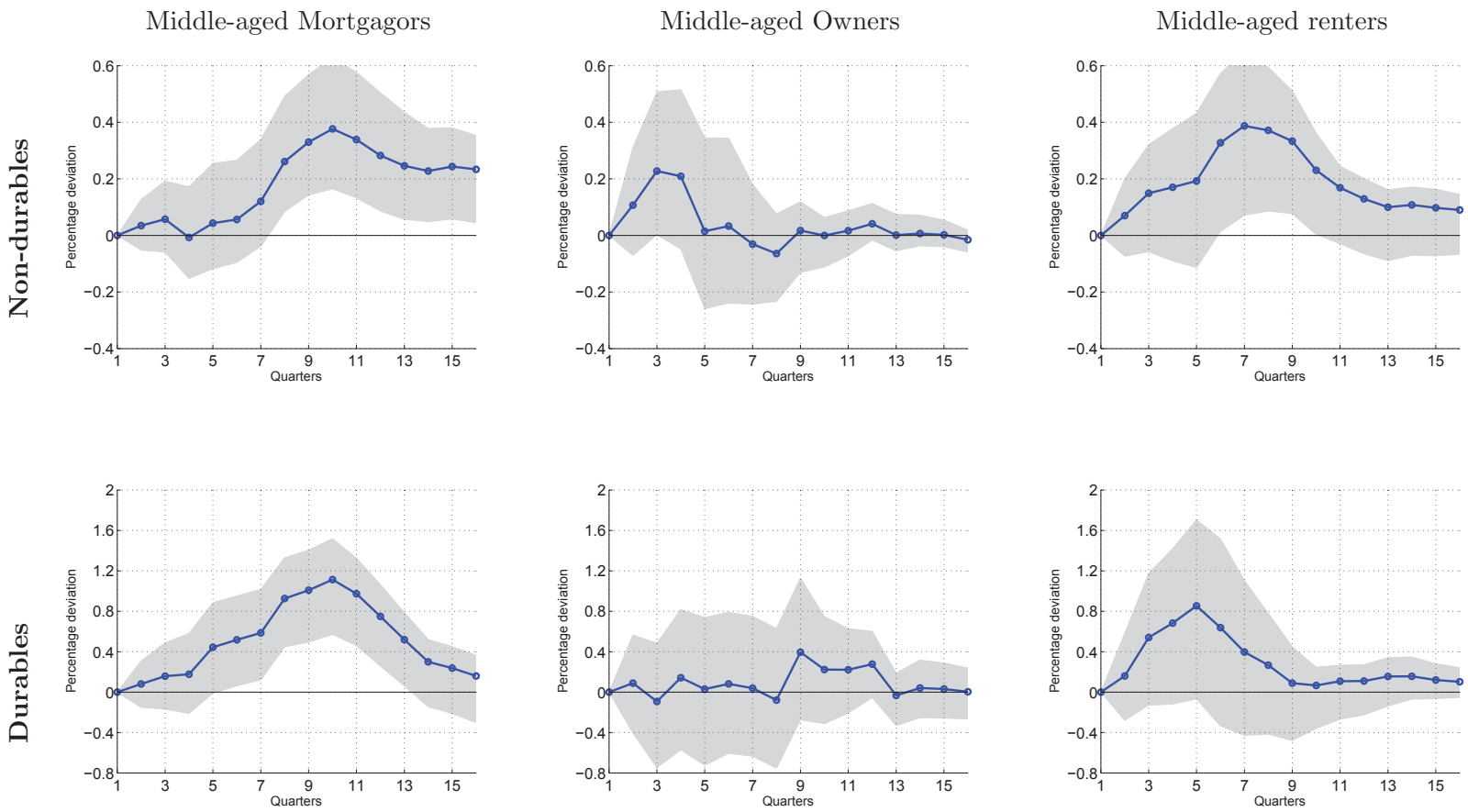


Figure 7: Dynamic effects of a 25 basis point unanticipated interest rate cut on non-durable consumption (top) and durable expenditure (bottom) for mortgagors born after 1949 (left column), mortgagors born between 1935 and 1949 (middle column) and outright owners born before 1935 (right column). Grey areas are bootstrapped 90% confidence bands. U.K. data: FES/LCFS (1975-2007).

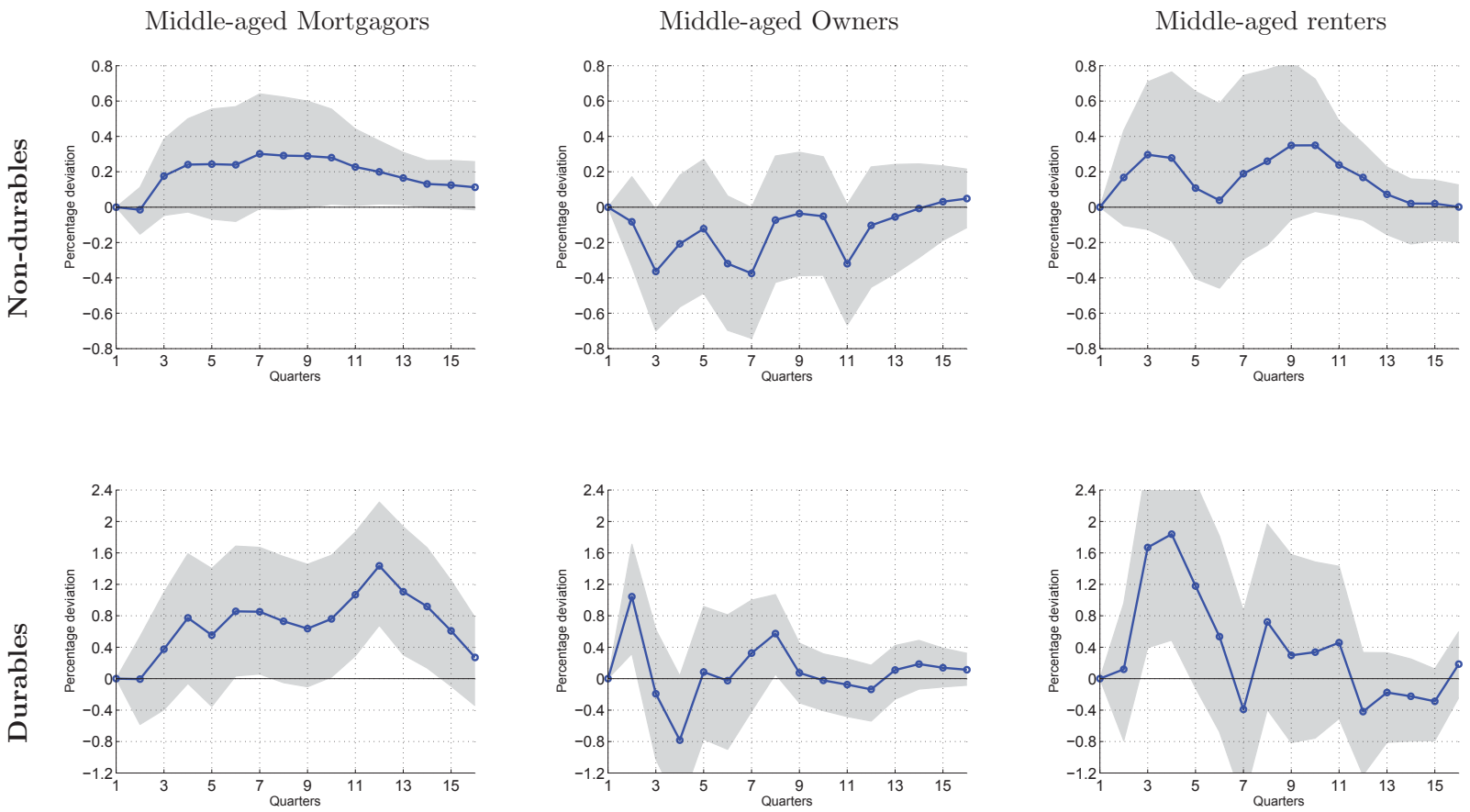


Figure 8: Dynamic effects of a 25 basis point unanticipated interest rate cut on non-durable consumption (top) and durable expenditure (bottom) for mortgagors born after 1949 (left column), mortgagors born between 1935 and 1949 (middle column) and outright owners born before 1935 (right column). Grey areas are bootstrapped 90% confidence bands. U.S. data: CEX (1981-2007).

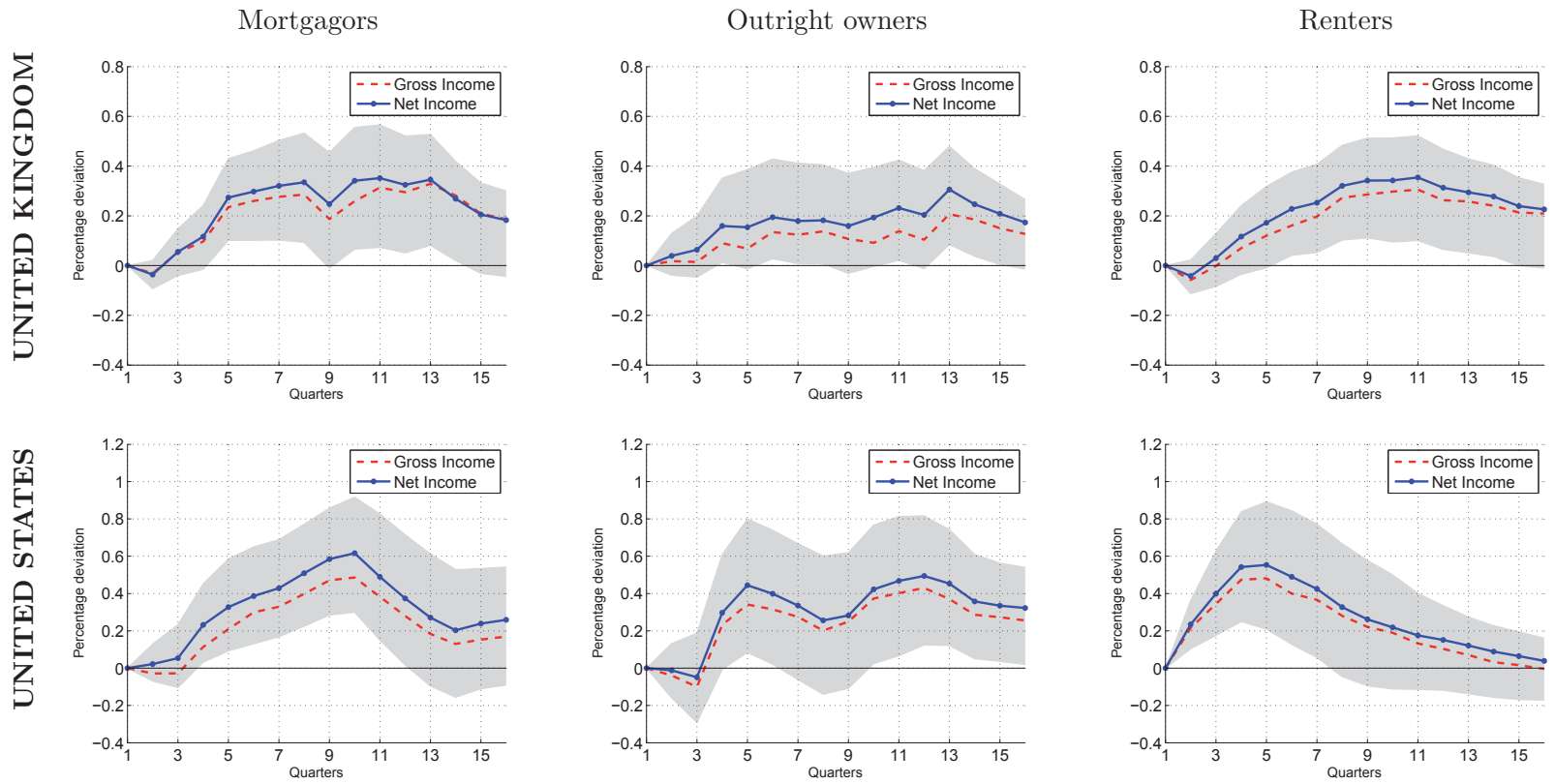


Figure 9: Dynamic effects of a 25 basis point unanticipated interest rate cut on net income (blue) and gross income (red). Mortgagors (left), outright owners (center) and renters (right). Grey areas are bootstrapped 90\% confidence bands for net income. Top row: UK (FES/LCFS data). Bottom row: US (CEX data).

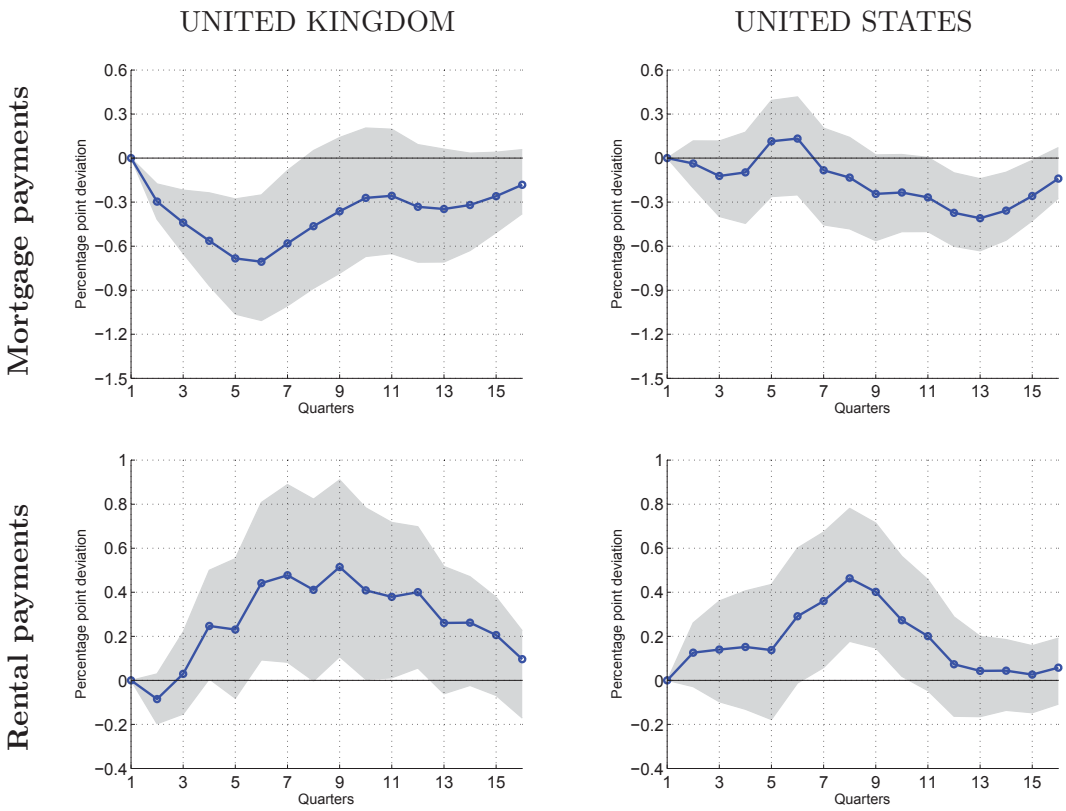


Figure 10: Dynamic effects of a 25 basis point unanticipated interest rate cut on mortgage and rental payments. Grey areas are bootstrapped 90% confidence bands. Left: UK (FES/LCFS data). Right: US (CEX data).

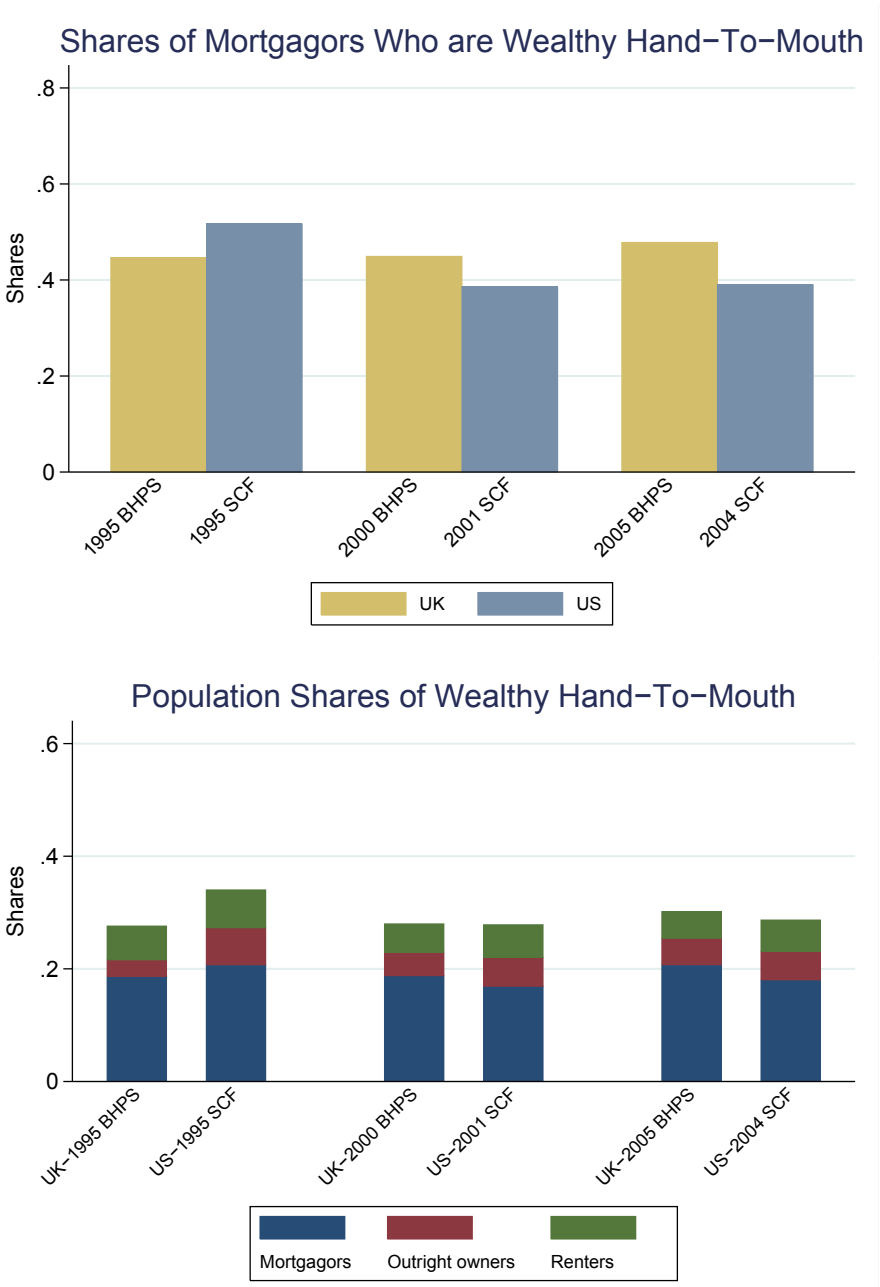


Figure 11: Shares of Wealthy Hand-To-Mouth (WHTM) mortgagors. U.K. (U.S.) data: 1995, 2000, 2005 waves of the British Household Panel Survey (Survey of Consumer Finances). A household is defined as WHTM if at any given point in time both (i) their net illiquid wealth is positive and (ii) their net liquid wealth is less than half of their total monthly household labor income.

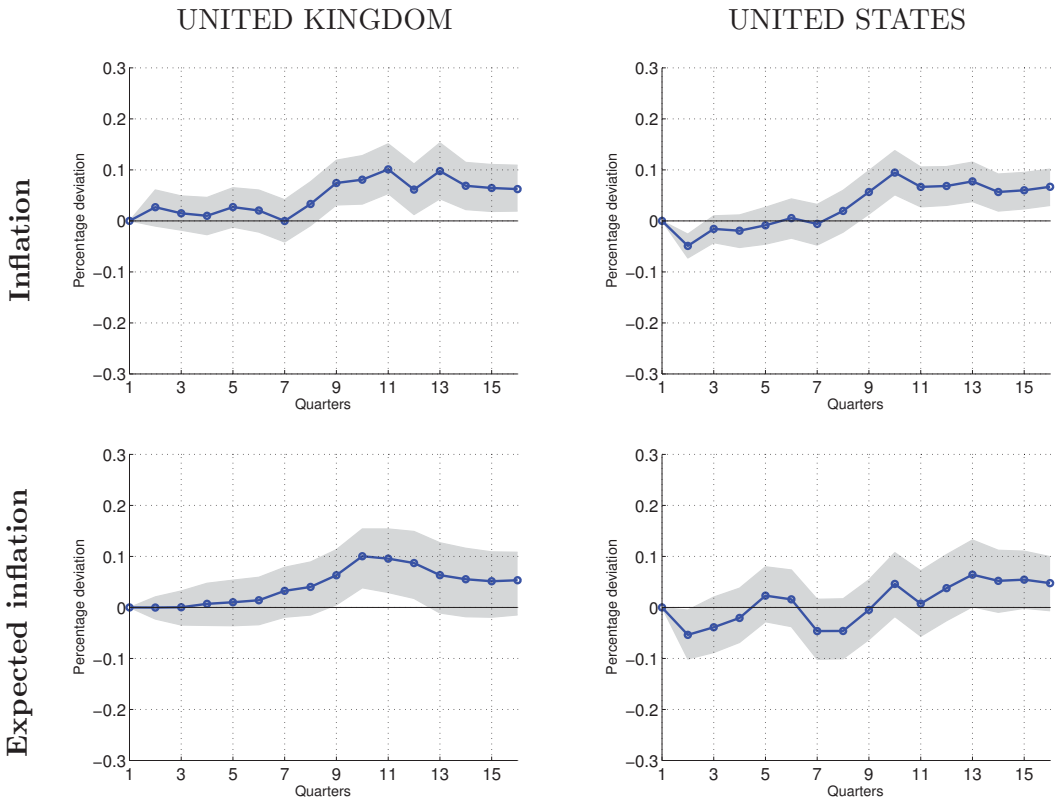


Figure 12: Dynamic effects of a 25 basis point unanticipated interest rate cut on CPI inflation (top row) and expected (1yr) inflation (bottom row). Left: UK. Right: US.

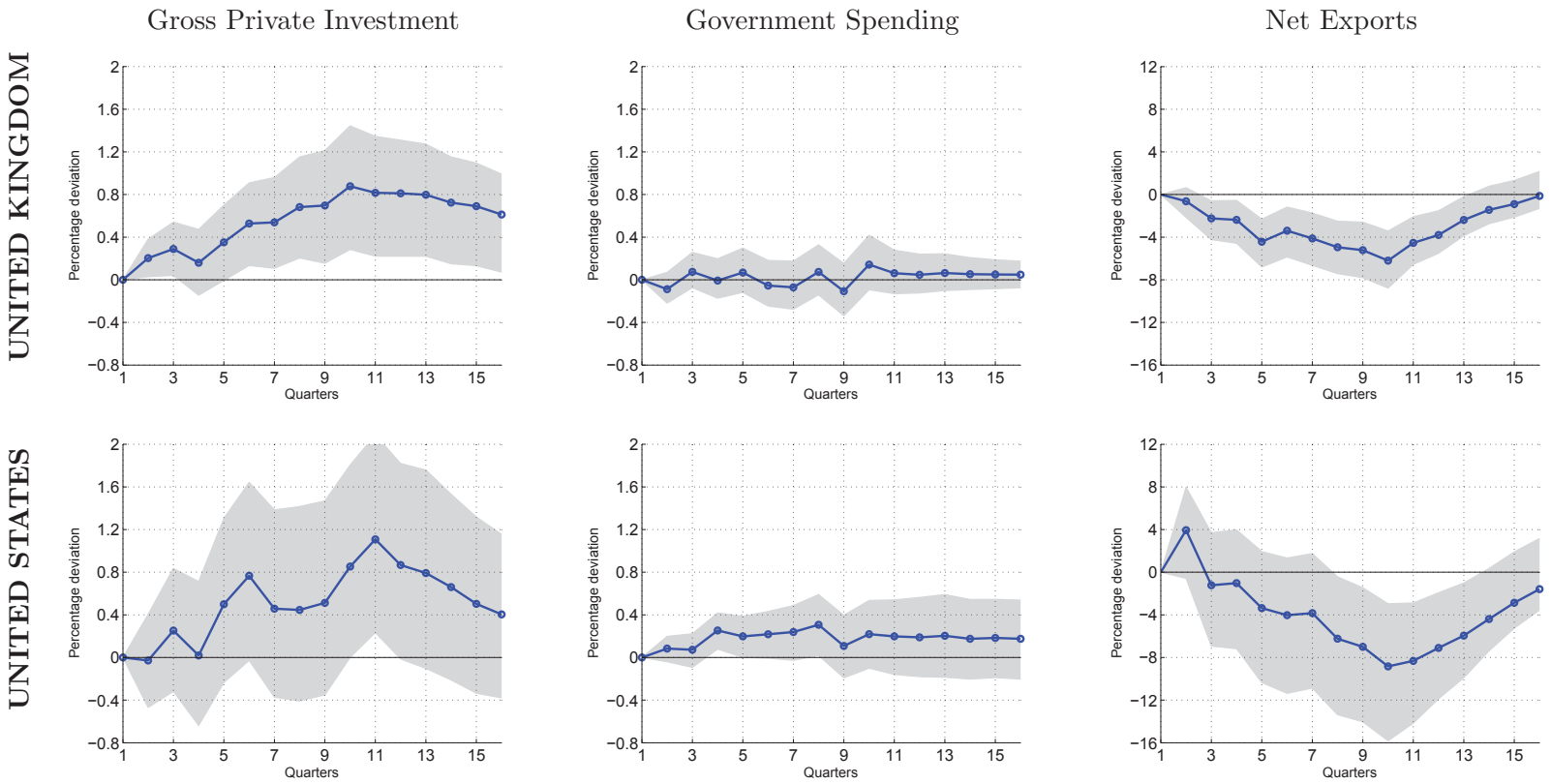


Figure 13: Dynamic effects of a 25 basis point unanticipated interest rate cut on gross private investment (first column), government expenditures (consumption plus investment; second column), and net exports (X-M) (third column). Top row: UK (aggregate ONS data). Bottom row: US (aggregate NIPA data).

Table 1: Cumulative changes over four years in US$

Panel A: United Kingdom

	Non-durable consumption	*Durable expenditure*	*Mortgage or rental payments*	*After-tax income*
Mortgagors	308.3	292.3	-166.4	695.9
	[112.8, 516.1]	[189.2 , 369.0]	**[-272.2 , -41.7]**	[186.5 , 1105.1]
Outright owners	-62.6	46.5		451.7
	[-148.2 , 77.4]	[-24.6 , 107.6]		[122.5 , 797.2]
Renters	155.3	19.0	64.7	397.3
	[17.9 , 261.8]	[-36.5 , 62.9]	[4.4 , 118.7]	[94.2 , 596.1]

Panel B: United States

	Non-durable consumption	*Durable expenditure*	*Mortgage or rental payments*	*After-tax income*
Mortgagors	305.8	229.3	-56.3	757.3
	[58.3 , 554.3]	[122.0 , 350.8]	**[-112.8 , -4.3]**	[196.8 , 1302.0]
Outright owners	-72.3	54.8		585.3
	[-324.8 , 186.0]	[-10.5 , 127.8]		[83.3 , 1012.8]
Renters	223.3	123.5	64.8	439.3
	[32.3 , 412.3]	[30.3 , 213.8]	[9.8 , 121.5]	[112.8 , 699.8]

Note: The Table reports the overall dollar change in expenditure over the four year period following a temporary 25bps cut in monetary policy, together with the bootstrapped 90% confidence bands. The magnitudes are per household averages. To compute these numbers we cumulate the IRFs and divide by the average value of each variable for each cohort in each country (shown in Appendix Table B.1). We use the U.S. price level in 2007 and the average exchange rate between pounds sterling and U.S. dollars in that year. Using the average exchange rate over the full sample would make the dollar changes for the U.K. some 10% lower but would not affect the fact that the estimated values in each column are of the same order of magnitude across the two countries.

Table 2: Household Financial and Housing Wealth for the UK and US.

	UK BHPS: 1995		US SCF: 1995	
	Median	[p25 , p75]	Median	[p25 , p75]
Net Financial wealth				
Outright owners	2,000	[0 , 10,000]	3,505	[165 , 18,455]
Mortgagors	150	[-753 , 3,450]	1,505	[-695 , 8,705]
Renters	0	[-25 , 559]	5	[-545 , 2,005]
Net Housing wealth				
Outright owners	59,000	[42,000 , 80,000]	86,000	[52,000 , 142,000]
Mortgagors	28,000	[10,000 , 51,750]	43,500	[20,000 , 86,000]
Renters	0	0	0	0
	UK BHPS: 2000		**US SCF: 2001**	
	Median	[p25 , p75]	Median	[p25 , p75]
Net Financial wealth				
Outright owners	3,300	[0 , 15,000]	8,305	[1,005 , 40,915]
Mortgagors	375	[-1,600 , 6,400]	4,605	[105 , 22,701]
Renters	0	[-68 , 1,000]	145	[-255 , 2,425]
Net Housing wealth				
Outright owners	70,000	[47,000 , 110,000]	111,500	[65,000 , 203,500]
Mortgagors	36,000	[16,000 , 70,000]	62,000	[25,000 , 126,000]
Renters	0	0	0	0
	UK BHPS: 2005		**US SCF: 2004**	
	Median	[p25 , p75]	Median	[p25 , p75]
Net Financial wealth				
Outright owners	3,050	[0 , 17,034]	5,580	[605 , 56,805]
Mortgagors	0	[-3,250 , 5,000]	2,500	[-95 , 25,505]
Renters	0	[-455 , 500]	70	[-345 , 2,305]
Net Housing wealth				
Outright owners	150,000	[100,000 , 220,000]	145,000	[76,000 , 265,000]
Mortgagors	97,000	[56,250 , 152,000]	77,000	[32,000 , 168,000]
Renters	0	0	0	0

Note: *Net financial wealth* (NLW): (i) from the BHPS, the value of savings and investments net of outstanding non-mortgage debt; (ii) from the SCF, the value of checking, saving and MM accounts, directly held mutual funds, stocks, bonds and t-bills, net of outstanding unsecured debt. *Net housing wealth* is the household's estimate of the property value net of any outstanding mortgage and home equity lines of credit. Trimmed at the top 5 percentiles of the NLW distribution.

References

Aguiar, M. and M. Bils (2015). Has Consumption Inequality Mirrored Income Inequality? *American Economic Review 105*(9), 2725–2756.

Attanasio, O., J. Banks, and S. Tanner (2002). Asset holding and consumption volatility. *Journal of Political Economy 110*, 771–792.

Attanasio, O. and G. Weber (1993). Consumption growth, the interest rate and aggregation. *The Review of Economic Studies 60*, 631–649.

Attanasio, O. and G. Weber (2010). Consumption and savings: Models of intertemporal allocation and their implications for public policy. *Journal of Economic Literature 48*, 693–751.

Auclert, A. (2015). Monetary policy and the redistribution channel. *MIT mimeo*.

Baker, S. (2017). Debt and the consumption response to household income shocks. *Journal of Political Economy*.

Barnichon, R. and C. Brownless (2017). Impulse response estimation by smooth local projections. *Mimeo*.

Barsky, R., C. House, and M. Kimball (2007). Sticky-price models and durable goods. *American Economic Review 97(3)*, 984–998.

Benati, L. (2006). Uk monetary regimes and macroeconomic stylised facts. *Bank of England Working Paper 290*.

Besley, T., N. Meads, and P. Surico (2013). Risk heterogeneity and credit supply: Evidence from the mortgage market. *NBER Macroeconomics Annual 27*, 375–419.

Best, M. C., J. Cloyne, E. Ilzetzki, and H. J. Kleven (2015). Interest rates, debt and intertemporal allocation: evidence from notched mortgage contracts in the united kingdom. *Bank of England Working Paper 543*.

Bilbiie, F. (2017). The New Keynesian Cross: Understanding Monetary Policy with Hand to Mouth Households. Technical report, Unpublished manuscript.

Blundell, R., M. Browning, and C. Meghir (1994). Consumer demand and the life-cycle allocation of household expenditures. *The Review of Economic Studies 61*.

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 (2013). Housing finance and monetary policy. *Journal of the European Economic Association 11*, 101–122.

Campbell, J. and G. Mankiw (1989). Consumption, income and interest rates: Reinterpreting the time series evidence. *NBER Macroeconomics Annual 4*, 185–216.

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. North-Holland.

Cloyne, J. and P. Huertgen (2016). The macroeconomic effects of monetary policy: a new measure for the United Kingdom. *American Economic Journal: Macroeconomics, forthcoming*.

Cloyne, J. and P. Surico (2017). Household debt and the dynamic effects of income tax changes. *Review of Economic Studies January*.

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 (2016). Innocent Bystanders? Monetary Policy and Inequality in the U.S. *Journal of Monetary Economics 88(June)*, 70–89.

Di Maggio, M., A. Kermani, B. J. Keys, T. Piskorski, R. Ramcharan, A. Seru, and V. Yao (2017). Interest rate pass-through: Mortgage rates, household consumption, and voluntary deleveraging. *American Economic Review 107(11)*.

Di Maggio, M., A. Kermani, and R. Ramcharan (2015). Monetary policy pass-through: Household consumption and voluntary deleveraging. *Mimeo, Columbia University, Berkeley University and Boards of Governors*.

Doepke, M. and M. Schneider (2006). Inflation and the redistribution of nominal wealth. *Journal of Political Economy 114(6)*.

Eggertsson, G. and P. Krugman (2012). Debt, deleveraging, and the liquidity trap: A Fisher-Minsky-Koo approach. *Quarterly Journal of Economics 127*, 1469–513.

Fagereng, A., M. Hom, and G. J. Natvik (2016). MPC heterogeneity and household balance sheets. Technical report, BI Norwegian Business School.

Floden, M., M. Kilstrom, J. Sigurdsson, and R. Vestman (2016). Household debt and monetary policy: Revealing the cash-flow channel. *Mimeo*.

Garriga, C., F. Kydland, and R. Sustek (2013). Mortgages and monetary policy. *Centre for Macroeconomics Discussion Paper DP2013-6*.

Gertler, M. and P. Karadi (2015). Monetary policy surprises, credit costs, and economic activity. *American Economic Journal: Macroeconomics 7(1)*, 44–76.

Gornemann, N., K. Kuester, A. Kermani, and M. Nakajima (2012). Monetary policy with heterogeneous agents. *mimeo FRB Philadelphia and University of Bonn*.

Greenwald, D. (2016). The mortgage credit channel of macroeconomic transmission. *NYU mimeo*.

Guvenen, F. (2006). Reconciling conflicting evidence on the elasticity of intertemporal substitution: a macroeconomic perspective. *Journal of Monetary Economics 53*, 1451–1472.

Iacoviello, M. (2005). House prices, borrowing constraints, and monetary policy in the business cycle. *American Economic Review vol. 95(3)*.

Jappelli, T. and L. Pistaferri (2010). The consumption response to income changes. *Annual Review of Economics 2*, 479–506.

Jappelli, T. and L. Pistaferri (2014). Fiscal policy and mpc heterogeneity. *American Economic Journal: Macroconomics Forthcoming*.

Jappelli, T. and A. Scognamiglio (2017). Monetary policy, mortgages and consumption: Evidence from italy. *Economic Policy Forthcoming*.

Johnson, D., N. S. and J. Parker (2006). Household expenditure and the income tax rebates of 2001. *American Economic Review 96*, 1589–1610.

Kaplan, G., B. Moll, and G. L. Violante (2016). A note on unconventional monetary policy in hank. *Mimeo*.

Kaplan, G., B. Moll, and G. L. Violante (2018). Monetary policy according to HANK. *The American Economic Review Forthcoming*.

Kaplan, G. and G. L. Violante (2014). A model of the consumption response to fiscal stimulus payments. *Econometrica 82(4)*, 11991239.

Kaplan, G., G. L. Violante, and J. Weidner (2014). The wealthy hand-to-mouth. *Brookings Papers on Economic Activity 48(Spring)*, 77–153.

Keys, B., T. Piskorski, A. Seru, and V. Yao (2015). Mortgage rates, household balance sheets, and the real economy. *Manuscript Columbia University*.

Kiyotaki, N. and J. Moore (1997). Credit cycles. *Journal of Political Economy 105(2)*.

La Cava, G., H. Hughson, and G. Kaplan (2016). The household cash flow channel of monetary policy. *RBA Research Discussion Papers*.

Luetticke, R. (2015). Transmission of monetary policy with heterogeneity in household portfolios. Technical report, UCL.

McKay, A., E. Nakamura, and J. Steinsson (2016). The power of forward guidance revisited. *American Economic Review 106*(10), 3133–58.

Mertens, K. and M. O. Ravn (2013). The dynamic effects of personal and corporate income tax changes in the United States. *American Economic Review 103(4)*, 1212–47.

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). What explains the 20072009 drop in employment? *Econometrica 82*, 2197–2223.

Misra, K. and P. Surico (2014). Consumption, income changes, and heterogeneity: Evidence from two fiscal stimulus programs. *American Economic Journal: Macroeconomics 6(4)*.

Mitman, K. (2016, August). Macroeconomic effects of bankruptcy and foreclosure policies. *American Economic Review 106*(8), 2219–55.

Mitman, K., F. Karahan, A. Hedlund, and S. Ozkan (2016). Monetary policy, heterogeneity and the housing channel. Technical report, Unpublished manuscript.

Monacelli, T. (2009). New Keynesian models, durable goods and collateral constraints. *Journal of Monetary Economics 56*, 242–254.

Mountford, A. and H. Uhlig (2009). What are the effects of fiscal policy shocks. *Journal of Applied Econometrics 24(6)*, 960–992.

Nelson, E. (2001). Uk monetary policy 1972-97: A guide using taylor rules. *CEPR Discussion Paper No 2931*.

Parker, J., N. Souleles, D. Johnson, and R. McClelland (2013). Consumer spending and the economic stimulus payments of 2008. *American Economic Review Forthcoming*.

Romer, C. D. and D. H. Romer (2004). A new measure of monetary shocks: Derivation and implications. *American Economic Review 94(4)*, 1055–84.

Rotemberg, J. (1982). Sticky Prices in the United States. *Journal of Political Economy 90*, 1187–1211.

Sterk, V. and S. Tenreyro (2015). The transmission of monetary policy operations through redistributions and durable purchases. *CEPR DP10785*.

Surico, P. and R. Trezzi (2018). Consumer spending and property taxes. *Journal of the European Economic Association Forthcoming*.

Tenreyro, S. and G. Thwaites (2016). Pushing on a string: Us monetary policy is less powerful in recessions. *American Economic Journal: Macroeconomics 8*(4), 43–74.

Tobin, J. (1980). *Asset Accumulation and Economic Activity*. University of Chicago Press.

Werning, I. (2015, August). Incomplete markets and aggregate demand. Working Paper 21448, National Bureau of Economic Research.

Wong, A. (2016). Population aging and the aggregate effects of monetary policy. *mimeo Northwestern University*.

ON-LINE APPENDIX

(not intended for publication)

A Data sources and definitions

A.1 National statistics

The aggregate time-series for the U.K. and the U.S. come from the Office for National Statistics (ONS) and the National Income and Product Accounts (NIPA), respectively. Personal consumption expenditure on non-durable goods and services expenditure, personal consumption expenditure on durable goods and disposable income are all seasonally adjusted at the source. The series are divided by total population to obtain per-capita values. The deflator used for the U.K. (U.S.) is the Retail Price Index excluding mortgage interest payments (Consumer Price Index).

A.2 Household survey data

For the U.K., we use the Living Costs and Food Survey (formerly known as Family Expenditure Survey) from 1975 to 2007 (1978 to 2007 when we use educational attainment for the probit regressions). For the U.S., we use the Consumer Expenditure Survey (interview section) from 1981 to 2007.

Household expenditure. *Non-durable goods and services*: includes food, alcohol, tobacco, fuel, light and power, clothing and footwear, personal goods and services, fares, leisure services, household services, non-durable household goods, motoring expenditures and leisure goods. Between 1982 and 1987, food at home in the CEX is adjusted following Aguiar and Bils (2015). *Durable goods*: durable household goods, motor vehicles and durable leisure goods. This includes expenditure such as furniture and furnishings, electrical appliances and audio-visual equipment.

Mortgage payments and income. *Mortgage payments*: includes both interest payments and capital repayments (not available individually over the whole sample). *Net income*: sum of labor- and non-labor household income net of taxes paid.

Restrictions. We exclude households: (i) that do not report income, (ii) that report negative net income, (iii) that are in either the top or the bottom 1% of either the non-durable or the durable expenditure distributions of each housing tenure group at any quarter and (iv) whose head is either below 25 years old or above 74 years old. Finally, for the CEX, which features a short panel dimension, we only keep households that have not changed housing tenure status between interviews. The LCFS comprises repeated cross-sections and thus each household is observed only once. For comparability across countries and over time, all household variables in the LCFS for the U.K. (in the CEX for the U.S.) are deflated by the Retail Price Index excluding mortgage interest payments (Consumer Price Index) and divided by the household size to obtain real values in per-capita terms.

B Descriptive statistics

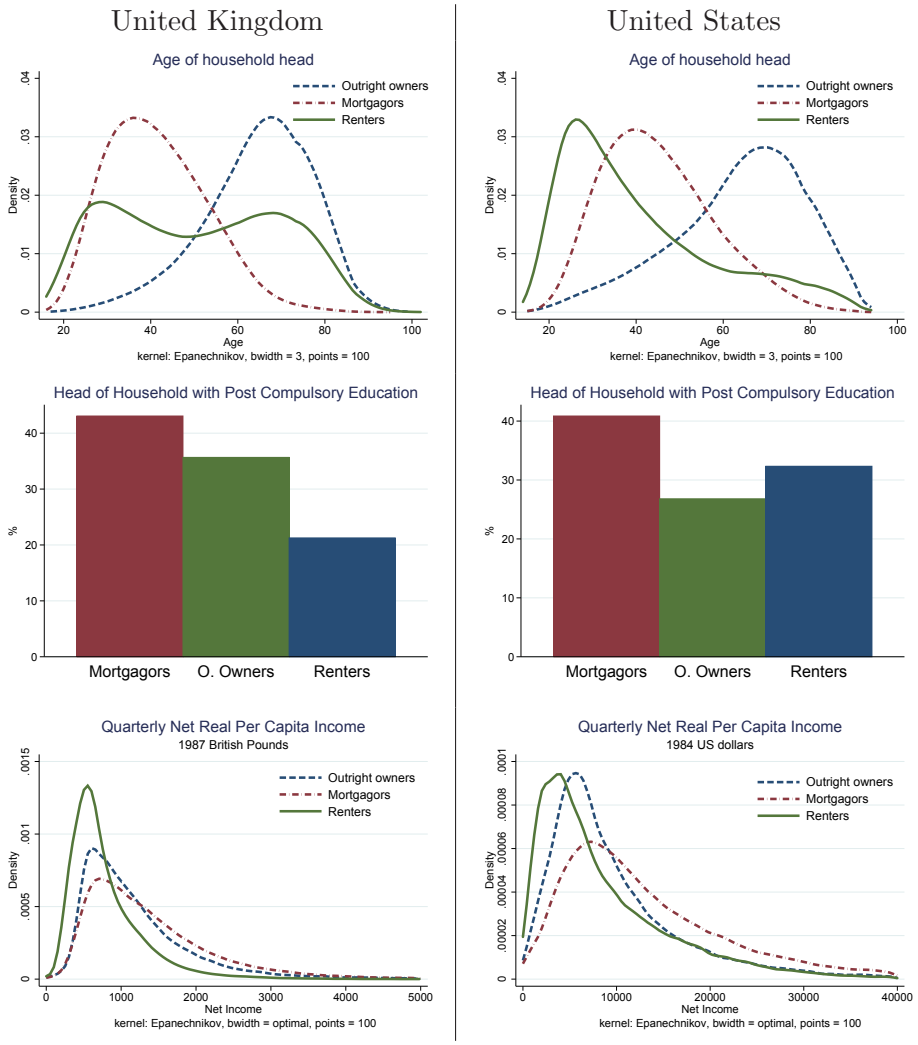


Figure B.1: Distribution of Demographic Characteristics Across Housing Tenure Groups. Top row: age of the household head at the time of interview; middle row: share of household heads who completed *more than* compulsory education; bottom row: real per capita income net of taxes. Left: U.K. (LCFS), 1975q1-2007q4. Right: U.S. (CEX), 1981q1-2007q4.

Table B.1: Mean Quarterly Household Expenditures and Income over the full sample, in 2007 US$

	Panel A: United Kingdom			
	non-durable expenditure	*durable expenditure*	*mortgage or rent payments*	*after-tax income*
Mortgagors	10,202	1,842	1,950	15,555
Outright Owners	10,030	1,625		13,617
Renters	6,807	750	1,613	9,310
	Panel B: United States			
	non-durable expenditure	*durables expenditure*	*mortgage or rent payments*	*after-tax income*
Mortgagors	14,767	2,470	2,352	20,500
Outright Owners	14,482	2,032		16,495
Renters	11,945	1,542	2,397	14,340

Note: Data for the UK comes from the Living Costs and Food Survey (LCFS) between 1975q1-2007q4; data for the US comes from the CEX between 1981q1-2007q4. The values in the table are average household level expenditures and income by cohort. In a given quarter these are constructed as a weighted average of all households within each cohort. Entries refer to sample averages converted into 2007 US dollars.

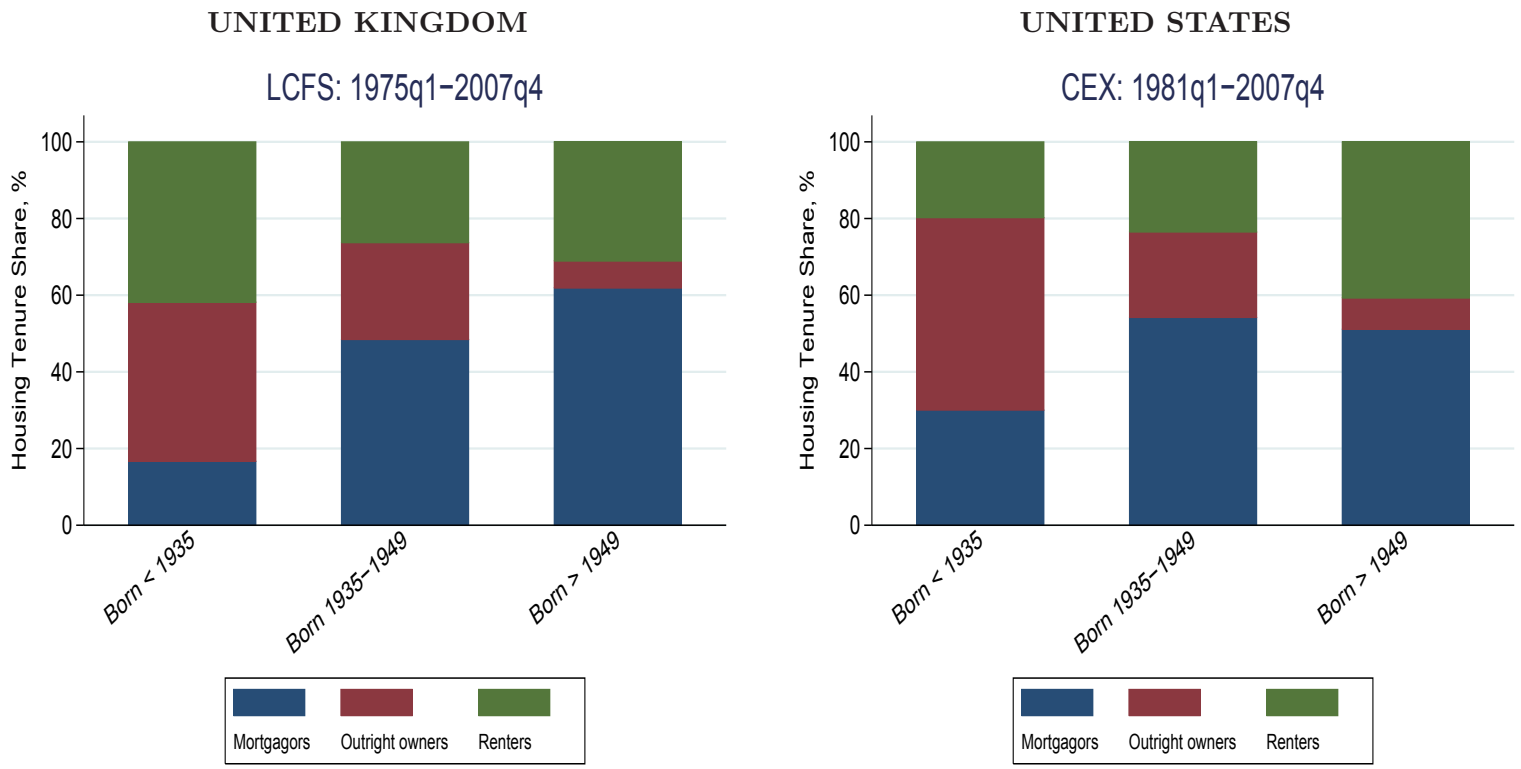


Figure B.2: The share of mortgagors, outright home owners and renters for different birth cohorts in the US and the UK. Birth cohorts are defined by the birth year of the household head. Three birth cohorts are considered: younger households, middle aged households and older households. The year cut-offs are chosen to ensure there are enough observations in each cohort group. The cut-offs also ensure that each birth cohort has approximately the same average age across the two countries.

C Evidence from official national statistics

It is useful to examine the aggregate response of non-durable expenditure, durable expenditure and household income from the U.K. and U.S. official aggregate statistics. These results are presented in Figure C.1. A cut in the policy rate raises durable expenditure, non-durable expenditure and disposable income. More specifically, a 25 basis point monetary policy expansion leads to (i) a persistent (but small) rise in non-durable consumption, which peaks at around 0.2% after about 10 quarters for the U.K. and 0.1% after 11 quarters for the U.S., (ii) a larger *percentage* increase in durable expenditure (peaking at 1.2% for the U.K. and 1% for the U.S.), consistent with the evidence in Barsky et al. (2007) and Sterk and Tenreyro (2015) and (iii) a rise in household income (that reaches its maximum at 0.4% in the U.K. and just below 0.3% in the U.S.). While the U.K. aggregate variables tend to exhibit a slightly larger adjustment, the differences between the two countries are not large or significant.

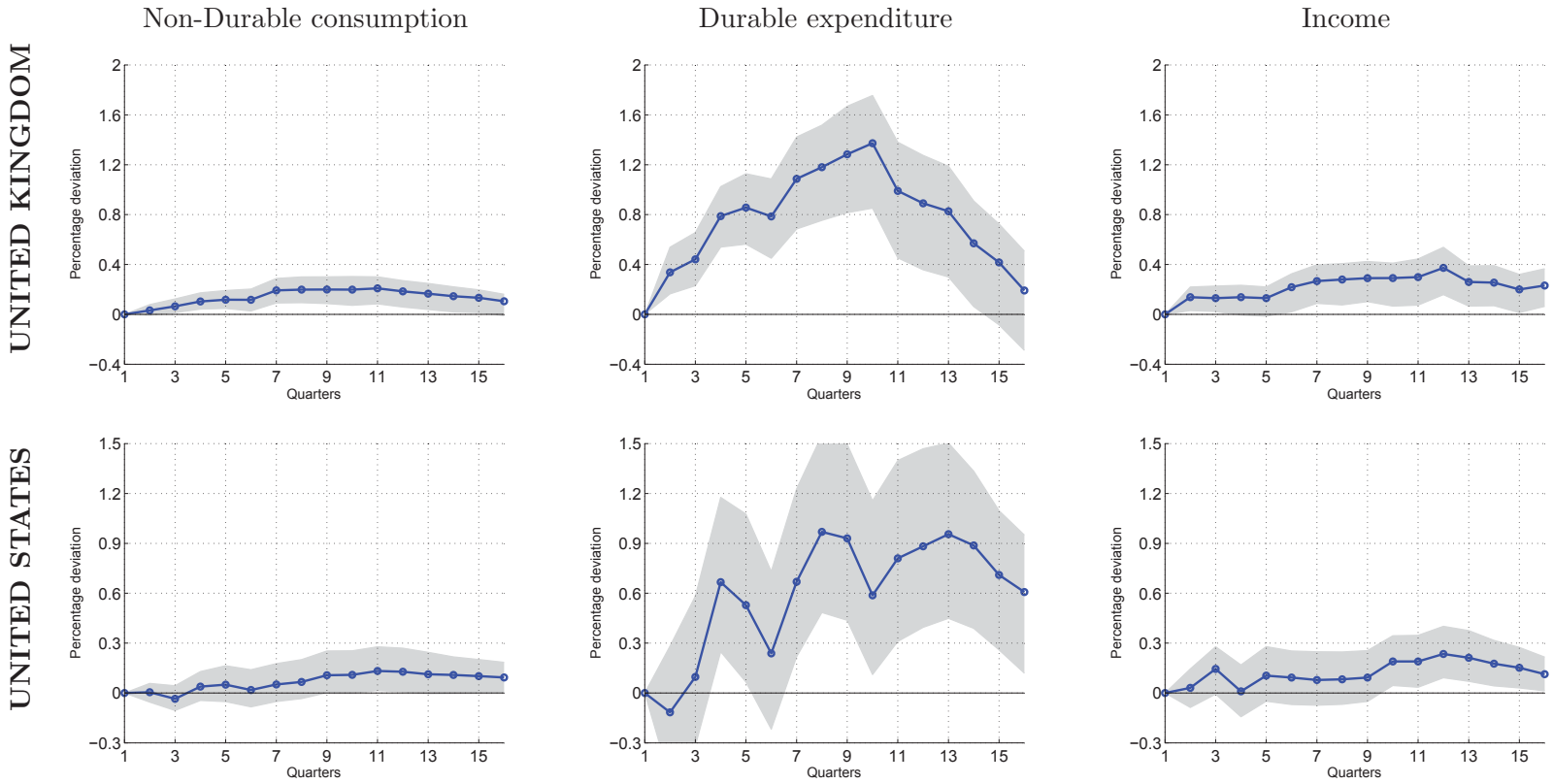


Figure C.1: Dynamic effects of a 25 basis point unanticipated interest rate cut on the consumption of non-durable goods and services, the expenditure on durable goods and household income from official aggregate national statistics. Grey areas are bootstrapped 90% confidence bands. Top row: UK, data range 1975q1-2007q4. Bottom row: US, data range: 1981q1-2007q4.

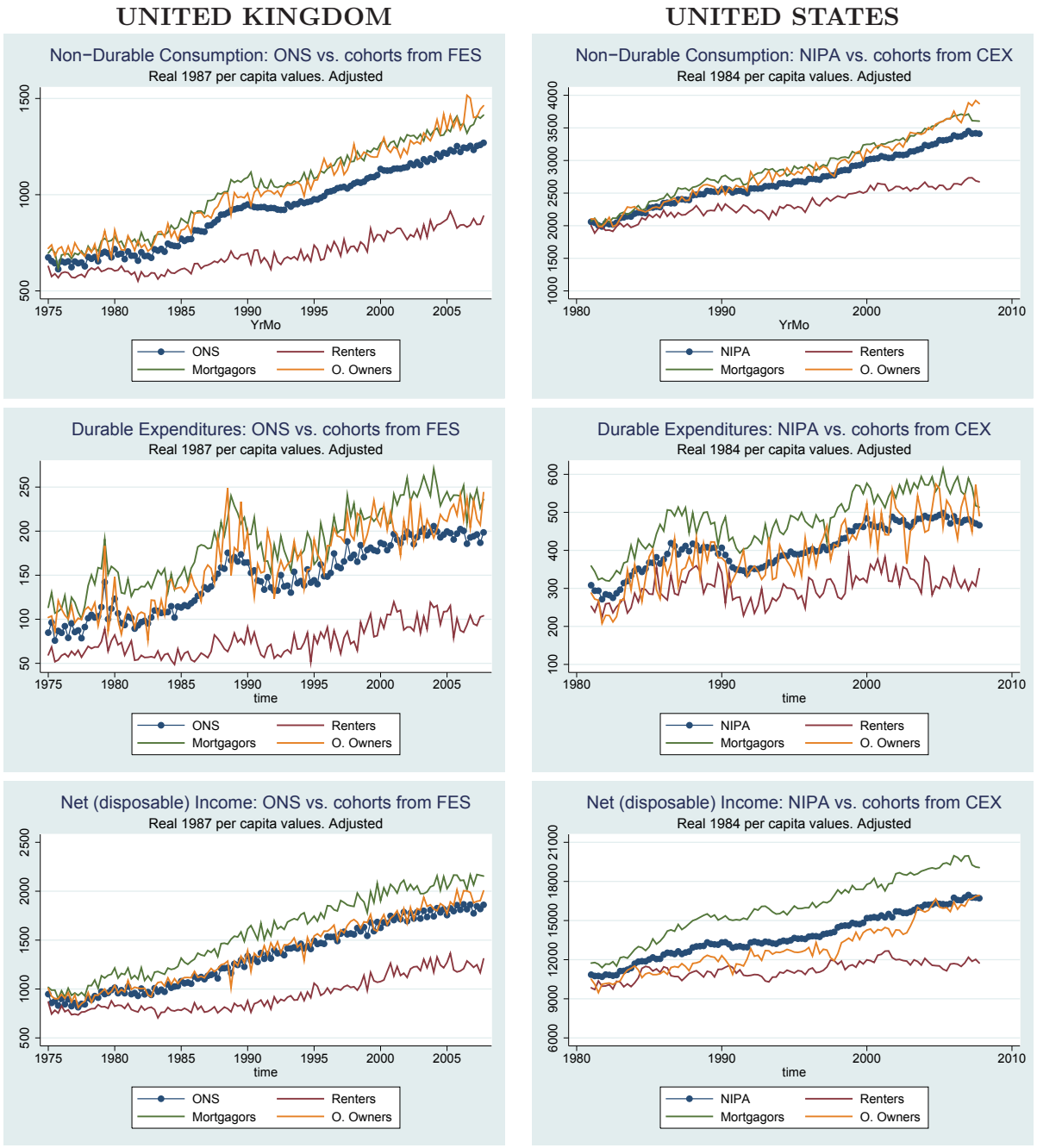


Figure C.2: Time series for real non-durable, durable and income per capita by cohort group from the LCFS/CEX, together with the equivalent aggregate measure form national statistics (US NIPA/UK ONS).

D Excluding retired households

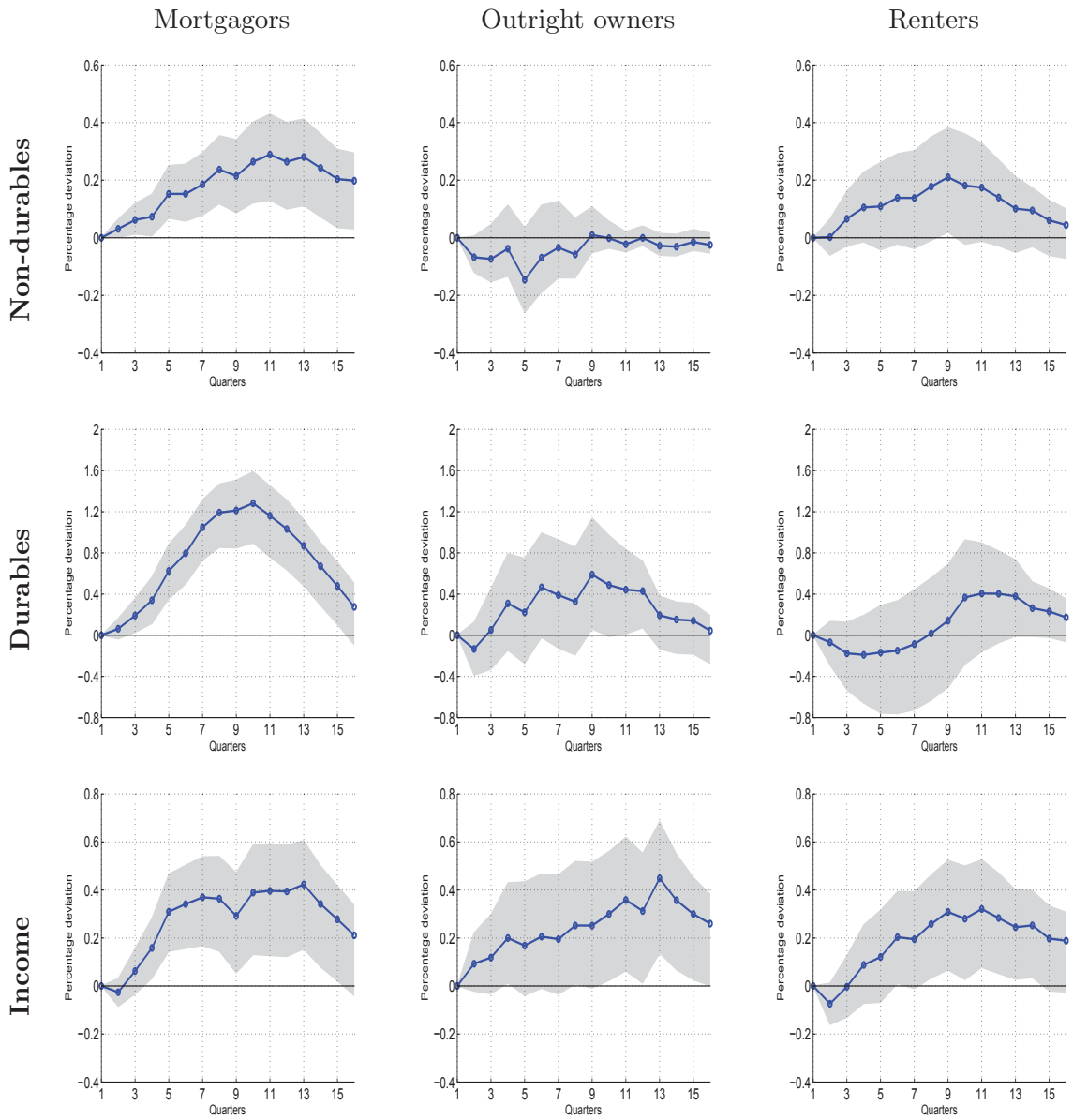


Figure D.1: Dynamic effects of a 25 basis point unanticipated interest rate cut on non-durable consumption (ND), durable expenditure (D) and income net of tax for households below age 65. U.K. data: FES/LCFS (1975-2007). Grey areas are bootstrapped 90% confidence bands.

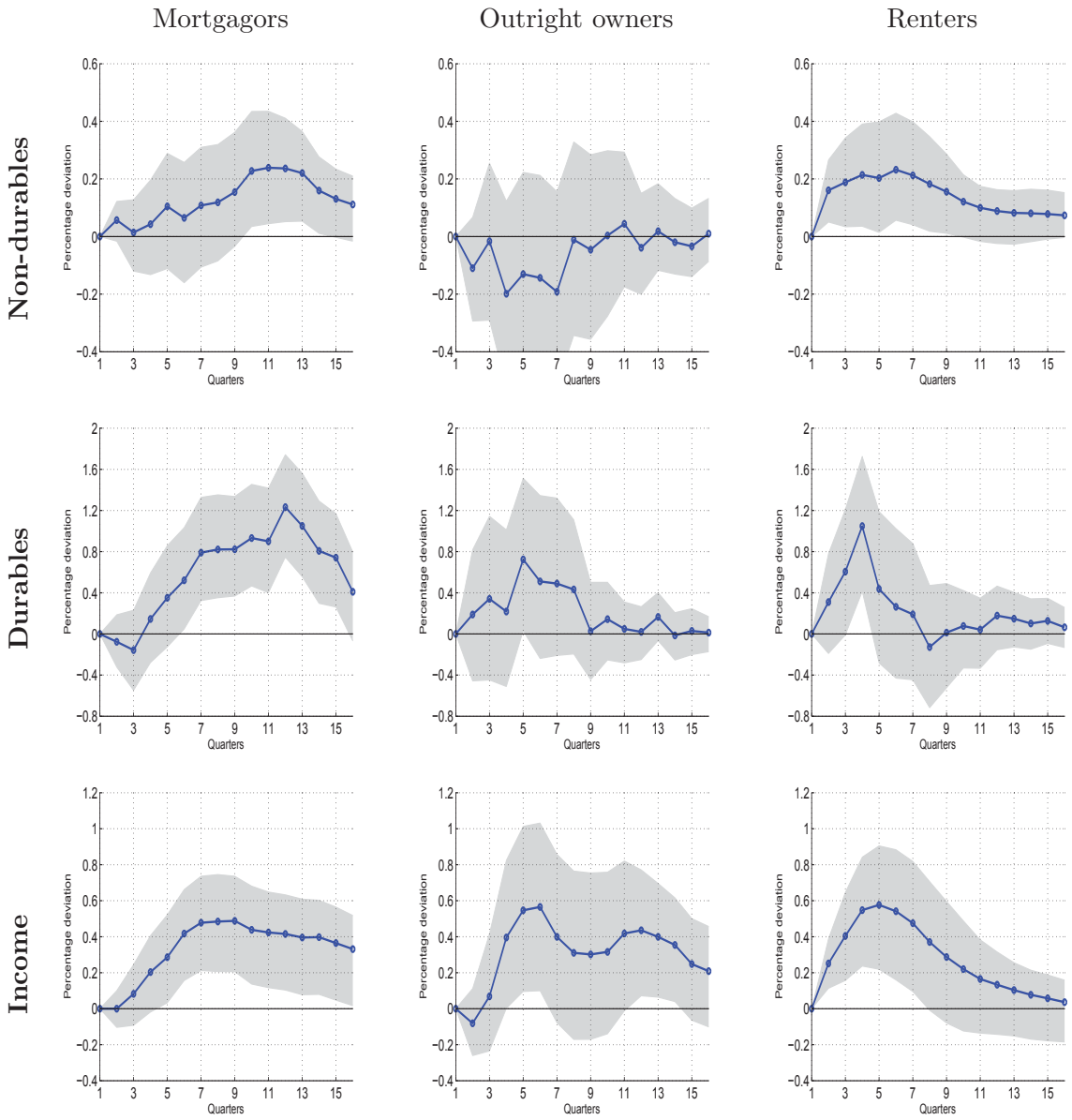


Figure D.2: Dynamic effects of a 25 basis point unanticipated interest rate cut on non-durable consumption (ND), durable expenditure (D) and income net of tax for households below age 65. U.S. data: CEX (1981-2007). Grey areas are bootstrapped 90% confidence bands.

E Compositional change

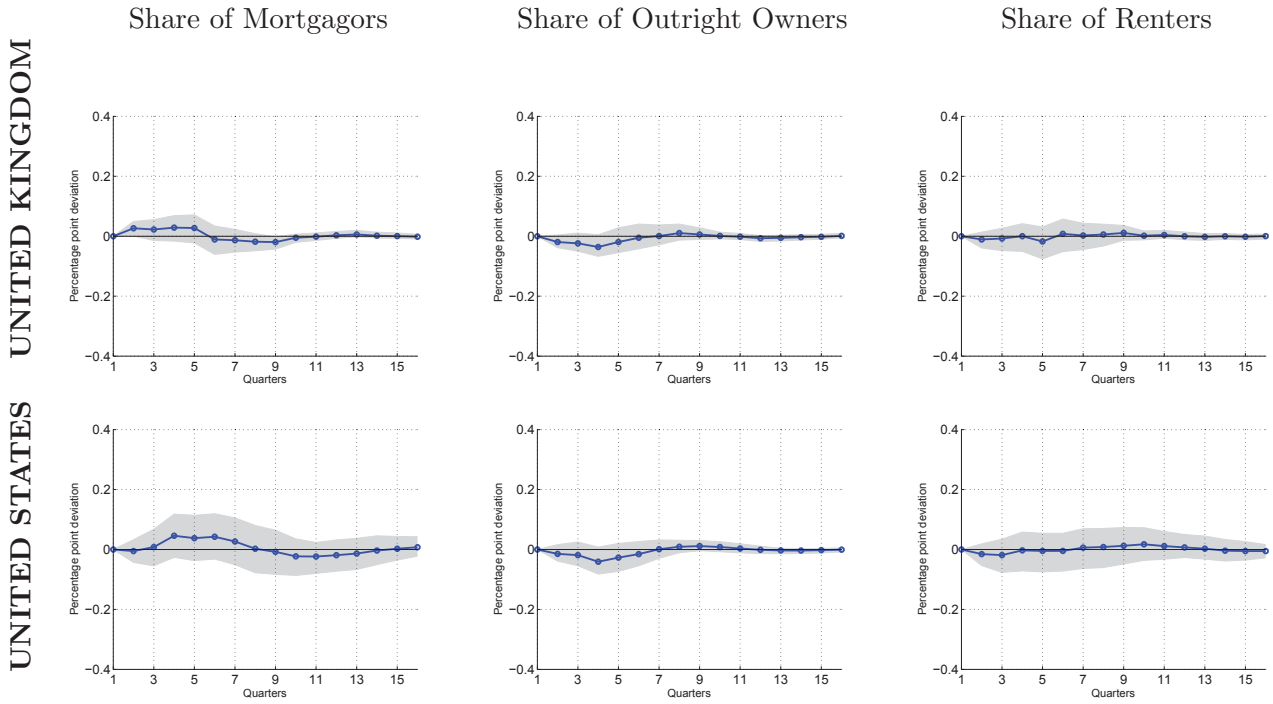


Figure E.1: Dynamic effects of a 25 basis point unanticipated interest rate cut on the share of mortgagors, outright owners and renters. Grey areas are bootstrapped 90% confidence bands. U.K. data: LCFS (1975-2007) in top row; U.S. data: CEX (1981-2007).

F US results post-1985

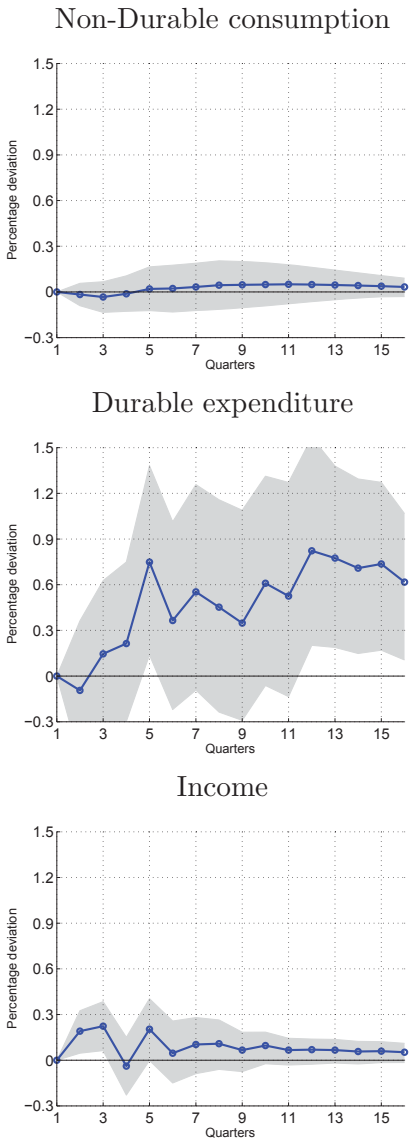


Figure F.1: Dynamic effects of a 25 basis point unanticipated interest rate cut on the consumption of non-durable goods and services, the expenditure on durable goods and household income from official aggregate national statistics (NIPA). Grey areas are bootstrapped 90% confidence bands. Sample: 1985q1-2007q4.

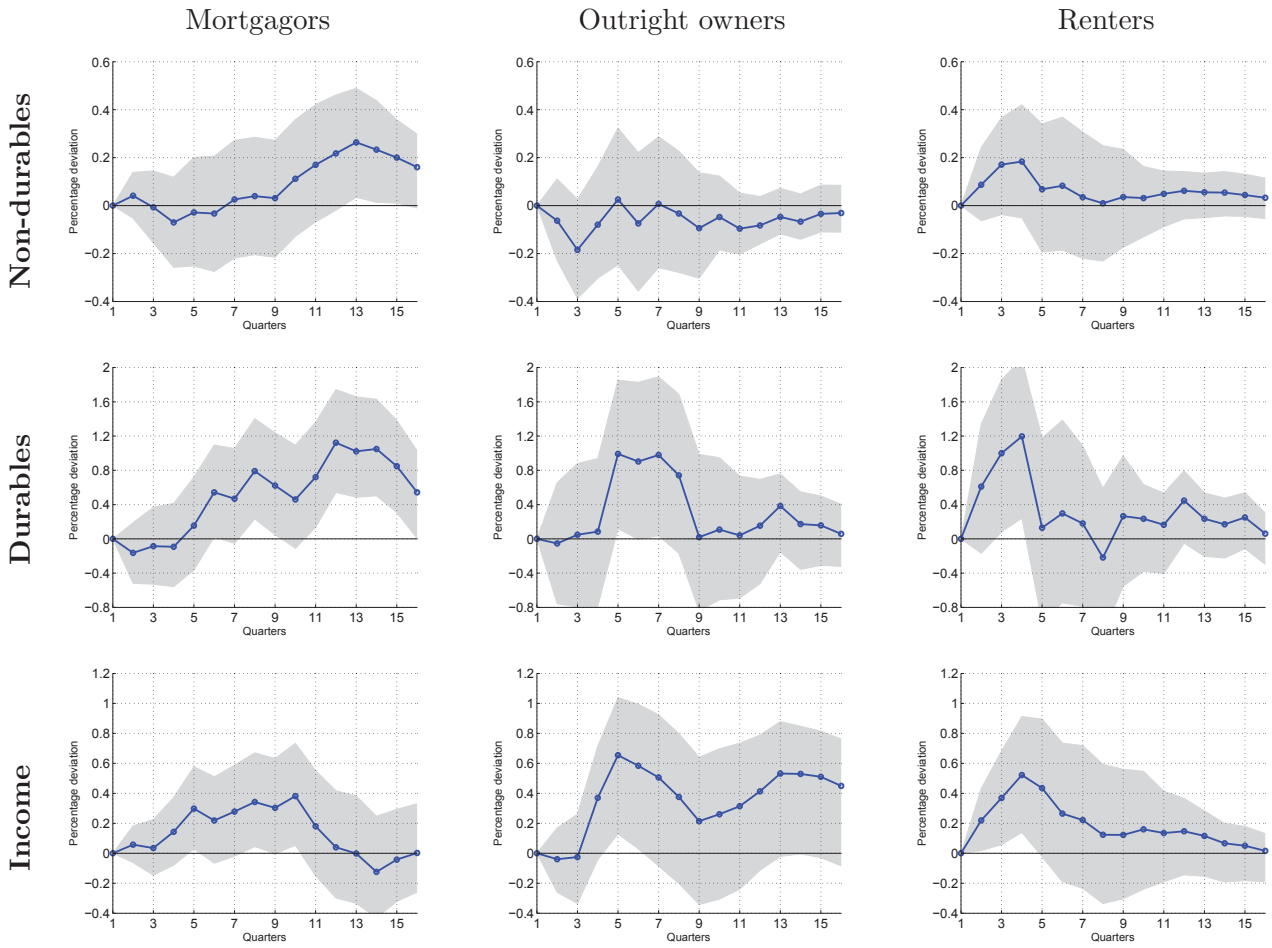


Figure F.2: Dynamic effects of a 25 basis point unanticipated interest rate cut on consumption of non-durable goods and services, expenditure on durable goods, and income. Mortgagors (left), outright owners (center) and renters (right). Grey areas are bootstrapped 90% confidence bands. Data from the CEX for the US. **Data range: 1985q1-2007q4**.

G Alternative measures income

To be added

H The response of house prices

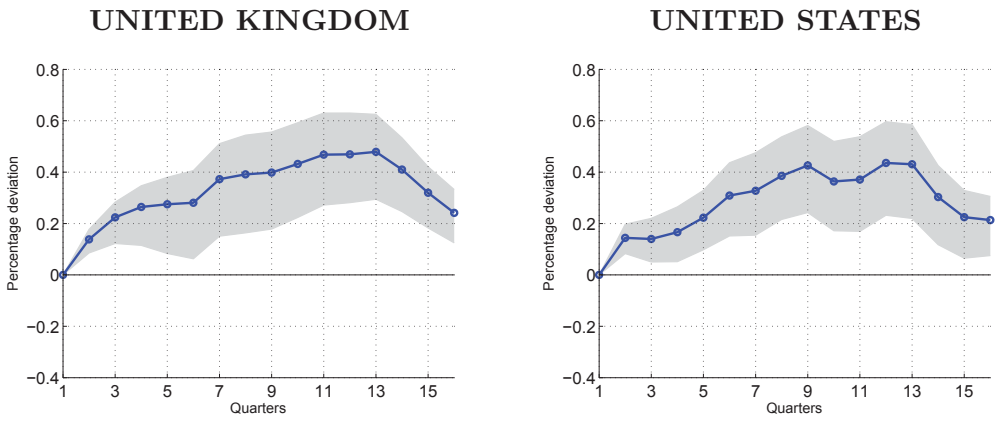


Figure H.1: IRF for aggregate real house prices. Grey areas are bootstrapped 90% confidence bands. Left: U.K. (1975-2007). Right: U.S. (1981-2007).

I A stylized model

I.1 Households

There are, ex-ante, two types of households: *patient households* (PH) and *impatient households* (IH). These are differentiated by their discount factors β^H and β^L respectively, with $0 < \beta^L < \beta^H < 1$.[35] They all derive utility from the consumption bundle x_t, housing stock and/or services $\tilde{h}_t$ and disutility from labor L_t:

$$E_0\left[\sum_{t=0}^{\infty}\left(\beta^i\right)^t\left(\frac{x_t^{1-\sigma}}{1-\sigma}+j\log\tilde{h}_t-\frac{L_t^{\eta}}{\eta}\right)\right]$$

where $\sigma > 0$ is a curvature parameter, j is a housing demand parameter, and $\eta > 0$ is related to the Frisch elasticity of labour supply. The consumption bundle x_t is defined as

$$x_t \equiv C_t^{\theta}V_t^{1-\theta} - \mu C_{t-1}^{\theta}V_{t-1}^{1-\theta} \tag{2}$$

with C_t and V_t being non-durable consumption and the stock of durables, receptively; $\theta \in [0,1]$ is a share parameter and $\mu \in [0,1)$ captures habit persistence. The stock of durables for a household evolves according to the following law of motion:

$$V_{t+1} = \left(1-\Phi\left(\frac{D_t}{D_{t-1}}\right)\right)D_t + (1-\delta)V_t \tag{3}$$

where D_t denotes purchases of new durables, $\Phi\left(\frac{D_t}{D_{t-1}}\right) = \frac{\phi_d}{2}\left(\frac{D_t}{D_{t-1}}\right)^2$ captures the costs of adjusting durables, and δ is the rate of depreciation of consumer durables. There is a fixed stock of houses H, which are sold and bought at a price q_t^h.

I.2 Assets

I.2.1 Mortgages

Households can borrow/save through a multi-period (long term) instrument, which we refer to as bond or mortgage. One unit of debt issued at t pays, starting in $t+1$, the sequence of nominal instalments $1, \rho, \rho^2, \ldots$, which decay at a rate $\rho \in [0,1]$. Therefore, if M_t units of debt are issued at t, the mortgage instalment at $t+j$ is given by

$$pay_{t,t+j} = \rho^{j-1}M_t \quad j \geq 1 \tag{4}$$

The *total amount of instalment payments* due at t is then given by

$$\begin{aligned} B_t &= \sum_{j=1}^{t} pay_{t-j,t} \\ &= M_{t-1} + \rho B_{t-1} \end{aligned} \tag{5}$$

[35] We assume that impatient (patient) households can trade a complete set of arrow securities with other impatient (patient) households, but not with the patient (impatient) households. This implies that idiosyncratic risk can be perfectly shared within households of the same type, but other risks cannot be insured with households of a different type.

Given this notation, the *value of the stock* of debt at the beginning of each period is given by

$$B_{t+1}^{stock} = \left(M_t + \rho M_{t-1} + \rho^2 M_{t-2} + ... + \rho^t M_0\right) \cdot S_t = B_{t+1} \cdot S_t$$

where S_t is the time-t price of one unit of debt. The value of the *real* stock is given by

$$b_{t+1}^{stock} \equiv \frac{B_{t+1}^{stock}}{P_{c,t}} = b_{t+1} S_t = \left(m_t + \rho \frac{b_t}{\pi_{c,t}}\right) S_t \tag{6}$$

where $m_t \equiv \frac{M_t}{P_{c,t}}$, $b_t \equiv \frac{B_t}{P_{c,t}}$ and $\pi_{c,t} \equiv \frac{P_{c,t}}{P_{c,t-1}}$.

I.2.2 One-period bonds

PH can also save through a nominal one-period bond, traded in zero net supply. One unit of such bond can be bought at a price of one, and earns a nominal return of R_t.

I.3 Production of durables and non-durables

Following Monacelli (2009), we model two sectors, producing durable investment goods D and non durable goods C using labour as the only input. In each sector, there are competitive final good producers and monopolistically competitive producers of intermediate varieties, facing the same cost of adjusting prices following Rotemberg (1982).

In the *symmetric equilibrium* where intermediate producers use the same amount of labor, it is possible to obtain an expression for the evolution of prices in each sector (Phillips curves)

$$\hat{\pi}_{D,t} = \beta^H E_t\left(\hat{\pi}_{D,t+1}\right) + \left(\frac{\epsilon_D - 1}{\vartheta_D}\right) \hat{mc}_{D,t} \tag{7}$$

$$\hat{\pi}_{c,t} = \beta^H E_t\left(\hat{\pi}_{c,t+1}\right) + \left(\frac{\epsilon_C - 1}{\vartheta_C}\right) \hat{mc}_{C,t} \tag{8}$$

where "$\hat{}$" variables denote deviation form a zero-inflation steady state, and $\pi_{j,t} \equiv \frac{P_{j,t}}{P_{j,t-1}}$ is the gross inflation rate in sector j.

Monetary policy

We assume that monetary policy is conducted through the short term (one-period) rate R_t, following a Taylor rule:

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

where $\pi_t \equiv \pi_{c,t}^{\alpha_\pi} \pi_{D,t}^{1-\alpha_\pi}$ is a composite inflation index, $Y_t = Y_{C,t}^{\alpha_y} Y_{D,t}^{1-\alpha_y}$ is a composite output index and $\bar{rr}, Y$ are steady state real rate and output.

I.4 The model with an exogenous credit limit

We first consider, along the lines of Eggertsson and Krugman (2012), the case where households face an exogenous[36] credit limit of the form

$$S_t b_{t+1} \leq E_t\left(\bar{\Omega}\frac{\pi_{t+1}}{R_t}\right) \tag{9}$$

If we define positive values of b_t as debt (negative values are savings), then the real budget constraint (in terms of the non-durable consumption good) for the impatient household reads

$$C_t + q_t^h \Delta h_t + q_t^d D_t + \frac{b_t}{\pi_{c,t}} = w_t L_t + S_t m_t \tag{10}$$

and for the patient household:

$$C_t^{'} + q_t^h \Delta h_t^{'} + q_t^d D_t^{'} - \frac{b_t^{'}}{\pi_{c,t}} = w_t L_t^{'} - S_t m_t^{'} + \Pi_{C,t} + \Pi_{D,c} \tag{11}$$

where patient household variables are denoted by "$'$".

The problem for the impatient household is to maximize the following expression:

$$W_{IH} = \max_{\{C_t, D_t, V_{t+1}, h_t, L_t, b_{t+1}, m_t\}} E_0 \sum_{t=0}^{\infty} \left(\beta^L\right)^t u\left(x_t, h_t, L_t\right)$$

subject to the budget constraint (10), the credit constraint (9), and the law of motion for the durable stock and the outstanding debt, (3), (5). We also assume a transversality (No-Ponzi games) condition.

Denote by λ_t the multiplier on the budget constraint; $\lambda_t q_t^v$ the multiplier on the law of motion for the durable stock, $\lambda_{M,t}$ the multiplier on the law of motion for mortgage repayments, and $\lambda_{CC,t}$ the multiplier on the credit constraint. The optimality conditions for $C_t, D_t, V_{t+1}, L_t, h_t$ as well as the Euler equation, can then be written respectively as

$$\lambda_t = \theta\left(\frac{C_t}{V_t}\right)^{\theta-1}\left(x_t^{-\sigma} - \mu\beta^L E_t\left(x_{t+1}^{-\sigma}\right)\right) \tag{12}$$

$$\begin{aligned} q_t^d = {} & q_t^v\left(1 - \Phi\left(\frac{D_t}{D_{t-1}}\right) - \frac{\partial\Phi\left(\frac{D_t}{D_{t-1}}\right)}{\partial D_t} D_t\right) + \\ & + \beta^L E_t\left(\frac{\lambda_{t+1} q_{t+1}^v}{\lambda_t}\frac{\partial\Phi\left(\frac{D_{t+1}}{D_t}\right)}{\partial D_t} D_{t+1}\right) \end{aligned} \tag{13}$$

$$\lambda_t q_t^v = \beta^L E_t\left(\lambda_{t+1}\left(\frac{1-\theta}{\theta}\frac{C_{t+1}}{V_{t+1}} + (1-\delta) q_{t+1}^v\right)\right) \tag{14}$$

[36] One could also think of this as a borrowing limit tied to the steady state value of collateral.

$$L_t^{\eta-1} = \lambda_t w_t \tag{15}$$

$$\lambda_t q_t^h \left(1+\phi_h \frac{\Delta h_t}{h_{t-1}}\right) = \frac{j}{\tilde{h}_t} + E_t\left(\beta^L \lambda_{t+1} q_{t+1}^h \left(1+\phi_h \frac{\Delta h_{t+1}}{h_t}\right)\right) \tag{16}$$

$$\lambda_t = \beta^L E_t\left(\lambda_{t+1}\frac{1+\rho S_{t+1}}{S_t \pi_{t+1}}\right) + \lambda_{CC,t} R_t \tag{17}$$

Condition (12) equates the shadow value of relaxing the budget constraint to the marginal utility of non-durable consumption, which is a function of habits μ. Conditions (13) and (14) are standard, and describe the expenditure and stock decisions for durables.[37] Equation (15) is the usual intra-temporal condition equating the marginal rate of substitution between non-durable consumption and labour to the real wage. This condition is important to understand how a constrained household adjusts hours worked in order to compensate for being borrowing constrained. Equation (16) relates the shadow price of consumption to the marginal service value of housing in the current period, and its expected resale value in the next period. Note that in this version of the model, the only difference between D and housing is how they enter the utility of households. Finally, (17) is the modified Euler equation, which involves the (expected) one-period *holding return* on the long term mortgage $\frac{1+\rho S_{t+1}}{S_t \pi_{t+1}}$.

The problem for the PH is similar, but only facing constraints (11) and (3), (5). The main difference arises in the Euler equation which, for the patient household, reads

$$\lambda_t^{'} = \beta^H E_t\left(\lambda_{t+1}^{'}\frac{1+\rho S_{t+1}}{S_t \pi_{t+1}}\right) \tag{18}$$

I.4.1 No-arbitrage pricing

The price S_t of the mortgage can then be written as

$$S_t = E\left(\sum_{j=1}^{\infty} Q_{t,t+j}\rho^{j-1}\right) = \frac{1}{R_t} + \rho E\left(Q_{t,t+1} S_{t+1}\right) \tag{19}$$

where $Q_{t,t+j} = \left(\beta^H\right)^j \frac{\lambda_{t+j}}{\lambda_t}$ for $j \geq 1$ is the stochastic discount factor (SDF) of the patient household, between t and $t+j$. This second equality assumes, crucially, that there is *no arbitrage* when pricing. This means that a condition needs to be satisfied between the return of the long term debt and an implicit one-period bond.[38]

[37] To see things clearly, assume for the moment no adjustment costs, i.e. $\Phi = \Phi^{'} = 0$. Then these two conditions can be combined into a standard optimality condition

$$q_t^d = \beta^L E_t\left(\frac{\lambda_{t+1}}{\lambda_t}\left(U_{V,t} + (1-\delta) q_{t+1}^d\right)\right)$$

[38] Up to a first order approximation, the key no-arbitrage pricing condition can be stated as

$$E_t\left(\frac{R_t}{\pi_{t+1}}\right) = E_t\left(\frac{1+\rho S_{t+1}}{S_t \pi_{t+1}}\right)$$

Alternatively, we could also have assumed markets for two types of assets: a one-period bond, and a long-term mortgage, with households being able to use the short term bond only as a *saving* instrument which pays a gross *nominal* interest rate R_t^1. On the other hand, the mortgage market can be used *both* for saving and borrowing.

We can define the (Macaulay) duration of this contract as

$$D_t(\rho) = \sum_{j=1}^{\infty} \left(Q_{t,t+j} \cdot j \frac{\rho^{j-1}}{S_t} \right) \tag{20}$$

In a zero inflation steady state, equation (18) implies $Q_{t,t+j} = \frac{1}{R^j} = \left(\beta^H\right)^j$ and therefore the mortgage price in steady state is

$$S = \frac{\beta^H}{1 - \beta^H \rho}$$

while the steady state duration is equal to

$$D(\rho) = \frac{1}{1 - \beta^H \rho} \tag{21}$$

Market Clearing

Goods, labour, housing and debt markets need to clear. In other words

$$\begin{aligned}
Y_{C,t} &= \omega_{IH} \left(C_t + \xi_{h,t}\right) + \omega_{PH} \left(C_t^{'} + \xi_{h,t}^{'}\right) + \frac{\vartheta_C}{2} \left(\pi_{C,t} - 1\right)^2 Y_{Ct} && (22)\\
Y_{D,t} &= \omega_{IH} D_t + \omega_{PH} D_t^{'} + \frac{\vartheta_D}{2} \left(\pi_{D,t} - 1\right)^2 Y_{Dt} && (23)\\
L_{C,t} + L_{D,t} &= \omega_{IH} L_t + \omega_{PH} L_t^{'} && (24)\\
H &= \omega_{IH} h_t + \omega_{PH} h_t^{'} && (25)\\
0 &= \omega_{IH} b_t + \omega_{PH} b_t^{'} && (26)
\end{aligned}$$

Competitive Equilibrium

A *competitive equilibrium* in this economy is a set of sequences for $C_t, C_t^{'},\ D_t, D_t^{'},\ V_t, V_t^{'},\ h_t, h_t^{'},\ L_t, L_t^{'},\ m_t, m_t^{'},\ b_t, b_t^{'}$, Lagrange multipliers and prices $P_{C,t}, P_{D,t}, w_t, q_t^h, q_t^d, S_t, R_t$ such that:

1. $C_t, C_t^{'},\ D_t, D_t^{'},\ V_t, V_t^{'},\ h_t, h_t^{'},\ L_t, L_t^{'},\ m_t, m_t^{'},\ b_t, b_t^{'}$, as well as the corresponding Lagrange multipliers, solve the household problems for given prices and interest rate R_t.
2. $P_{C,t}, P_{D,t}, L_{C,t}, L_{D,t}$ solve the firms problem for given w_t
3. R_t is set according to (I.3), and S_t, R_t satisfy a no arbitrage condition.
4. Prices $P_{C,t}, P_{D,t}, w_t, q_t^h, q_t^d, S_t, R_t$ are such that all markets clear.

I.4.2 Parametrization

The exogenous credit limit model is parametrized using the values in Table I.1 below. Most of these are relatively standard and well within the range of estimates available in the literature. Two parameters, however, deserve further explanation. In the collateral constraint model of the next section, the value of the housing demand shifter, j, pins down the maximum loan-to-value ratio in the impatient household's budget constraint. To set the latter to the empirically plausible value of 75%, we need $j = 0.468$. For the sake of comparability across the two models, we then impose the same value for j here.

Our framework abstracts from investment, government spending and net exports. Accordingly, at the aggregate level, income is equal to expenditure and therefore we need to calibrate the debt to expenditure ratio $\bar{\Omega}/Y$. The household debt to disposable income ratio (or the private credit to GDP) in the two countries has averaged around 110% while household expenditure tends to represent about 60% of output, implying a debt to expenditure ratio of about 1.8. Finally, we assume there are equal shares of constrained and unconstrained households.

Parameter	Description	Value
$\theta/(1-\theta)$	elasticity of substitution between ND and D stock	4
σ	elasticity of intertemporal substitution	0.5
β^L, β^H	discount factor: mortgagors, outright owners	0.95, 0.99
$1/(\eta-1)$	Frisch elasticity of labor supply	2
μ	habits parameter	0.5
j	housing demand shifter	0.468
δ	depreciation rate durables	0.025
$\varepsilon_{C,D}$	elasticity of varieties	4
$\vartheta_{C,D}$	cost of adjusting prices	150
r_π, r_Y, r_R	Taylor rule: CPI, output, smoothing	1.5,.05,.6
ω_{IH}	share constrained households	50%
ω_{PH}	share unconstrained households	50%
$\bar{\Omega}/Y$	debt to expenditure ratio	1.8
$1/(1-\beta^H\rho)$	Benchmark long term debt duration	1 year

Table I.1: Calibration of the model.

I.5 The model with an endogenous collateral limit

We now assume that the housing stock h_t can be used as collateral, following Kiyotaki and Moore (1997) and Iacoviello (2005).[39] The credit constraint (9) now reads

$$S_t b_{t+1} \leq \phi E\left(q^h_{,t+1} h_t \frac{\pi_{t+1}}{R_t}\right) \tag{27}$$

where ϕ is the steady state loan-to-value (LTV) ratio, and $q^h_{,t+1}h_t$ is the real value of the housing stock at t+1.

There is a *rental market* through which households can rent (from/to others) housing services for one period at a rate p_t. Households are now also heterogeneous with respect to the utility they derive from renting.[40] Within the impatient households, there are now two groups of agents. We denote IHm those households who derive relatively higher utility from owned housing, and IHr those households who derive similar utility from renting or owning. The population shares of IHm, PH and IHr are *exogenous* and given by $(\omega_{IHm}, \omega_{PH}, 1-\omega_{IH}-\omega_{PH})$, consistent with the evidence in

[39] Note that we are not allowing the stock of durable goods V_t to be collateralizable. The reason for this is twofold. First, although there might be some durable goods in the data that are collateralizable, this is not typically the case, even for large durables such as vehicles. Second, we want to distinguish the role of durable goods from that of the housing stock.

[40] This way of modelling renting and owning is a simplification. One could think of this as a reduced form way of capturing life-cycle considerations which are not present in this class of model.

Section 4.2 that the shares of each housing tenure group do not vary with changes in monetary policy. But, importantly, the housing tenure choice (how much house to own vs. rent) will be endogenous.

Housing utility (services) can be derived from housing owned or rented. Let $h_t \in \mathbb{R}^+$ be the housing stock *owned*, $s_t^- \in \mathbb{R}^+$ the housing rented *to* others, and $s_t^+ \in \mathbb{R}^+$ the housing stock rented *from* others. Housing services are then given by

$$\tilde{h}_{t,i} = h_{t,i} - s_{t,i}^- + \gamma_i s_{t,i}^+ \quad i \in \{PH, IHm, IHr\} \tag{28}$$

with $\gamma \in [0,1)$ capturing different reasons why households might preference to own rather than to rent.

Crucially, γ is household specific: $0 < \gamma_{IHm} = \gamma_{PH} < \gamma_{IHr} = 1$. This means that PH and IHm derive a higher marginal utility from their housing stock that is not rented out, $h_{t,i} - s_{t,i}^-$, than from the housing stock that they may rent from others, s_t^+. For IHr, on the other hand, the marginal utility is equal whether its owned or rented. All households face an individual housing *feasibility* constraint

$$h_{t,i} - s_{t,i}^- \geq 0 \tag{29}$$

meaning that they cannot rent out more than they currently own, $h_{t,i}$, and they cannot sub-let.[41]

Households also face a quadratic adjustment cost when adjusting the housing stock, given by

$$\xi_{h,t} = \phi_h \left(\frac{\Delta h_t}{h_{t-1}} \right)^2 \frac{q_t^h h_{t-1}}{2} \tag{30}$$

The impatient household (whether borrower or mortgagor/renter in equilibrium) solves the following optimization problem

$$W_{IH} = \max_{\{C_t, D_t, V_{t+1}, h_t, s_t^+, s_t^-, L_t, b_{t+1}, m_t\}} E_0 \sum_{t=0}^{\infty} \left(\beta^i\right)^t u\left(x_t, \tilde{h}_t, L_t\right)$$

subject to (Lagrange multipliers in parenthesis)

$$\begin{aligned}
C_t + q_t^d D_t + q_t^h \Delta h_t + \frac{b_t}{\pi_{c,t}} + \xi_{h,t} &= w_t L_t + S_t m_t + p_t \left(s_t^- - s_t^+\right) + T_t \quad (\lambda_t) \\
V_{t+1} &= \left(1 - \Phi\left(\frac{D_t}{D_{t-1}}\right)\right) D_t + (1-\delta) V_t \quad (\lambda_t q_t^v) \\
\tilde{h}_t &= \begin{cases} h_{t,i} + \gamma s_{t,i}^+ - s_{t,i}^- & \text{if } i = IHm \\ h_{t,i} + s_{t,i}^+ - s_{t,i}^- & \text{if } i = IHr \end{cases} \quad \left(\lambda_t^3\right) \\
h_t - s_t^- &\geq 0 \quad \left(\lambda_t^5\right) \\
s_t^- &\geq 0 \quad \left(\lambda_t^6\right) \\
s_t^+ &\geq 0 \quad \left(\lambda_t^7\right) \\
b_{t+1} &= m_t + \rho \frac{b_t}{\pi_t} \quad \left(\lambda_t^8\right)
\end{aligned}$$

[41] Note that restriction (29) together with the non-negativity of $s_{t,i}^-$ already imply that $h_{t,i} \geq 0$.

$$S_t b_{t+1} \leq \phi E\left(\frac{q^h_{,t+1} h_t \pi_{t+1}}{R_t}\right) \quad (\lambda_{BC,t})$$

The patient household solves

$$W_{PH} = \max_{\{C_t, D_t, V_{t+1}, h_t, s_t^+, s_t^-, L_t, b_{t+1}, m_t\}} E_0 \sum_{t=0}^{\infty} \left(\beta^H\right)^t u\left(x_t, \tilde{h}_t, L_t\right)$$

subject to (Lagrange multipliers in parenthesis)

$$\begin{aligned}
C_t + q_t^d D_t + q_t^h \Delta h_t - \frac{b_t}{\pi_{c,t}} + \xi_{h,t} &= w_t L_t - S_t m_t + p_t\left(s_t^- - s_t^+\right) + \Pi_{C,t} + \Pi_{D,c} + T_t \quad (\lambda_t) \\
V_{t+1} &= \left(1 - \Phi\left(\frac{D_t}{D_{t-1}}\right)\right) D_t + (1-\delta) V_t \quad (\lambda_t q_t^v) \\
\tilde{h}_t &= h_{t,i} + \gamma s_{t,i}^+ - s_{t,i}^- \quad \left(\lambda_t^3\right) \\
h_t - s_t^- &\geq 0 \quad \left(\lambda_t^5\right) \\
s_t^- &\geq 0 \quad \left(\lambda_t^6\right) \\
s_t^+ &\geq 0 \quad \left(\lambda_t^7\right) \\
b_{t+1} &= m_t + \rho \frac{b_t}{\pi_t} \quad \left(\lambda_t^8\right)
\end{aligned}$$

Market clearing

Denote with $''$ (double tilde) the variables of IHr and with $'$ (single tilde) the ones for PH . Clearing of markets implies

$$\begin{aligned}
Y_{C,t} &= \omega_{IH}\left(C_t + \xi_{h,t}\right) + \omega_{PH}\left(C_t^{'} + \xi_{h,t}^{'}\right) + \left(1 - \omega_{IH} - \omega_{PH}\right) C_t^{''} + \frac{\vartheta_C}{2}\left(\pi_{C,t} - 1\right)^2 Y_{Ct} \\
Y_{D,t} &= \omega_{IH} D_t + \omega_{PH} D_t^{'} + \left(1 - \omega_{IH} - \omega_{PH}\right) D_t^{''} + \frac{\vartheta_D}{2}\left(\pi_{D,t} - 1\right)^2 Y_{Dt} \\
L_{C,t} + L_{D,t} &= \omega_{IH} L_t + \omega_{PH} L_t^{'} + \left(1 - \omega_{IH} - \omega_{PH}\right) L_t^{''} \\
0 &= \omega_{IH} m_t + \omega_{PH} m_t^{'} + \left(1 - \omega_{IH} - \omega_{PH}\right) m_t^{''} \\
H &= \omega_{IH} h_t + \omega_{PH} h_t^{'} + \left(1 - \omega_{IH} - \omega_{PH}\right) h_t^{''} \\
s_t^+ + s_t^{+'} + s_t^{+''} &= s_t^- + s_t^{-'} + s_t^{-''}
\end{aligned}$$

I.5.1 Housing tenure in steady state

Proposition. For an owning-preference threshold $\bar{\gamma}$ such that $\gamma < \bar{\gamma}$, there exists zero-inflation steady state ($SS^{\pi=0}$) in which:[42]

1. The PHs own housing stock ($h^{'} > 0$) and rent out part of it ($s^{-'} > 0$).
2. Impatient renters do not own housing ($h^{''} = 0$) which means they cannot: (i) borrow ($b^{''} = 0$), or (ii) rent to others ($s^{-''} = 0$). They instead rent housing services ($s^{+''} > 0$).
3. The IHms own housing ($h > 0$) but do not participate in the rental market ($s^- = s^+ = 0$).

Proof. See section I.6 ■

I.5.2 Parametrization

In Table I.2, we report the values used for the collateral constraint model which are, in most cases, the same as in Table I.1. The steady state loan-to-value ratio, ϕ, (which did not appear in the previous parametrization) is set to 75%, consistent with the sample averages reported by Besley et al. (2013). On the other hand, the shares of mortgagors and outright owners mimic the average values we observe in the FES/LCSF and CEX.

Parameter	Description	Value
$\theta/(1-\theta)$	elasticity of substitution between ND and D stock	4
σ	elasticity of intertemporal substitution	0.5
β^L, β^H	discount factor: mortgagors, outright owners	0.95, 0.99
$1/(\eta-1)$	Frisch elasticity of labor supply	2
μ	habits parameter	0.5
j	housing demand shifter	0.468
δ	depreciation rate durables	0.025
$\varepsilon_{C,D}$	elasticity of varieties	4
$\vartheta_{C,D}$	cost of adjusting prices	150
r_π, r_Y, r_R	Taylor rule: CPI, output, smoothing	1.5,.05,.6
ω_{IH}	share of mortgagors	45%
ω_{PH}	share outright owners	35%
m	max LTV	0.75
$\bar{\Omega}/Y$	debt to expenditure ratio	1.8
$1/(1-\beta^H\rho)$	Benchmark long term debt duration	1 year

Table I.2: Calibration of the model.

[42] We assume that the conditions above also hold for states "near the SS". This is equivalent to requiring that the wedge between the rental rate p_t and the house price q_t^h not to diverge "too much" from its value in the steady state $SS^{\pi=0}$. The assumption of no change in housing tenure following a monetary policy shock is, however, consistent with the results presented in Section 4.2.

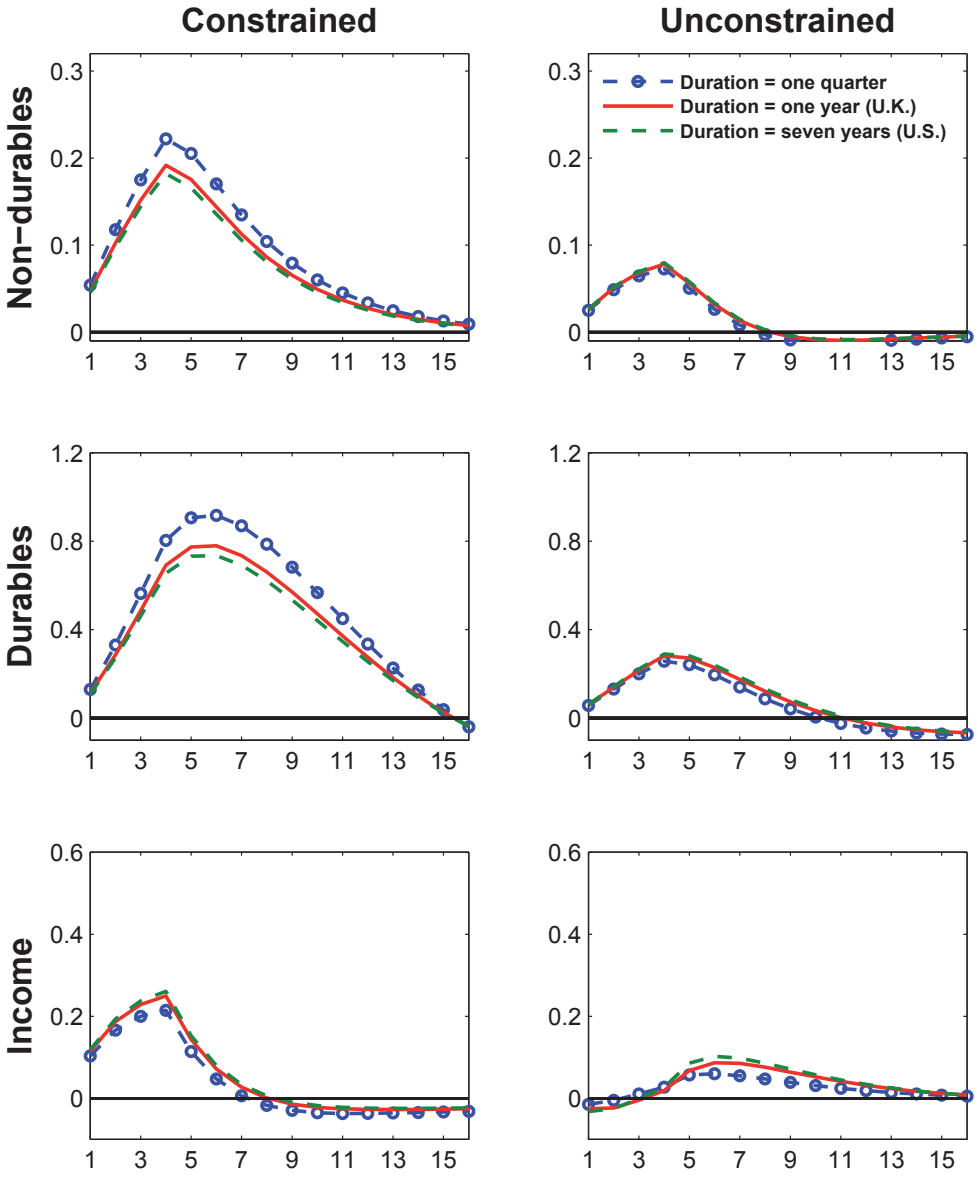


Figure I.1: Response of non-durable consumption, durable expenditure and income in the exogenous debt limit model: constrained vs. unconstrained agents. Duration refers to the effective duration of fixed-rate mortgage contracts in the aggregate economy, which on average is about one year for the U.K. and 7 years for the U.S.

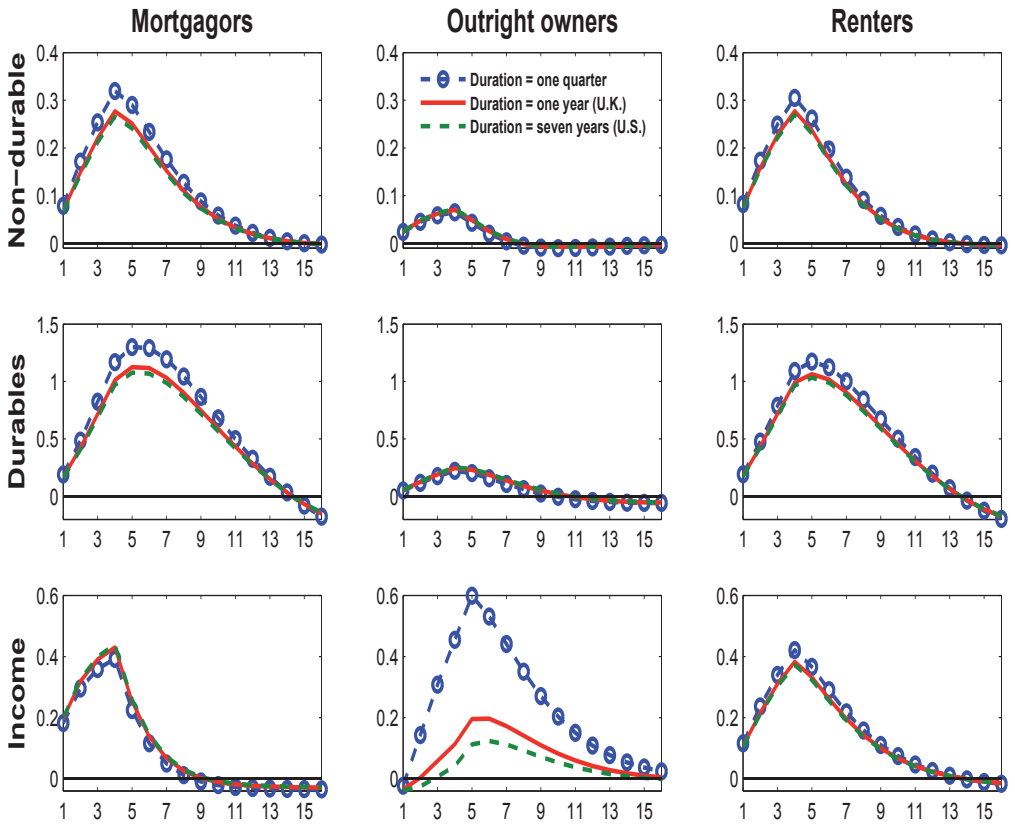


Figure I.2: Response of non-durable consumption, durable expenditure and income in the housing collateral constraint model: mortgagors versus outright owners. Duration refers to the effective duration of fixed-rate mortgage contracts in the aggregate economy, which on average is about one year for the U.K. and 7 years for the U.S.

I.6 Proof of Proposition I.5.1: "Separation" In Steady State

Here we show that there is a steady state (SS) in which:

1. PH own housing stock ($h^{'} > 0$) and rents out part of it ($s^{-'} > 0$)
2. Impatient renters do not own housing ($h^{''} = 0$) which means they cannot: (i) borrow ($b^{''} = 0$), and (ii) rent to others ($s^{-''} = 0$). They instead rent housing services from others ($s^{+''} > 0$)
3. IHm own housing ($h > 0$) but do not participate in the renting market ($s^{-} = s^{+} = 0$)

Intuition of the Proof:

At the SS interest rate $R = \frac{1}{\beta'}$, both IHm and IHr households want to borrow in order to shift consumption from the future to the current period. To do so, due to frictions in credit markets, they need to own housing stock to use as collateral. A crucial element is the LTV being ¡1, or the "haircut" on the value of the collateral being ¿0. This will imply that an increase in the amount of collateralizable asset (in this case housing stock) they own, translates into a less than proportional increase in the resources available to borrow. The SS relative rental rate $\frac{p}{q^h} = 1 - \beta^{'}$ (determined such that assets have the same returns) implies that, given the perfect substitutability between renting and owning in terms of utility, a positive down-payment (m¡1) will make it suboptimal for the IHr to own (i.e. invest) in *any* amount housing stock. For the IHm, however, a sufficiently high "bias for owning", reflected in a sufficiently low γ, implies they can overcome the relatively high $\frac{q^h}{p}$ by buying a house "smaller" than the one they would otherwise rent, and using it to get a collateralized loan (a mortgage).

What the above means is that the collateral value of a house *per se* is not enough incentive for the impatient households to invest / buy a house. This is true more in general in this kind of set-ups where the assets are priced by the patient (unconstrained) guys, including Iacoviello (2005). What we are adding in our set-up is the assumption that, for some households, the services provided by a rented house are less valuable in terms of utility than the services provided by an own house.

The arguments above make use of the fact that owning a house and renting are substitutes in terms of the utility generated. This implies that an increase of Δ units of housing stock h generates the *same* increase in utility as an increase of $\frac{1}{\gamma}\Delta$ units of rented housing s^{+} (with $\gamma = 1$ in the case of IHr households):

$$u\left(h + \Delta + \gamma s^{+} - s^{-}\right) = u\left(h + \gamma\left(s^{+} + \frac{1}{\gamma}\Delta\right) - s^{-}\right) \tag{31}$$

The idea of the proof is to show that, in a SS equilibrium with active mortgage markets, the relative rental rate needs to be

$$p = q^h\left(1 - \beta^{'}\right)$$

in which case the PH will be indifferent between lending and buy-to-rent, and under which IHm will want to own for a sufficiently low γ. For $p > q^h\left(1 - \beta^{'}\right)$, the PH would prefer not to lend funds through the mortgage market, but to buy-to-let as much as possible. For such relative prices, we will see that the return of a buy-to-let strategy is such that $R^{buy-to-let} > R$. This would imply a collapse of the mortgage market and unbounded consumption growth, unless it bring the housing

price up and back to $p = q^h\left(1-\beta^{'}\right)$. For $p < q^h\left(1-\beta^{'}\right)$, it will be the case that neither PH nor IHm will be willing to engage in buy-to-let, and therefore no household will be willing to rent to IHr.

Patient Households' Problem

Recall the relevant optimality conditions of the PH for the housing and renting variables, assuming for the time being that there are no adjustment cost to changing housing

$$\begin{aligned}
\lambda_t^{'} q_t^h &= \frac{j_t}{\tilde{h}_t^{'}} + \beta^{'} E_t\left(\lambda_{t+1}^{'} q_{t+1}^h\right) + \lambda_t^{5'} \\
p_t \lambda_t^{'} &= \frac{j_t \gamma}{\tilde{h}_t^{'}} + \lambda_t^{7'} \\
p_t \lambda_t^{'} &= \frac{j_t}{\tilde{h}_t^{'}} + \lambda_t^{5'} - \lambda_t^{6'}
\end{aligned}$$

In SS these conditions imply

$$\lambda^{'} q\left(1-\beta^{'}\right) = \frac{j}{\tilde{h}^{'}} + \lambda^{5'} \tag{32}$$

$$\lambda^{'} p = \frac{j\gamma}{\tilde{h}^{'}} + \lambda^{7'} \tag{33}$$

$$\lambda^{'} p = \frac{j}{\tilde{h}^{'}} + \lambda^{5'} - \lambda^{6'} \tag{34}$$

I will now consider different cases regarding the choice of (h, s^+, s^-) in SS, and analyze their pricing and market clearing implications.

- Case I: Assume $\boldsymbol{s^{+'} = 0}$

  This implies that, due to Inada conditions, $h^{'} - s^{-'} > 0$ and therefore $\lambda^{5'} = 0, \lambda^{7'} \geq 0$ from the KT conditions. Now, we have two possibilities:

  - $\boldsymbol{\lambda^{6'} = 0}$: From equations (32) and (34) we then have that

    $$p = q^h\left(1-\beta^{'}\right) \tag{35}$$

    while the KT conditions require $s^{-'} \geq 0$. Is the relative rental rate (35) consistent with $s^{+'} = 0$ as assume above? To check this, assume that, while in SS, the household switches, once and for all, from 1 unit of rented housing to γ units of owned housing that are not rented out to other households, so that housing utility $u\left(\tilde{h}^{'}\right)$ remains the same. The resource cost at t is simply γq^h while the resource benefit at t and in the future are the rents not payed, $q^h\left(1-\beta^{'}\right)$. The net present value (NPV), or net resource gain is

    $$\begin{aligned}
    NPV &= q^h\left(1-\beta^{'}\right) - \gamma q^h + \beta^{'} \sum_{\tau=0}^{\infty} \beta^{'} q^h\left(1-\beta^{'}\right) \\
    &= q^h\left(1-\gamma\right)
    \end{aligned}$$

which is ¿0 for any value of γ.

What are the choices of IHr and IHm households given the relative prices in (35)? Consider the case of the IHm (the case of IHr is similar but with $\gamma = 1$). As above, assume that the household switches, once and for all, from 1 unit of rented housing to γ units of owned housing that are not rented out to other households, so that housing utility $u\left(\tilde{h}'\right)$ remains the same. The resource cost at t is γq^h while the resource benefit at t is the rent not paid, $q^h\left(1-\beta'\right)$ plus the extra amount the household can (and will, given the binding borrowing constraint) borrow, $\Delta b = \beta' m\gamma q^h$. The net resource gain **in the current period** is then

$$\Delta W_t = q^h\left(1-\beta'\right) + \beta' m\gamma q^h - \gamma q^h \tag{36}$$

From $t+1$ onwards, assuming nothing else changes, the household rolls over the debt and avoids paying rents. Therefore, the discounted value of all future gains starting in $t+1$ is

$$\begin{aligned} \Delta W_{\tau>0} &= \beta\sum_{\tau=0}^{\infty}\beta^{\tau}\left(q^h\left(1-\beta'\right) - \frac{1-\beta'}{\beta'}\beta' m\gamma q^h\right) \\ &= \frac{\beta}{1-\beta}q^h\left(1-\beta'\right)(1-m\gamma) \end{aligned} \tag{37}$$

Note that $\Delta W > 0$ for $\gamma < 1, m < 1$. The net resource change at t is positive if

$$\bar{\gamma}_t \equiv \frac{1-\beta'}{1-\beta' m} > \gamma$$

while the net (present value) of resource change is positive if

$$\begin{aligned} NPV \equiv \Delta W_t + \Delta W_{\tau>0} &> 0 \\ &\Leftrightarrow \\ \bar{\gamma} \equiv \frac{1-\beta'}{(1-\beta' m)(1-\beta) + m\beta(1-\beta')} &> \gamma \end{aligned}$$

In other words, for $\gamma < \bar{\gamma}$, IHm households prefer to buy houses with a mortgage, while it is optimal for IHr households to rent, since for them, $\gamma = 1$.

At the relative price $\frac{q^h}{p}$ implied by (35), a PH household is indifferent between buying an extra unit of housing stock to rent out to other other households, and not doing so (or lending it through the mortgage market). To see this, consider the following investment strategy: at t, buy one unit of housing at price q^h, and then rent it out. At $t+1$, sell that unit at price q^h. Given that the PH is not constrained in her borrowing capacity, she will not use this extra unit of housing as collateral to borrow. The net present value of this strategy in SS (recall again that the stochastic discount factor in SS is 1)

$$\begin{aligned} NPV &= q^h\left(1-\beta'\right) - q^h + \beta' q^h \\ &= 0 \end{aligned} \tag{38}$$

This is consistent with the condition $\lambda^{6'} = 0$ and $s^{-'} \geq 0$.

Is this investment strategy optimal for a constrained IHm? Since the IHm household uses the housing stock as collateral for borrowing more today, the NPV of a buy-to-let strategy would be

$$\begin{aligned} NPV_{invest} &= q^h\left(1-\beta^{'}\right) - q^h + \beta^{'} mq + \beta \sum_{\tau=0}^{\infty} \beta^{\tau} \left(q^h\left(1-\beta^{'}\right) - mq^h\left(1-\beta^{'}\right) \right) \\ &= q^h (1-m) \frac{\beta - \beta^{'}}{1-\beta} < 0 \end{aligned} \tag{39}$$

since $\beta < \beta^{'}$. Therefore, if $p = q^h\left(1-\beta^{'}\right)$, IHm households will not engage in buy-to-let, and IHr can only rent from patient households. We have one possible SS:

$$\left\{h > 0, s^{-} = s^{+} = 0\right\}; \left\{h^{'} > 0, s^{-'} > 0, s^{+'} = 0\right\};$$
$$\left\{h^{''} = s^{-''} = 0, s^{+''} > 0\right\}; p = q^h\left(1-\beta^{'}\right)$$

– $\underline{\boldsymbol{\lambda^{6'} > 0}}$: From the KT conditions, this implies $s^{-'} = 0$, and from eqs. (32) and (34), we have that

$$p < q^h\left(1-\beta^{'}\right) \tag{40}$$

With this relative prices, IHr have even more incentives to rent. However, since $s^{-'} = 0$, they can only rent from IHm households. The individual feasibility condition (29) rules out sub-letting; therefore, if an IHm household rents to an IHr household, it has to do so from their stock of housing. However, since a buy-to-let strategy, which keeps the utility from housing constant, has a negative NPV_{invest} when $p = q^h\left(1-\beta^{'}\right)$ as shown in (39) above, it will be more negative for $p < q^h\left(1-\beta^{'}\right)$. Therefore, this can not be an equilibrium in SS.

- Case II: Assume $\boldsymbol{s^{+'} > 0}$

This implies $\lambda^{7'} = 0$ from the KT conditions. Linearity within the housing utility implies it cannot be optimal for a household to rent and buy at the same time. Therefore it must be either that: (i) $h^{'} = s^{-'} > 0$, in which case the PH buys-to-let, or (ii) $h^{'} = s^{-'} = 0$. Lets consider these cases separately.

– $\underline{\boldsymbol{h^{'} = s^{-'} > 0}}$: In this case we have $\lambda^{6'} = 0$. From equations (32) and (33) it follows that

$$p = q^h\left(1-\beta^{'}\right) \tag{41}$$

Someone has to rent to the PH. However, as shown above in eq (39), when $p = q^h\left(1-\beta^{'}\right)$ it is not optimal for an IH household to buy-to-let. This cannot be an equilibrium.

– $\underline{\boldsymbol{h}' = \boldsymbol{s}^{-\prime} = \mathbf{0}}$: This means that the PH does not own houses, and rents from other households. In this case we have $\lambda^{5'} \geq 0, \lambda^{6'} \geq 0$ and therefore

$$p \leq \gamma q^h \left(1 - \beta'\right) \tag{42}$$

Note, however, that the relative price $\frac{q^h}{p}$ implied by (42) is even bigger than the one implied by (41). Therefore, we can conclude that it wont be optimal for either IH household to rent to the PH households. This cannot then be an equilibrium.

Impatient Households' Problem

Equation (38) above showed that, when $p = q^h \left(1 - \beta'\right)$, a buy-to-let strategy for the PH has NPV = 0. Note that the NVP of lending 1 consumption unit through the mortgage market is also 0 in SS:

$$\begin{aligned} NPV^{mortgage} &= -1 + \beta' R \\ &= -1 + \frac{\beta'}{\beta'} = 0 \end{aligned}$$

This implies that for $p > q^h \left(1 - \beta'\right)$, a patient household in SS will prefer to invest all resources in a buy-to-let strategy, since in that case we would have

$$R^{buy-to-let} > R = \frac{1}{\beta'}$$

and we are assuming no uncertainty. This would imply that the mortgage market would collapse unless house prices increase, since the PH would prefer to invest by a buy-to-let strategy rather than by mortgage lending. Moreover, since $R^{buy-to-let}\beta' > 1$, consumption would grow un-boundlessly This cannot be a SS equilibrium that satisfies a transversality condition.

We now proceed from the IHm households optimal conditions in order to check whether there is an alternative SS.

Without adjustment cost, the optimality conditions are

$$\begin{aligned} \lambda_t q_t^h &= \frac{j_t}{\tilde{h}_t} + \beta E_t \left(\lambda_{t+1} q_{t+1}^h\right) + E_t \left(m \lambda_{BC,t} q_{t+1}^h \pi_{t+1}\right) + \lambda_t^5 \\ p_t \lambda_t &= \frac{j_t \gamma}{\tilde{h}_t} + \lambda_t^7 \\ p_t \lambda_t &= \frac{j_t}{\tilde{h}_t} + \lambda_t^5 - \lambda_t^6 \end{aligned}$$

which in SS imply

$$\begin{aligned}\lambda q^h \left(1-\beta-m(\beta^{'}-\beta)\right) &= \frac{j}{\tilde{h}}+\lambda^5 \\ \lambda p &= \frac{j\gamma}{\tilde{h}}+\lambda^7 \\ \lambda p &= \frac{j}{\tilde{h}}+\lambda^5-\lambda^6\end{aligned}$$

- Case I: Assume $\boldsymbol{s^+=0}$

  This implies $\lambda^7 \geq 0$, and due to the inada conditions on $u\left(\tilde{h}\right)$, it must be that $h-s^- > 0$, implying $\lambda^5 = 0$. Now we can consider two cases:

  - $\boldsymbol{s^- > 0}$: then we have $\lambda^6 = 0$ which implies

$$p = q^h \left(1-\beta-m(\beta^{'}-\beta)\right) \tag{43}$$

    It is easy to check that, for such relative rental rate, switching from one rental unit to γ units of housing stock has a positive net resource gain for the IHm for any value of $\gamma < 1$, confirming indeed that it is optimal for the IHm to have $s^+ = 0$. For the IHr, the net resource gain (or NPV) of switching is

$$\begin{aligned}NPV &= q^h \left(1-\beta-m(\beta^{'}-\beta)\right)-q^h+\beta^{'}mq^h \\ &\quad +\frac{\beta}{1-\beta}\left(q^h\left(1-\beta-m(\beta^{'}-\beta)\right)-(1-\beta^{'})mq^h\right) \\ &= 0\end{aligned}$$

    implying they are indifferent between renting and buying.

    As argued above, however, the relative prices in (43) imply that the PH would prefer to engage in buy-to-let rather than lend through the mortgage market, and her consumption would grow un-boundlessly since the return of such strategy would satisfy $R^{buy-to-let}\beta^{'} > 1$. This **cannot** be a SS equilibrium, since it would violate a transversality condition.

  - $\boldsymbol{s^- = 0}$: We then have $s^- = s^+ = 0$ and $\lambda^5 = 0$, $\lambda^6, \lambda^7 \geq 0$. From the FOCs in SS, we have that this is an optimal choice if

$$p = q^h \left(1-\beta-m(\beta^{'}-\beta)\right)-\frac{\lambda^6}{\lambda} \leq q^h \left(1-\beta-m(\beta^{'}-\beta)\right)$$

    and

$$p = \gamma q^h \left(1-\beta-m(\beta^{'}-\beta)\right)+\frac{\lambda^7}{\lambda} \geq \gamma q^h \left(1-\beta-m(\beta^{'}-\beta)\right)$$

BANCO DE ESPAÑA PUBLICATIONS

WORKING PAPERS

1701 JAVIER ANDRÉS, JAVIER J. PÉREZ and JUAN A. ROJAS: Implicit public debt thresholds: an empirical exercise for the case of Spain.

1702 LUIS J. ÁLVAREZ: Business cycle estimation with high-pass and band-pass local polynomial regression.

1703 ENRIQUE MORAL-BENITO, PAUL ALLISON and RICHARD WILLIAMS: Dynamic panel data modelling using maximum likelihood: an alternative to Arellano-Bond.

1704 MIKEL BEDAYO: Creating associations as a substitute for direct bank credit. Evidence from Belgium.

1705 MARÍA DOLORES GADEA-RIVAS, ANA GÓMEZ-LOSCOS and DANILO LEIVA-LEON: The evolution of regional economic interlinkages in Europe.

1706 ESTEBAN GARCÍA-MIRALLES: The crucial role of social welfare criteria for optimal inheritance taxation.

1707 MÓNICA CORREA-LÓPEZ and RAFAEL DOMÉNECH: Service regulations, input prices and export volumes: evidence from a panel of manufacturing firms.

1708 MARÍA DOLORES GADEA, ANA GÓMEZ-LOSCOS and GABRIEL PÉREZ-QUIRÓS: Dissecting US recoveries.

1709 CARLOS SANZ: Direct democracy and government size: evidence from Spain.

1710 HENRIQUE S. BASSO and JAMES COSTAIN: Fiscal delegation in a monetary union: instrument assignment and stabilization properties.

1711 IVÁN KATARYNIUK and JAIME MARTÍNEZ-MARTÍN: TFP growth and commodity prices in emerging economies.

1712 SEBASTIAN GECHERT, CHRISTOPH PAETZ and PALOMA VILLANUEVA: Top-down vs. bottom-up? Reconciling the effects of tax and transfer shocks on output.

1713 KNUT ARE AASTVEIT, FRANCESCO FURLANETTO and FRANCESCA LORIA: Has the Fed responded to house and stock prices? A time-varying analysis.

1714 FÁTIMA HERRANZ GONZÁLEZ and CARMEN MARTÍNEZ-CARRASCAL: The impact of firms' financial position on fixed investment and employment. An analysis for Spain.

1715 SERGIO MAYORDOMO, ANTONIO MORENO, STEVEN ONGENA and MARÍA RODRÍGUEZ-MORENO: "Keeping it personal" or "getting real"? On the drivers and effectiveness of personal versus real loan guarantees.

1716 FRANCESCO FURLANETTO and ØRJAN ROBSTAD: Immigration and the macroeconomy: some new empirical evidence.

1717 ALBERTO FUERTES: Exchange rate regime and external adjustment: an empirical investigation for the U.S.

1718 CRISTINA GUILLAMÓN, ENRIQUE MORAL-BENITO and SERGIO PUENTE: High growth firms in employment and productivity: dynamic interactions and the role of financial constraints.

1719 PAULO SOARES ESTEVES and ELVIRA PRADES: On domestic demand and export performance in the euro area countries: does export concentration matter?

1720 LUIS J. ÁLVAREZ and ANA GÓMEZ-LOSCOS: A menu on output gap estimation methods.

1721 PAULA GIL, FRANCISCO MARTÍ, JAVIER J. PÉREZ, ROBERTO RAMOS and RICHARD MORRIS: The output effects of tax changes: narrative evidence from Spain.

1722 RICARDO GIMENO and ALFREDO IBÁÑEZ: The eurozone (expected) inflation: an option's eyes view.

1723 MIGUEL ANTÓN, SERGIO MAYORDOMO and MARÍA RODRÍGUEZ-MORENO: Dealing with dealers: sovereign CDS comovements.

1724 JOSÉ MANUEL MONTERO: Pricing decisions under financial frictions: evidence from the WDN survey.

1725 MARIO ALLOZA: The impact of taxes on income mobility.

1726 DANILO LEIVA-LEON: Measuring business cycles intra-synchronization in US: a regime-switching interdependence framework.

1727 PIERRE GUÉRIN and DANILO LEIVA-LEON: Model averaging in Markov-Switching models: predicting national recessions with regional data.

1728 MÁXIMO CAMACHO and DANILO LEIVA-LEON: The propagation of industrial business cycles.

1729 JAMES COSTAIN: Costly decisions and sequential bargaining.

1730 MARIO ALLOZA: Is fiscal policy more effective in uncertain times or during recessions?

1731 PIERRE GUÉRIN and DANILO LEIVA-LEON: Monetary policy, stock market and sectoral comovement.

1732 HENRIK JENSEN, IVAN PETRELLA, SØREN HOVE RAVN and EMILIANO SANTORO: Leverage and deepening business cycle skewness.

1733 CÉSAR MARTÍN MACHUCA: External stress early warning indicators.

1734 RODOLFO G. CAMPOS: International migration pressures in the long run.
1735 ANDREA ARIU, ELENA BIEWEN, SVEN BLANK, GUILLAUME GAULIER, MARÍA JESÚS GONZÁLEZ, PHILIPP MEINEN, DANIEL MIRZA, CÉSAR MARTÍN MACHUCA and PATRY TELLO: Firm heterogeneity and aggregate business services exports: micro evidence from Belgium, France, Germany and Spain.
1736 LEONARDO GAMBACORTA, STEFANO SCHIAFFI and ADRIAN VAN RIXTEL: Changing business models in international bank funding.
1737 ENRIQUE MORAL-BENITO and FRANCESCA VIANI: An anatomy of the Spanish current account adjustment: the role of permanent and transitory factors.
1738 MARÍA J. NIETO and LARRY D. WALL: Cross-border banking on the two sides of the Atlantic: does it have an impact on bank crisis management?
1739 JACOPO TIMINI: Currency unions and heterogeneous trade effects: the case of the Latin Monetary Union.
1740 PAULINO FONT, MARIO IZQUIERDO and SERGIO PUENTE: Subsidising mature age employment or throwing coins into a wishing well: a quasi-experimental analysis.
1741 THOMAS FUJIWARA and CARLOS SANZ: Norms in bargaining: evidence from government formation in Spain.
1742 ENRIQUE ALBEROLA, ÁNGEL ESTRADA and FRANCESCA VIANI: Global imbalances from a stock perspective.
1743 ÓSCAR ARCE, RICARDO GIMENO and SERGIO MAYORDOMO: Making room for the needy: the credit-reallocation effects of the ECB's corporate QE.
1744 M. D. GADEA-RIVAS, ANA GÓMEZ-LOSCOS and EDUARDO BANDRÉS: Clustering regional business cycles.
1745 NEZIH GUNER, YULIYA KULIKOVA and JOAN LLULL: Marriage and health: selection, protection, and assortative mating.
1746 SERGIO MAYORDOMO and MARÍA RODRÍGUEZ-MORENO: Did the bank capital relief induced by the supporting factor enhance SME lending?
1747 KATALIN BODNÁR, LUDMILA FADEJEVA, MARCO HOEBERICHTS, MARIO IZQUIERDO PEINADO, CHRISTOPHE JADEAU and ELIANA VIVIANO: Credit shocks and the European Labour market.
1748 PIERRE GUÉRIN, DANILO LEIVA-LEON and MASSIMILIANO MARCELLINO: Markov-switching three-pass regression filter.
1749 ISABEL ARGIMÓN: Decentralized multinational banks and risk taking: the Spanish experience in the crisis.
1750 BING XU: Permissible collateral and access to finance: evidence from a quasi-natural experiment.
1751 GERGELY AKOS GANICS: Optimal density forecast combinations.
1801 OLYMPIA BOVER, LAURA HOSPIDO and ERNESTO VILLANUEVA: The impact of high school financial education on financial knowledge and choices: evidence from a randomized trial in Spain.
1802 IGNACIO HERNANDO, IRENE PABLOS, DANIEL SANTABÁRBARA and JAVIER VALLÉS: Private Saving. New Cross-Country Evidence Based on Bayesian Techniques.
1803 PABLO AGUILAR and JESÚS VÁZQUEZ: Term structure and real-time learning.
1804 MORITZ A. ROTH: International co-movements in recessions.
1805 ANGELA ABBATE and DOMINIK THALER: Monetary policy and the asset risk-taking channel.
1806 PABLO MARTÍN-ACEÑA: Money in Spain. New historical statistics. 1830-1998.
1807 GUILHERME BANDEIRA: Fiscal transfers in a monetary union with sovereign risk.
1808 MIGUEL GARCÍA-POSADA GÓMEZ: Credit constraints, firm investment and growth: evidence from survey data.
1809 LAURA ALFARO, MANUEL GARCÍA-SANTANA and ENRIQUE MORAL-BENITO: On the direct and indirect real effects of credit supply shocks.
1810 ROBERTO RAMOS and CARLOS SANZ: Backing the incumbent in difficult times: the electoral impact of wildfires.
1811 GABRIEL JIMÉNEZ, ENRIQUE MORAL-BENITO and RAQUEL VEGAS: Bank lending standards over the cycle: the role of firms' productivity and credit risk.
1812 JUAN S. MORA-SANGUINETTI and ROK SPRUK: Industry vs services: do enforcement institutions matter for specialization patterns? Disaggregated evidence from Spain.
1813 JAMES CLOYNE, CLODOMIRO FERREIRA and PAOLO SURICO: Monetary policy when households have debt: new evidence on the transmission mechanism.

BANCO DE **ESPAÑA**
Eurosistema

Unidad de Servicios Auxiliares
Alcalá, 48 - 28014 Madrid
E-mail: publicaciones@bde.es
www.bde.es