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Household debt and labour supply

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Abstract

In this paper, we first develop a theoretical framework with three types of household: outright homeowners, mortgagors and renters. We then examine empirically how household debt affects the response of labour supply to shocks to income, mortgage interest rates and house prices for each type of household. In line with our framework, we find that negative income shocks lead to lower participation among outright homeowners while increasing mortgagors' desired hours; surprise rises in interest rates lead to increases in desired hours that are larger the higher is the household's debt level; and falls in house prices increase mortgagors' desired hours.

Key words: Household debt, housing, labour supply, participation, hours worked.

JEL classification: D1, E21, J22.

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1 Introduction and motivation

The aim of this paper is to assess the link between household debt and labour supply. In order to do this, we first develop a theoretical framework within which we can examine the behaviour of three types of household: outright homeowners, mortgagors and renters. We use the model to generate some testable hypotheses as to the extent to which the gross level of household debt is related to labour supply (ie, participation and hours worked) and how it affects the response of labour supply to shocks to income, mortgage interest rates and house prices. We then examine whether microeconomic data for the United Kingdom supports these hypotheses.

We motivate this paper with two features of recent UK macroeconomic data. First, as shown in Chart 1, below, household debt – both mortgage debt and total debt – increased considerably as a proportion of household income in the lead-up to the financial crisis and remains relatively high. Second, labour force participation remained high and stable during and after the recession while employment remained higher than we might have expected given its previous relationship with GDP (Chart 2). The question asked by this paper is whether higher household debt may have led to a greater labour supply response to the income, credit and house price shocks experienced by households at the time of the financial crisis than we might otherwise have expected. If this is the case, we can bring all these stylised facts together.

Chart 1: Household debt to income ratio

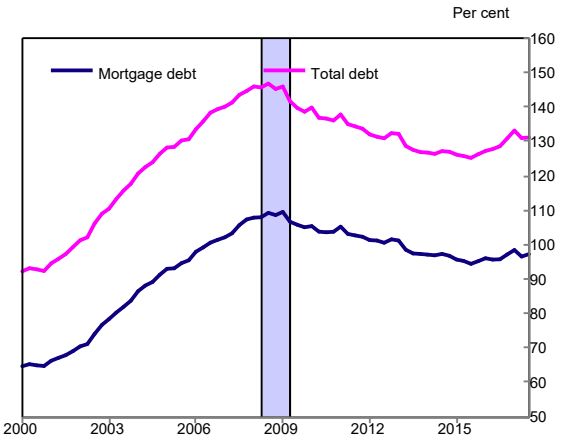
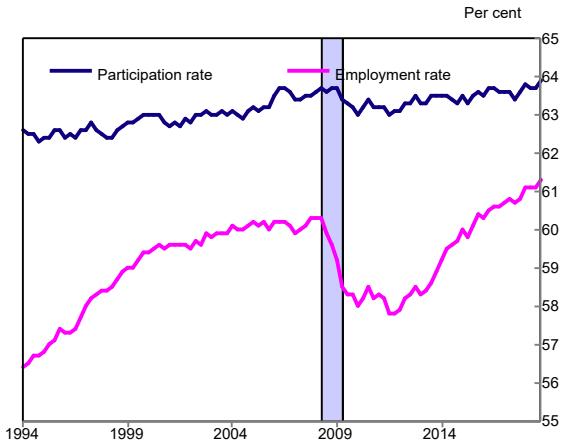


Chart 2: Employment and participation rates



Further motivation for this work is provided by UK survey evidence. In particular, the Bank of England/NMG Survey of Household Finances suggests that households consider their labour supply an important margin of adjustment available to them when facing debt constraints.[1] Chart 3 shows how households respond either to being concerned about their debt or to facing higher mortgage payments due to increasing interest rates. The red and yellow lines show that the majority of households report that they would cut back their spending, a channel that has received a lot of attention in the literature, eg, Mian *et al.* (2013) and Cloyne *et al.* (2016). But, around 20-

[1] The Bank of England/NMG Survey of Household Finances is a household survey carried out by NMG Consulting on behalf of the Bank of England covering households' finances and expectations.

30% say they would increase their labour supply. Furthermore, when asked how they would respond to a hypothetical 20% fall in their household income, nearly 25% of households say they would respond by increasing their labour supply. Breaking this down by tenure, mortgagors are much more likely to increase their labour supply than outright owners, suggesting that balance sheets could play an important role in explaining which households adjust their labour supply in response to shocks.

Chart 3: How households respond to being concerned about their debt and higher mortgage rates, NMG

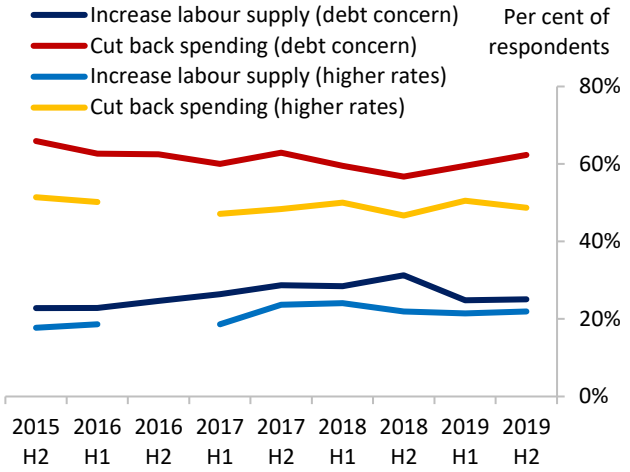
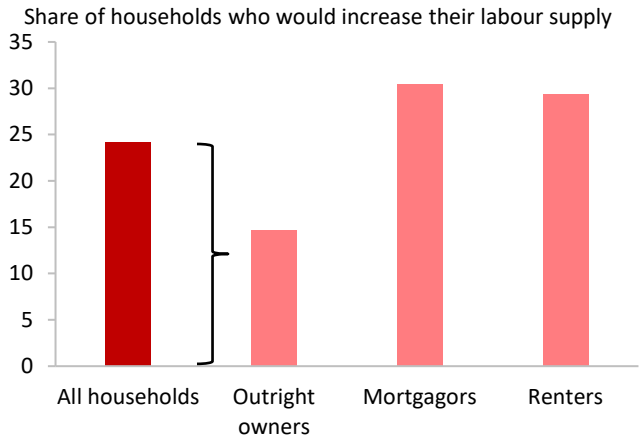


Chart 4: How households would respond to a hypothetical 20% fall in income, NMG



In this paper, we first develop a framework within which we can examine the implications of the rise in household debt for labour supply and how the level of household debt affects the response of labour supply (ie, participation and average hours) to shocks at the microeconomic level. Our framework augments the model of Iacoviello (2015) in which there are two types of households – savers and borrowers – by adding renters. Each type of household obtains utility from consumption, housing and leisure. The savers – whom we refer to as 'outright homeowners' – hold financial assets and housing, some of which they rent out to renters. The borrowers – whom we refer to as mortgagors – are subject to a collateral constraint affecting their borrowing. The renters spend their entire income on consumption of goods and housing services (ie, renting).

We use this framework to generate some hypotheses that we can take to the microeconomic data. In particular, the model suggests that higher wealth (both housing and financial) is associated with lower labour supply and higher household debt is associated with higher labour supply. For mortgagors, a surprise fall in wages (eg, resulting from a member of the household losing their job) leads to an increase in labour supply (eg, an increase in participation or hours of other member(s) of the household), whereas for outright owners, the same shock leads to a fall in labour supply. For renters, their labour supply response to a wage shock will depend on their intertemporal elasticity of substitution. Surprise rises in interest rates are associated with

increases in labour supply and this effect is rising in the initial level of household debt. Finally, for mortgagors, a surprise fall in house prices leads to an increase in labour supply.

Given these hypotheses, we then test them, making use of available data from the Labour Force Survey (LFS) and the Wealth and Assets Survey (WAS). More specifically, our microeconometric analysis exploits variation across regions and households in how individuals and cohorts respond to shocks, specifically shocks to household income, mortgage interest rates and house prices, by altering their labour supply. Our main specifications use the panel element of the LFS to explore these responses by housing tenure, which we use to proxy for households' balance sheets, along the lines of Cloyne *et al.* (2016). We then extend this analysis using the WAS, from which we can estimate the contribution of personal and household characteristics in determining housing wealth and household debt. We then use these estimated relationships in conjunction with LFS microdata to predict levels of debt for households that participate in the LFS survey. In this way, we take advantage of the greater cross-sectional detail in the LFS while still exploiting the granular wealth and debt information contained in the WAS. We use this composite dataset to examine further how labour supply responses within mortgagors vary by debt level.

A key issue with our microeconometric analysis is identification. Clearly, the causality between decisions to take on debt and to supply labour can go both ways: households might choose to take on more debt if they supply more labour and have higher income, or they might be more likely to supply more labour if they have a higher level of outstanding debt to service. This is likely to be particularly true for mortgage debt since failure to keep up with mortgage interest payments can potentially lead to the loss of your home. We address the identification problem by focussing on how labour supply responds to a set of exogenous shocks. In particular, we focus on the difference between changes in labour supply in response to shocks of outright homeowners, mortgagors and renters, given that shocks are likely to affect these three types of household differently. This is similar to the approach taken by Bunn and Rostom (2016) in the context of analysing the relationship between debt and consumption.

The remainder of the paper is structured as follows. In the next section, we briefly review the literature that is most relevant to our paper before going on to describe our theoretical framework in Section 3. Section 4 describes the data we are using in our work and generates some useful 'stylised facts' about labour supply for different types of household. Section 5 describes our empirical approach and Sections 6 and 7 describe our results. Section 8 presents some robustness checks and Section 9 concludes.

2 Literature review

There is a relatively large literature concentrating on the impact of households' balance sheets on their behaviour, which has received particular interest since the global financial crisis. But, little work has considered the impact of household debt on labour supply. Instead, many papers have shown household debt to have a significant effect on households' consumption, particularly in

response to shocks. Mian *et al.* (2013), for example, exploit heterogeneity in household balance sheets by ZIP code to show that ZIP codes with more levered households experienced much larger falls in consumption during the 2006-9 house price collapse in the United States. They show that this appears to be driven by larger reductions in credit limits and the likelihood of refinancing in these neighbourhoods. Similarly, Bunn and Rostom (2016) use household level microdata from the Living Costs and Food Survey to show that more highly indebted households cut their spending by more during the financial crisis. They find that this might have reduced the level of aggregate private consumption by up to 2% after 2007. Cloyne *et al.* (2016) examine how households' balance sheet positions affect the transmission of monetary policy to consumption. Because they do not observe debt and assets directly, they use a household's tenure status to proxy for it (assuming mortgagors have debt, outright owners have debt and assets, and renters have neither). They find that the vast majority of the consumption response to a temporary interest rate shock is driven by mortgagors (with the consumption of outright owners not responding at all).

Moving beyond consumption, Bracke *et al*. (2018) study the effects of mortgage debt on entrepreneurship. They create a model where agents choose their occupation as either dependent workers or entrepreneurs, conditional on their housing tenure and the extent of their mortgage debt. They then empirically test the predictions of the model using both individual and housing-spell fixed-effects specifications, and instrument for loan-to-value ratios (LTVs) using variation in national house prices in the year of purchase interacted with local supply proxies. Their model predicts that, as long as the mortgage interest rate exceeds the risk-free rate, mortgage debt diminishes the likelihood of entrepreneurship by amplifying risk aversion, and this negative relationship strengthens with income volatility. It also predicts that an increase in housing equity will have an ambiguous effect because of competing wealth and portfolio effects. Empirically, they find that a one standard deviation increase in leverage reduces the probability of entrepreneurship by 10-20%. Unlike this paper, their focus is more on risky investment rather than participation: in their model, all agents are employed and simply choose between dependent employment and entrepreneurship.

Existing research into the link between labour supply and household debt has tended to concentrate on the link between participation and debt at the level of the individual household. Fortin (1995) and Aldershof *et al*. (1997) address directly our question of how debt affects labour supply. They both find that mortgage commitments have a significant effect on the labour supply of married women. However, unlike us, they only consider the labour participation of married women rather than of households, and they assume mortgage commitments are exogenous, ie, they do not control for possible reverse causality. Bottazzi (2002) takes a similar approach, but attempts to address the potential endogeneity. She does this in two ways: first, her main specification captures individual fixed effects, allowing her to control for individual unobserved heterogeneity, and, second, she separately performs a test for any additional endogeneity of the mortgage variable, rejecting the null of no endogeneity. But, again, she only focuses on the labour participation of married women, and although she tests for endogeneity, she does not attempt to control for it in her empirical analysis. In our work, we examine the participation of all the individuals in our sample while also controlling for endogeneity.

Bottazzi *et al*. (2004) examine why home owners with large mortgage debt work longer hours than those who own their homes outright. They first report life-cycle patterns and correlations of home ownership and labour supply in the British Household Panel Survey (BHPS) and use these to calibrate a structural model and conduct life-cycle simulations. They find that labour supply is non-linear in the level of debt, being particularly responsive only at high levels of debt. They also find that participation is not responsive to the debt to house price ratio, but rather the DSR. This suggests that flows are more important than the total stock of debt. Finally, they find that large current liabilities, in combination with low current head-of-household income, leads to an increase in non-head-of-household labour supply. The main limitation of this work is that they only use the microeconometric data to identify correlations and features in the data that could then be replicated in the simulated structural model. In contrast, we use the microeconometric data as a test of the predictions of our structural model.

Farnham and Sevak (2015) also address the effect of debt on labour supply, but focus on the age of retirement, rather than female participation. Using a linear probability model, they find that debt has no effect on the actual retirement age. But using a panel fixed effects approach, they do find a significant effect of debt on households' expectations of when they will retire. They suggest that these apparently inconsistent results are driven by the fact that the expectations model controls for unobserved heterogeneity through the individual fixed effects.

Following a long literature (eg, Layard *et al.* (1980) and Lundberg (1985)) examining the 'added worker' and 'discouraged worker' effects, Benito and Saleheen (2013) estimate the impact of exogenous financial shocks on participation. The financial shock measure is constructed using individuals' expected change to their financial situation in the year ahead relative to the perceived outcome one year later. They estimate a dynamic random effects probit model using BHPS data and find that both men and women adjust their hours in response to financial shocks. The probability of participating in the labour market also appears to respond to this shock, but this result is less robust. Bryan and Longhi (2018) examine whether the labour supply response of the 'second earner' in the household to the 'first earner' losing their job varies with the business cycle. The find evidence for both an added-worker and a discouraged-worker effect and that couples tend to increase their labour market attachment in a recession, with larger positive labour supply responses and smaller negative labour supply responses. In our work, we examine whether being an outright-owner or a mortgagor can explain whether we see an added or a discouraged worker effect.

Finally, a number of recent papers have looked specifically at the links between the housing market and labour force participation, hours and employment. Disney and Gathergood (2018) examine the effect of changes in house prices on labour supply (both in terms of hours worked and participation). They estimate the effect of higher house prices on both household hours worked and on household participation using a difference in differences specification by homeownership status (with renters as the control group). They also perform a robustness check where they instrument self-reported house prices with local authority prices, which produces similar results. They find that other than for young married/cohabiting women, there is no

evidence of a statistically significant effect of house prices on hours of work. But, for young married/cohabiting women, they find that for homeowners, higher house prices have a significant negative effect on hours of work, and for renters higher house prices have a positive (but insignificant) effect. They also find that higher house prices decrease the likelihood of participation among young married/cohabiting women, and among all older men and that moving activity biases the main result downwards: excluding home-movers causes the absolute value of the coefficients to increase. Part of the reason the participation effect appears stronger than the hours effect might be that participation captures those who want to work but cannot, whereas they can only observe actual hours worked, rather than desired hours.

In contrast to the microeconometric analysis of Disney and Gathergood (2018) and our paper, Pinter (2019) studies the co-movement between house prices and job losses at the macroeconomic level. He first uses a structural vector autoregression model (SVAR) to examine the effects of house price shocks on macro variables before developing an estimated DSGE model. He finds that shocks to housing demand explain 10-20% of output fluctuations and 20-30% of labour market fluctuations. His model suggests that this effect occurs through a collateral channel, in much the same vein as Kiyotaki and Moore (1997), but on the household side.

In our work, we seek to combine the econometric and modelling approaches by developing a theoretical framework for household behaviour at the microeconomic level and testing the predictions of this framework using the microeconomic data.

3 A theoretical framework

In this section, we develop a simple microeconomic framework, which enables us to generate some hypotheses that we can then take to the data. Our framework augments the model of Iacoviello (2015) in which there are two types of households – savers (who we equate with 'outright homeowners') and borrowers (who we equate with 'mortgagors') – by adding renters. We assume that renters cannot access loans, ie, live 'hand-to-mouth'. We discuss the problem facing each type of household in turn and generate hypotheses as to how the labour supplied by each type of household is related to its characteristics. We also use the model to show how household labour supply responds to different shocks – to wages, interest rates and house prices – for each type of household. Note that we are only considering the partial equilibrium effects of each shock on each type of household. We are not considering general equilibrium effects or the underlying causes of movements in wages, interest rates or house prices.

3.1 Outright Homeowners

We start with the maximisation problem for households who own their homes outright. Each household will want to maximise the present discounted value of their current and future expected flows of utility. They obtain utility from consumption, the consumption of housing services and leisure. They treat the real interest rate, real wages, real house prices and the real rental rate on housing as exogenous.

Mathematically, we can write the problem for household *j* as:

Maximise $E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_{j,t}^{1-\sigma}-1}{1-\sigma} + \varphi ln HS_{j,t} - \frac{1}{1+\xi} h_{j,t}^{1+\xi} \right)$

Subject to $A_{j,t} = r_{H,t} q_t \left(H_j - HS_{j,t} \right) + (1 + r_{t-1}) A_{j,t-1} + w_{j,t} h_{j,t} - c_{j,t}$

Where c_j denotes consumption of household *j*, H_j denotes the housing stock owned by household *j*, HS_j denotes the housing services consumed by household *j*, h_j denotes the labour supplied by household *j*, A_j denotes household *j*'s (end-of-period) real holdings of financial wealth, q is the real price of a unit of the housing stock, r_H denotes the real rental cost of housing, r is the real interest rate earned on financial wealth and w_j is the real wage rate for household *j*. Note that we have assumed these households hold more housing than they wish to consume, renting the difference out to the renters. Furthermore, since these households hold assets, they are not subject to credit constraints that might prevent consumption smoothing.

The first-order conditions for this problem imply:

$$c_{j,t}^{-\sigma} = \beta (1 + r_t) E_t c_{j,t+1}^{-\sigma} \quad \textbf{(1)}$$

$$HS_{j,t} = \frac{\varphi c_{j,t}^{\sigma}}{r_{H,t} q_t} \quad \textbf{(2)}$$

$$w_{j,t} = {h_{j,t}}^{\xi} c_{j,t}^{\sigma} \quad \textbf{(3)}$$

3.1.1 Comparative statics

In steady state, the budget constraint, combined with equation **(3)**, implies:

$$0 = r_H q \left(H_j - HS_j \right) + rA + w_j h_j - \left(w_j {h_j}^{-\xi} \right)^{\frac{1}{\sigma}} \quad \textbf{(4)}$$

Combine equations **(2)** and **(3)** gives:

$$r_H q HS_j = \varphi w_j {h_j}^{-\xi} \quad \textbf{(5)}$$

Substituting into equation **(4)** gives:

$$0 = q r_H H_j - \varphi w_j {h_j}^{-\xi} + rA + w_j h_j - \left(w_j {h_j}^{-\xi} \right)^{\frac{1}{\sigma}} \quad \textbf{(6)}$$

Total differentiation implies,

$$\partial h_j = \frac{\left(\frac{c_j}{\sigma}+r_H q H S_j - w_j h_j\right)}{w_j\left(w_j+\xi\varphi\frac{c_j^{\sigma}}{h_j}+\frac{\xi c_j}{\sigma h_j}\right)}\partial w_j - \frac{A}{w_j+\xi\varphi\frac{c_j^{\sigma}}{h_j}+\frac{\xi c_j}{\sigma h_j}}\partial r - \frac{qH_j}{w_j+\xi\varphi\frac{c_j^{\sigma}}{h_j}+\frac{\xi c_j}{\sigma h_j}}\partial r_H - \frac{r_H H_j}{w_j+\xi\varphi\frac{c_j^{\sigma}}{h_j}+\frac{\xi c_j}{\sigma h_j}}\partial q - \frac{r_H q}{w_j+\xi\varphi\frac{c_j^{\sigma}}{h_j}+\frac{\xi c_j}{\sigma h_j}}\partial H_j - \frac{r}{w_j+\xi\varphi\frac{c_j^{\sigma}}{h_j}+\frac{\xi c_j}{\sigma h_j}}\partial A \quad \textbf{(7)}$$

This leads us to proposition 1.

Proposition 1
For outright homeowners, a lower real interest rate, a lower real rental rate on housing, lower house prices, and lower housing and financial wealth are all associated with higher labour supply. For typical values of σ (ie, close to unity), higher real wages will be associated with higher labour supply.

Proof
Follows directly from equation **(7)**.

3.1.2 Shocks

Here we examine the responses of labour supply (ie, total hours) for a household that owns its home outright to temporary shocks to house prices, real interest rates and wages. To get at this, we log-linearise the first-order conditions for the owner-occupying household. This implies:

$$\widehat{c_{J,t}} = E_t\widehat{c_{J,t+1}} - \frac{1}{\sigma}r_t \quad \textbf{(8)}$$

$$\widehat{HS_{J,t}} = \sigma\widehat{c_{J,t}} - \widehat{r_{H,t}} - \widehat{q_t} \quad \textbf{(9)}$$

$$\widehat{w_{J,t}} = \xi\widehat{h_{J,t}} + \sigma\widehat{c_{J,t}} \quad \textbf{(10)}$$

Holding expectations of future consumption fixed, equation **(8)** suggests that a rise in real interest rates will lead to a fall in consumption as households tilt their intertemporal consumption path. Hence, from equation **(10)**, labour supply increases. Equation **(8)** also implies that consumption will be unaffected by shocks that do not affect the real interest rate or expectations of future consumption. That is, because these households are not subject to credit constraints, they will act to smooth consumption unless the relative price of consumption today vis-à-vis consumption tomorrow (ie, the real interest rate) changes. Hence, for an individual household that takes the real interest rate as given, equation **(10)** implies that a fall in the real wage will lead to a fall in labour supply. Similarly, equations **(9)** and **(10)** imply that an increase in house prices or the rental rate on housing will lead to a fall in housing consumed by an outright owner household and an increase in housing rented out by them with no effect on labour supply.

We summarise this discussion in proposition 2.

Proposition 2
For outright homeowners, a surprise increase in wages or a surprise increase in interest rates will lead to a rise in labour supply. A surprise increase in house prices or the rental rate on housing has no effect on labour supply.

Proof
Follows from the proceeding discussion.

3.2 Mortgage-holding households

We again assume that 'mortgage holders' will want to maximise the present discounted value of their current and future expected flows of utility. They obtain utility from consumption and housing services and have disutility from working. We assume that they do not rent their housing to renters, nor do they rent housing from outright homeowners. As a result, 'housing services' will be equivalent to 'housing stock' for these agents. They borrow from the banks and this borrowing is subject to a collateral constraint. Again, they treat the real mortgage interest rate, real wages and real house prices as exogenous. Mathematically, we can write the problem for mortgage-holding household, *i*, as:

$$\text{Maximise} \quad E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_{i,t}^{1-\sigma}-1}{1-\sigma} + \varphi ln H_i - \frac{1}{1+\xi} h_{i,t}^{1+\xi} \right)$$

$$\text{Subject to} \quad L_{i,t} = \left(1 + r_{L,t-1}\right) L_{i,t-1} - w_{i,t} h_{i,t} + c_{i,t} \qquad \textbf{(11)}$$

$$L_{i,t} = LTV q_t H_i \qquad \textbf{(12)}$$

Where c_i denotes consumption of household *i*, H_i denotes the housing stock owned by/housing services consumed by household *i*, h_i denotes the labour supplied by household *i*, L_i denotes real bank lending to household *i*, r_L is the real interest rate paid on bank loans and w_i is the real wage rate for household *i*. Equation **(12)** is the collateral constraint, which states that household *i* can only borrow up to a fraction, *LTV*, of the value of their housing stock.
The first-order conditions for this problem imply:

$$c_{i,t}^{-\sigma}(1-\mu_t) = \beta\left(1 + r_{L,t}\right) E_t c_{i,t+1}^{-\sigma} \qquad \textbf{(13)}$$

$$w_{i,t} = {h_{i,t}}^{\xi} c_{i,t}^{\sigma} \qquad \textbf{(14)}$$

Where μ is the Lagrange multiplier on the collateral constraint. Note that equation **(13)** simply defines μ, so we can drop it from the analysis that follows. The equation makes clear that mortgagors are not able to smooth consumption to the extent that they would wish given that they

are credit-constrained. The Lagrange multiplier, μ, measures the value to the mortgagors of this constraint being relaxed.

3.2.1 Comparative statics

In steady state, combining equations **(11)** and **(14)** implies:

$$w_i h_i = r_L L_i + w_i^{\frac{1}{\sigma}} h_i^{-\frac{\xi}{\sigma}} \quad \textbf{(15)}$$

Total differentiation implies,

$$\partial h_I = \frac{L}{w_i + \frac{\xi c_i}{\sigma h_i}} \partial r_L + \frac{r_L}{w_i + \frac{\xi c_i}{\sigma h_i}} \partial L + \frac{\frac{c_i}{\sigma} - w_i h_i}{w_i\left(w_i + \frac{\xi c_i}{\sigma h_i}\right)} \partial w_I \quad \textbf{(16)}$$

This leads us to proposition 3.

Proposition 3
For mortgage holders, higher lending rates (tighter conditions more generally) or higher household debt will be associated with higher labour supply. The effect of higher lending rates on labour supply will be greater the higher is the initial level of debt. The effect of a higher real wage is ambiguous and will depend upon whether the positive substitution effect, $\frac{c_i}{\sigma}$, outweighs the wealth effect, $w_i h_i$. For log utility (ie, σ equal to unity), higher real wages will be associated with lower labour supply.

Proof
Follows directly from equation **(16)**.

3.2.2 Shocks

Here, we examine the responses of labour supply and debt to shocks to house prices, mortgage interest rates and wages. To get at this, we log-linearise the first-order conditions for the mortgage-holding household. This implies:

$$\left(\widehat{w_{i,t}} + \widehat{h_{i,t}}\right) + \frac{L_i}{w_i h_i}\left(\widehat{L_{i,t}} - \left((1 + r_L)\widehat{L_{i,t-1}} + r_{L,t-1}\right)\right) = \frac{c_i}{w_i h_i}\widehat{c_{i,t}} \quad \textbf{(17)}$$

$$\widehat{L_{i,t}} = \widehat{q_t} \quad \textbf{(18)}$$

$$\widehat{w_{i,t}} = \xi\widehat{h_{i,t}} + \sigma\widehat{c_{i,t}} \quad \textbf{(19)}$$

From the budget constraint (equation **(17)**) we can see that an increase in the initial level of debt or the mortgage interest rate will lead, other things equal, to a rise in labour supply. Now equation **(18)** suggests that a rise in house prices will lead to a rise in borrowing. This rise in borrowing

will lead, initially, to a rise in consumption and, since leisure is a normal good, a fall in labour supply. However, next period's labour supply will have to rise in order to enable the household to cover their increased debt service burden. Finally, a fall in wages has an ambiguous effect on labour supply depending on whether or not the positive wealth effect (resulting from lower consumption) outweighs the negative substitution effect. We examine this proposition empirically by looking at the effects of one household member losing their job – which would imply a sudden fall in household wages – on their subsequent labour supply and on the labour supply of the other household member in two-person households.

This discussion is summarised in Proposition 4.

Proposition 4

For mortgage holders, a surprise rise in interest rates or fall in house prices (at least initially) will lead to a rise in labour supply, and this rise will be greater the higher initial level of debt or mortgage interest rates (effectively, the debt service ratio). A surprise fall in wages will lead to a rise in labour supply iff $w_i h_i > \frac{c_i}{\sigma}$.

Proof

Combining equations **(17)** to **(19)** implies:

$$\widehat{h_{i,t}} = \frac{L_i\left((1+r_L)\widehat{L_{i,t-1}} + r_{L,t-1}\right) - L_i\widehat{q_t} - \left(w_i h_i - \frac{c_i}{\sigma}\right)\widehat{w_{i,t}}}{\left(w_i h_i + \frac{\xi}{\sigma}c_i\right)} \qquad \textbf{(20)}$$

From which the proposition follows. Note that $w_i h_i > \frac{c_i}{\sigma}$ will hold for $\sigma = 1$, the case of log utility.

3.3 Renters

We assume that renters want to maximise the present discounted value of their current and future expected flows of utility, but that they have no access to financial markets. We assume that they obtain housing services by renting from outright homeowners. Again, they treat the real rental rate, real wages and real house prices as exogenous. Mathematically, we can write the problem for renting household, *k*, as:

$$\text{Maximise} \quad E_0 \sum_{t=0}^{\infty} \beta^t \left(\frac{c_{k,t}^{1-\sigma} - 1}{1-\sigma} + \varphi ln HS_{k,t} - \frac{1}{1+\xi} h_{k,t}^{1+\xi} \right)$$

$$\text{Subject to} \quad w_{k,t} h_{k,t} = r_{H,t} q_t HS_{k,t} + c_{k,t} \qquad \textbf{(21)}$$

Where c_k denotes consumption of household *k*, HS_k denotes the housing services consumed by household *k*, w_k denotes the wage received by household *k* and h_k denotes the labour supplied by household *k*.

The first-order conditions for this problem imply:

$$HS_{k,t} = \frac{\varphi c_{k,t}^{\sigma}}{r_{H,t} q_t} \quad \textbf{(22)}$$

$$w_{k,t} = {h_{k,t}}^{\xi} c_{k,t}^{\sigma} \quad \textbf{(23)}$$

3.3.1 Comparative statics and shocks

In steady state, the budget constraint implies:

$$w_k h_k = r_H q HS_k + \left(w_k {h_k}^{-\xi}\right)^{\frac{1}{\sigma}} \quad \textbf{(24)}$$

Combining equations **(22)** and **(23)** gives:

$$r_H q HS_k = \varphi w_k {h_k}^{-\xi} \quad \textbf{(25)}$$

Substituting into equation **(24)** gives:

$$w_k h_k = \varphi w_k {h_k}^{-\xi} + \left(w_k {h_k}^{-\xi}\right)^{\frac{1}{\sigma}} \quad \textbf{(26)}$$

Total differentiation implies,

$$\partial h_k = \frac{\left(r_H q HS_k + \frac{c_k}{\sigma} - w_k h_k\right)}{w_k\left(w_k + \xi\frac{c_k^{\sigma}}{h_k} + \frac{\xi c_k}{\sigma h_k}\right)} \partial w_k \quad \textbf{(27)}$$

Equation **(27)** implies that higher wages will be associated with higher labour supply iff $\sigma < 1$ and will be associated with lower labour supply iff $\sigma > 1$. For $\sigma = 1$, labour supply will have no steady-state relationship with wages. Note that for all values of σ, there is no relationship between labour supply and the rental rate or house prices in steady state.

Turning to the response of labour supply to shocks, we can log-linearise equations **(21)** through **(23)** and combine to obtain:

$$\widehat{h_{k,t}} = \frac{r_H q HS_k + \frac{c_k}{\sigma} - w_k h_k}{wh + \xi\left(r_H q HS_k + \frac{c_k}{\sigma}\right)} \widehat{w_{k,t}} \quad \textbf{(28)}$$

Again, labour supply will not respond to shocks to the rental rate of housing or house prices. The response of labour supply to a positive shock to wages will depend on whether the positive substitution effect, $r_H q HS_k + \frac{c_k}{\sigma}$, outweighs the negative wealth effect, $w_k h_k$. And, this will again depend upon the intertemporal elasticity of substitution. For $\sigma < 1$, ie, an intertemporal elasticity of substitution greater than unity, the substitution effect will dominate and labour supply will rise,

whereas for $\sigma > 1$, ie, an intertemporal elasticity of substitution lower than unity, the wealth effect will dominate and labour supply will fall. For $\sigma = 1$, a shock to wages will have no effect on labour supply.

This discussion leads us to Proposition 5.

Proposition 5
The labour supply of renters – both in and out of steady state – does not respond to the rental rate on housing or to house prices. The response to wages is ambiguous and depends on whether the income effect outweighs the substitution effect or *vice versa*. In turn, this depends on the magnitude of the intertemporal elasticity of substitution. If the elasticity of intertemporal substitution is greater (lower) than unity, labour supply will rise (fall) in response to a positive shock to wages.

Proof
Follows from the proceeding discussion.

3.4 Summary

In this section, we have developed a simple microeconomic framework, which enabled us to generate some hypotheses that we can take to the data. In particular, we generated the following results:

- Higher wealth (both housing and financial) is associated with lower labour supply and higher household debt is associated with higher labour supply;
- For owner-occupiers, a surprise fall in wages (eg, resulting from a member of the household losing their job) is likely to lead to a fall in labour supply (eg, a fall in participation or hours of other member(s) of the household);
- For mortgagors, a surprise fall in wages (eg, resulting from a member of the household losing their job) is likely to lead to an increase in labour supply (eg, an increase in participation or hours of other member(s) of the household);
- For renters, a surprise fall in wages will lead to an increase (fall) in labour supply if the elasticity of intertemporal substitution is greater (smaller) than unity;
- Surprise rises in interest rates (which we can think of as proxying a surprise tightening of financial conditions more generally) are associated with increases in labour supply and this effect is rising in the initial level of household debt;
- For mortgagors, a surprise fall in house prices leads to an increase in labour supply.

In Sections 6 and 7, we take these hypotheses to the data. Before doing so, we first describe the data we use and present some stylised facts about household debt and labour supply based on these data. In particular, we are interested in whether or not the data are consistent with the first result above (ie, Propositions 1 and 3).

4 Data

In this section, we briefly describe the datasets that we use in our microeconometric analysis before presenting some stylised facts about labour supply and household debt.

4.1 Household survey data

Our main dataset for assessing labour supply is the Labour Force Survey (LFS), a rolling survey of households living at private addresses in the United Kingdom. The largest household survey in the United Kingdom, it has an achieved sample of approximately 40,000 households, containing 90,000 individuals, each quarter. The LFS is intended to be representative of the entire population of the UK. Each household, once selected, is interviewed five times at three-monthly intervals, with one fifth of all households being replaced each quarter. Although predominantly a cross-sectional survey, the LFS is therefore also contains longitudinal element that can be used to track individuals and households for up to five quarters. It is this panel element that we make use of in our analysis to assess how households' labour supply respond to shocks

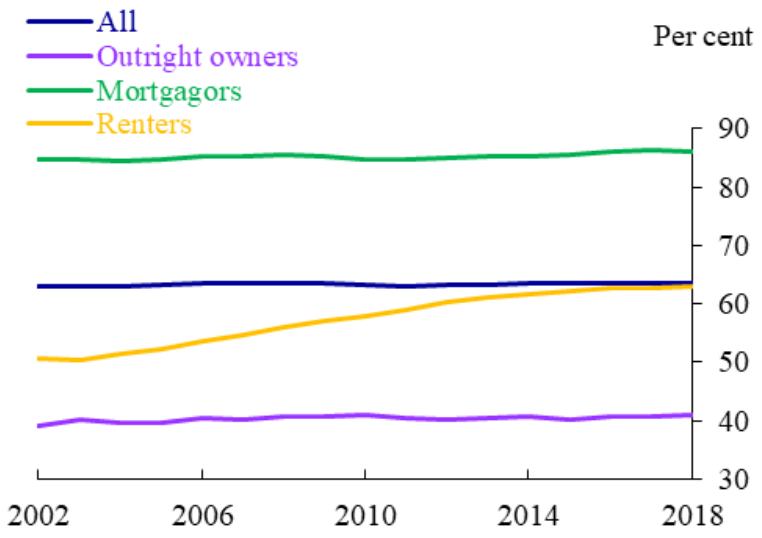
The LFS has detailed information on labour supply at both the intensive and extensive margin, with questions on participation, actual hours worked, and desired hours. It also contains information on a number of household and individual characteristics including age, income, employment, education and region at a granular level. However, the LFS contains no data on either debt or asset holdings. Instead, it does contain data on whether the household owns their home outright, owns it with a mortgage, or rents. Following Cloyne *et al.* (2016), for our main specification we therefore use tenure as a proxy for each household's balance sheet. Consistent with the theoretical framework laid out above, we can think of outright owners as having assets (in the form of housing wealth) but no debt, mortgagors as having both sizeable debt and assets, and renters as having neither debt nor assets.

We also consider an extension to our main specification using detailed microdata evidence on household balance sheets from the Wealth and Assets Survey (WAS). Another household survey, the WAS runs biennially from 2006, with five waves available. Income and hours data is only available from wave three, but all waves contain detailed information on the level and type of assets and debt held by households, as well as a range of household characteristics. Using the WAS, we can estimate the contribution of personal and household characteristics (including the age of the head of household, when they bought their house, how long they have lived there, and region) in determining housing wealth and household debt. We can then use these estimated relationships in conjunction with LFS microdata to impute initial mortgage debt for households that participate in the LFS survey. In this way, we can take advantage of the superior labour supply information in the LFS, and the five-quarter panel, while still exploiting the granular wealth and debt information contained in the WAS.

4.2 Labour supply

We start developing our stylised facts about recent labour market data by looking at participation rates and hours worked among different households. As we showed in Chart 4 in Section 1 above, participation has increased steadily over the past 25 years, and the aggregate participation rate in the LFS (the official measure) is now the highest it has been since 1991.[2] Chart 5 suggests that renters have, in large part, driven this increase as they have increased their participation by the most. That said, the participation and hours of mortgagors is the highest of all tenure groups. This is what we would expect given the prediction of our theoretical model that higher debt is associated with higher labour supply. Similarly, the participation of outright owners is the lowest of the tenure groups. This, again, is in line with our model prediction that higher wealth is associated with lower labour supply.

Chart 5: Participation rate by tenure, LFS



In contrast to participation, average hours worked have declined somewhat over this period, and are currently below their pre-crisis highs as shown in Chart 6. Chart 7 shows that the hours of mortgagors is the highest of all tenure groups, followed by renters then outright owners. Again, this is in line with our theoretical model. Within each tenure group, the trend in average hours has been broadly flat. The fall in average hours in aggregate instead reflects compositional effects, with renters (with lower than average hours) now making up a greater share of the labour force (Chart 5).

[2] The aggregated LFS microdata produces very similar estimates to the official release.

Chart 6: Average weekly hours (all employed), LFS

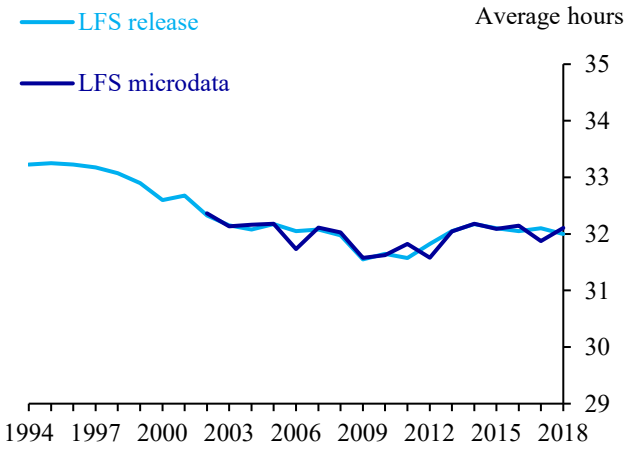
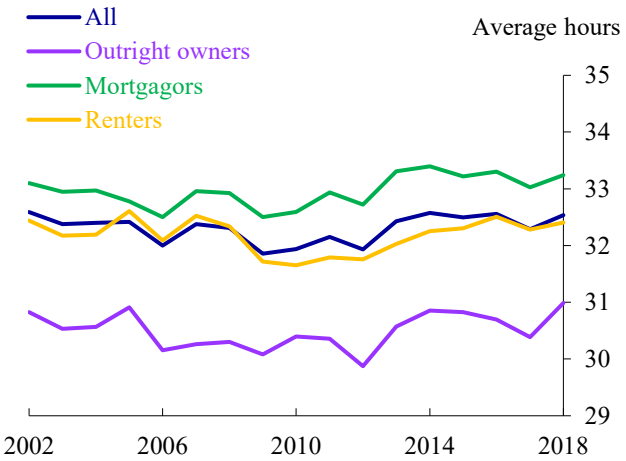


Chart 7: Average weekly hours worked by tenure, LFS



4.3 Debt

Turning now to household debt, evidence from a range of household surveys, including the WAS, suggests household debt holdings increased significantly over this period. Consistent with aggregate data from the National Accounts, evidence from household surveys shows average outstanding mortgage balances at series highs (Chart 8). Similarly, across household surveys average LTVs saw a strong increase in the run-up to, and during, the crisis, with the share of mortgagors with an LTV of 75% or more peaking in 2011 (Chart 9). Average LTVs have subsequently fallen back, reflecting tighter lending standards and strong house price growth.

Chart 8: Mean outstanding mortgage balances

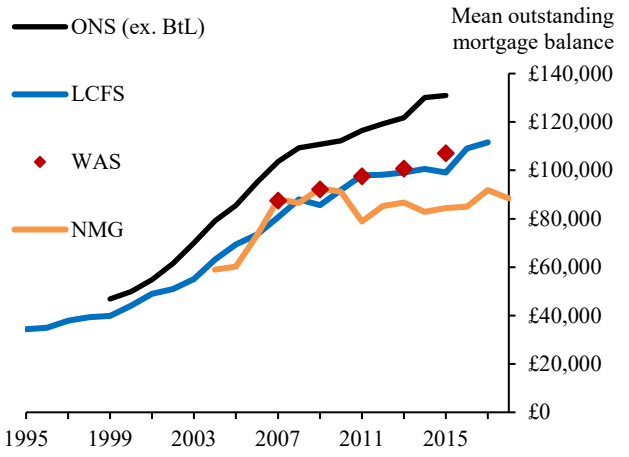
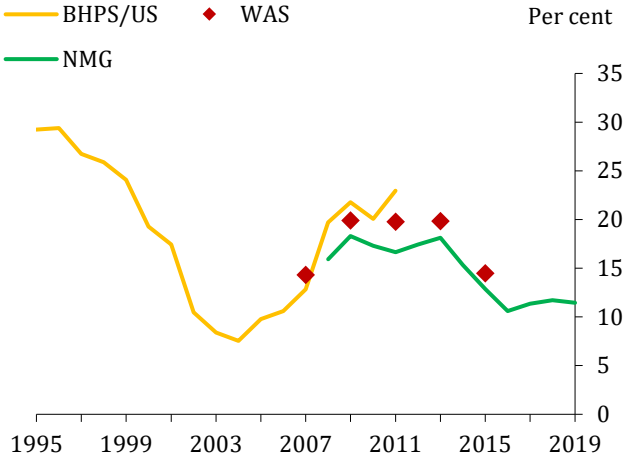


Chart 9: Share of mortgagors with LTVs 75%+



Notes: We exclude 'buy-to-let' (BtL) mortgages from the aggregate ONS series. 'LCFS' denotes the *Living Costs and Food Survey*, 'WAS' denotes the *Wealth and Assets Survey*, BHPS/US' denotes the *British Household Panel Survey*, which became part of the *Understanding Society* in 2010/11, 'NMG' denotes the *Bank of England/NMG Survey of Household Finances*. A summary of these different household surveys can be found in Table A in the appendix.

5 Econometric approach

5.1 Exogenous shocks

In Section 3, we laid out a number of hypotheses generated by our framework, on how households' labour supply interacts with their balance sheets, captured by their tenure. In particular, recalling Propositions 2 and 4, we would expect that for mortgagors, a surprise fall in wages (eg, resulting from a member of the household losing their job) leads to an increase in labour supply (eg, an increase in participation or hours of other member(s) of the household); surprise rises in interest rates are associated with increases in labour supply and this effect is rising in the initial level of household debt; and, for mortgagors, a surprise fall in house prices leads to an increase in labour supply.

This means that in terms of shocks, we want to examine the effects, in particular, of three primary 'shocks': a member of the household experiencing job loss (we think of this in terms of a shock to household income, w, in our theoretical framework); an exogenous interest rate shock (for mortgagors, a shock to r_L in our theoretical framework); and a fall in local area house prices. We discuss each of these shocks in turn.

5.1.1 Involuntary job loss

Here, we want to exploit the panel nature of the data to examine the impact on household labour supply from the head of household involuntarily losing their job, both on the head of household themselves, and the other household members. First, we define involuntary job loss for household heads. The LFS asks people about whether they have left a paid job within the last three months and the reasons why they left. We use these questions to define whether the head of each household involuntarily lost their job during the last quarter. This variable equals one if they either become unemployed due to redundancy, termination or failure to renew contract or had to leave employment for health reasons, and zero otherwise.

For the heads of household, we are interested in the extent to which we see a 'discouraged worker effect', where those who lose their job are generally more likely to leave the labour market and become inactive. For the non-heads of household, we can instead examine the extent to which an 'added worker effect' is present, where previously inactive members of the household join the labour market (or increasing their existing labour supply) to make up the shortfall in income.

The key identifying assumption is that the shock (head of household job loss) is not determined by our outcome of interest (future household labour supply), other than through determinants we can control for (such as time invariant household characteristics). For example, we would not want to include heads of household who leave their job through voluntary separation, as they may be more likely to leave if they know that their partner is planning to return to work. This is why we define involuntary job loss as only 'being made redundant/contract not renewed' or 'having to leave a job for health reasons'.

As a robustness check, we also repeat our analysis considering a narrower measure of involuntary job loss for the head of household based only on them being made redundant. This separation is arguably the most likely to be exogenous with respect to households' subsequent labour supply decisions. This tighter definition gives us fewer shocks to work with, but our findings still hold (despite larger standard errors due to the smaller sample).

5.1.2 Exogenous rate shocks

To test our second hypothesis, we use a series of exogenous monetary policy shocks, developed by Cesa-Bianchi *et al.* (2020). The idea is that monetary policy shocks should exogenously result in changes in households' mortgage rates (and thus the repayments they face), separate from, for example, demand conditions that may themselves affect labour supply. Such a shock will potentially feed through into the households' collateral constraints, altering the cost of borrowing for households that are unable to adjust borrowing in response to changes to interest rates and we include the shock series directly in the regression as a proxy for the retail interest rates that households face.

5.1.2 A fall in house prices

Finally, we want to consider the effect of changing house prices on household labour supply. This can impact households through changing the value of the assets they hold, and therefore how likely they are to be collateral constrained. Disney and Gathergood (2018), for example, show that changes in house prices impact hours worked at the individual level. Proposition 4 suggests that mortgagors should respond to a positive house price shock by reducing their labour supply, due to a wealth effect, while Propositions 2 and 5 suggest that outright homeowners and renters, respectively, should have a zero response. In our specification, we therefore include the log of real local authority house prices, both in levels and interacted with tenure.

5.2 Regression approach

Within our dataset, we have three measures of labour supply, which we use as our primary dependent variables of interest:

- participation (ie, whether or not the person participated in the labour market in the 'reference week' of the survey);
- hours worked (ie, how many hours the person worked during the 'reference week' of the survey);
- desired hours (ie, how many hours the person would like to work during a week).

Both hours measures are continuous, but participation is a binary outcome variable. Given that, we model participation in a linear probability model (LPM), including fixed effects. Specifically, for all three dependent variables, we ran four regression specifications:

$$Y_{i,t} = \beta_0 + \beta_1 income\ shock_{i,t} + \beta_2 income\ shock_{i,t} * tenure_{i,t} + \beta_3 interest\ rate\ shock_{i,t} + individual\ controls_{i,t} + demand\ controls_{i,t} + \nu_i + u_{i,t} \quad \textbf{(29)}$$

$$Y_{i,t} = \beta_0 + \beta_1 income\ shock_{i,t} + \beta_2 income\ shock_{i,t} * tenure_{i,t} + \beta_3 interest\ rate\ shock_{i,t} + \beta_4 interest\ rate\ shock_{i,t} * tenure_{i,t} + \beta_5 house\ price\ shock_{i,t} + \beta_6 house\ price\ shock_{i,t} * tenure_{i,t} + individual\ controls_{i,t} + demand\ controls_{i,t} + \nu_i + u_{i,t} \quad \textbf{(30)}$$

$$Y_{i,t} = \beta_0 + \beta_1 income\ shock_{i,t} * HoH_i + \beta_2 income\ shock_{i,t} * tenure_{i,t} * HoH_i + \beta_3 interest\ rate\ shock_{i,t} + \beta_4 interest\ rate\ shock_{i,t} * tenure_{i,t} + \beta_5 house\ price\ shock_{i,t} + \beta_6 house\ price\ shock_{i,t} * tenure_{i,t} + individual\ controls_{i,t} + demand\ controls_{i,t} + \nu_i + u_{i,t} \quad \textbf{(31)}$$

$$Y_{i,t} = \beta_0 + \beta_1 income\ shock_{i,t} * HoH_i + \beta_2 income\ shock_{i,t} * tenure_{i,t} * HoH_i + \beta_3 interest\ rate\ shock_{i,t} + \beta_4 interest\ rate\ shock_{i,t} * tenure_{i,t} + \beta_5 house\ price\ shock_{i,t} + \beta_6 house\ price\ shock_{i,t} * tenure_{i,t} + individual\ controls_{i,t} + demand\ controls_{i,t} + \nu_i + u_{i,t} \quad \textbf{(32)}$$

Where $Y_{i,t}$ denotes the labour supply outcome – *Participation*, *Actual hours* or *Desired hours* – observed for each individual *i* in each quarter *t* of the survey. Since each household is interviewed a maximum of five times in the LFS, no household/individual appears in our sample for more than five quarters. There is also attrition within the survey and not all households complete all interviews; we include all households/individuals who are interviewed in at least two consecutive quarters. Our sample period runs from 2002 to 2018 and therefore our panel is highly unbalanced.[3]

Whether or not the head of the individual's household involuntarily separated from their job in period *t* is denoted by, $income\ shock \in \{0,1\}$, *tenure* denotes whether the individual is an owner-occupier, mortgagor or renter, *interest rate shock* denotes the value of the monetary policy shock in period *t*, *house price shock* denotes the change in the log of real local authority house prices from period *t*-1 to period *t*, $HoH \in \{0,1\}$ denotes whether or not the individual is the head of their household, ν_i captures the fixed effect for individual *i*. We also include two forms of additional control variables: *individual-specific controls* (including age, age squared, a dummy for whether

[3] This limitation makes it difficult for us to study how persistent the effects on labour supply of these shocks are and explains why we focus only on the initial response.

the individual becomes eligible for the state pension in the period, changes in the number of dependent children under 16 in the household, total number of adults, change in tenure, and wave of observation), and local-area *demand controls* to take account of macroeconomic conditions (including regional unemployment and average regional real hourly wages, following Disney and Gathergood (2018)).[4] In equations **(29)** and **(30)**, $\beta_1, \beta_3, \beta_5$ capture the average impact of the shocks on labour supply for our base tenure group (mortgagors). In equations **(31)** and **(32)**, β_1 captures the average change in labour supply of each group of mortgagors (heads of households unaffected by an income shock, heads of households affected by an income shock and non heads of households affected by an income shock) relative to non-heads of mortgage-holding households that were not affected by an income shock. Again, β_3 and β_5 capture the average impact of the interest rate and house price shocks on the labour supply of mortgagors. In all equations, $\beta_2, \beta_4, \beta_6$ capture the average difference in the impact of the shocks on labour supply for other tenure groups relative to the base tenure group.

6 Baseline Results

Table 1 reports the results from our estimation of equations **(29)** (1st column), **(30)** (second column), **(31)** (third column) and **(32)** (fourth column) for participation. Table 2 reports the results for actual weekly hours worked and Table 3 reports the results for desired weekly hours. Charts 10-15 present the implied responses for each group (with one standard error bands) to each shock based on the results for the specification given by equation **(32)** graphically. In each case, the regression equations were estimated over the period 2002 Q1 to 2018 Q2.

We first consider the participation response of households to a surprise fall in wages, proxied by involuntary job loss. If we do not separate the responses of heads of household from those of non-heads of household, we find that mortgagors reduce their probability of participating by 2.3% (the specification given by equation **(29)**) or 2.7% (the specification given by equation **(30)**). Renters do not respond in a significantly different way to mortgagors. Outright owners, on the other hand, reduce their labour supply by much more: 10.9% in the specification given by equation **(29)** or 11.4% in the specification given by equation **(30)**. These results are in line with our theoretical framework in the sense that the reduction in labour supply of outright owners is much greater than that of mortgagors. But we would have expected mortgagors to increase their labour supply in response to the shock. It is possible that heads of household are unable to do this and the increase in labour supply of mortgage holders comes from the non-head of household. We investigate this possibility in the specifications given by equations **(31)** and **(32)**.

[4] We also considered a specification with year dummies to capture time fixed effects, but the inclusion of these did not change our findings, and were not significant once the other demand controls are included.

Table 1: Estimation results for participation

Dependent Variable:	*1*	*2*	*3*	*4*
Job loss	-0.023***	-0.027***		
	[0.003]	[0.004]		
Tenure*Job loss				
Outright owner*1	-0.086***	-0.087***		
	[0.009]	[0.011]		
Renter*1	-0.005	-0.013		
	[0.006]	[0.009]		
Job loss*HoH				
0*1			0.089***	0.065***
			[0.004]	[0.005]
1*0			0.019***	0.015**
			[0.005]	[0.006]
1*1			0.026***	-0.001
			[0.006]	[0.008]
Job loss*HoH*Tenure				
0*1*Outright owner			-0.033***	-0.027***
			[0.004]	[0.005]
0*1*Renter			-0.036***	-0.022***
			[0.006]	[0.008]
1*0*Outright owner			-0.024**	-0.021*
			[0.01]	[0.012]
1*0*Renter			-0.021**	-0.018
			[0.009]	[0.012]
1*1*Outright owner			-0.171***	-0.169***
			[0.014]	[0.018]
1*1*Renter			-0.017*	-0.02
			[0.01]	[0.014]
Monetary shock		0.007***		0.006***
		[0.002]		[0.002]
Tenure*Monetary shock				
Outright owner		-0.005		-0.005
		[0.003]		[0.003]
Renter		-0.008*		-0.007
		[0.004]		[0.004]
House prices		-0.000		-0.002
		[0.008]		[0.008]
Tenure*House prices				
Outright owner		-0.004		-0.004
		[0.007]		[0.007]
Renter		-0.031***		0.031***
		[0.012]		[0.012]
Individual-specific controls[ı]	Yes	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes
R squared	0.37	0.38	0.39	0.38
Observations	3,501,556	2,098,694	3,501,556	2,098,694

Note: Job loss captures heads of households being made redundant, involuntarily unemployed, or having to stop work due to illness or an accident.

[ı]Household-specific controls: age, age squared, whether eligible for state pension, number of dependent children under 16, number of adults, control for change in tenure, wave of observation.

‡Demand controls: regional unemployment rate, regional real hourly wages.

*=10%, **=5%, ***=1%

The results in columns 3 and 4 of Table 1 suggest that if the head of a mortgage-holding household involuntarily separates from their job, they reduce their probability of participating in the labour market by 6.3% ($= 0.089 - 0.026$ for the specification in equation **(31)**) or 6.6% ($= 0.065 + 0.001$ for the specification in equation **(32)**). In contrast, non-heads of mortgage-holding households increase their probability of participating by 1.9% (for the specification in equation **(31)**) or 1.5% (for the specification in equation **(32)**). This suggests that the added worker effect holds for mortgagors as might have been expected given our theoretical framework.

Again, outright owners see a much larger decline in their probability of participating in response to the shock. The results in columns 3 and 4 in Table 1 suggests that if the head of an owner-occupying household involuntarily separates from their job, their probability of participating in the labour market falls, by 14.7 percentage points ($= 0.171 - 0.024$) for the specification in equation **(31)**) or 14.2 percentage points ($= 0.169 - 0.027$) for the specification in equation **(32)**, relative to that of mortgagors. Hence, the income shock leads to a fall in the probability of participating in the labour market of 21% (for either specification). Again, heads of renting households do not respond in a significantly different way to mortgagors.

Non heads of outright-owner households barely change their labour supply, reducing their probability of participating by 0.5% ($= 0.024 - 0.019$) for the specification in equation **(31)**) or 0.6% ($= 0.021 - 0.015$) for the specification in equation **(32)**). The same is true of non-heads of renting households who reduce their probability of participating by 0.2% ($= 0.021 - 0.019$) for the specification in equation **(31)** or 0.3% ($= 0.018 - 0.015$) for the specification in equation **(32)**). As expected, we therefore do not find evidence of an added worker effect for these groups.

Chart 10: Impact of involuntary job loss on participation, by tenure

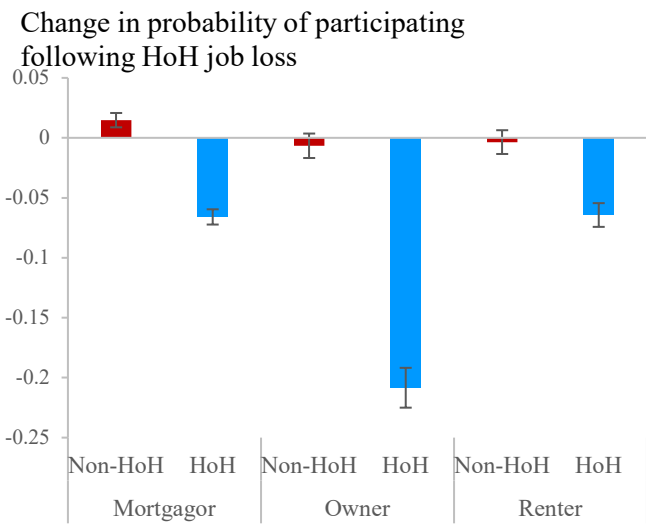
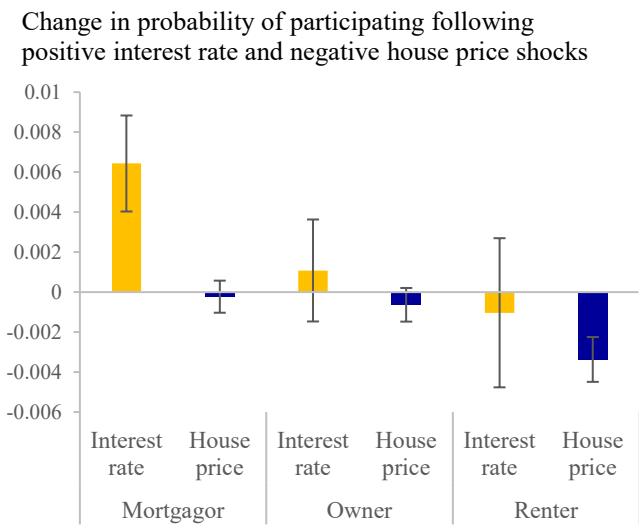


Chart 11: Impact of interest rate and house price shocks on participation, by tenure



The results in columns 2 and 4 of Table 1 show that a 100 basis point monetary policy shock leads to no significant change in the probability of participating in the labour market of owner-occupiers or renters. Mortgagors, on the other hand, increase their probability of participating in the labour market by 0.7% (specification given by equation **(30)**) or 0.6% (specification given by equation **(31)** and shown in Chart 11). This result is in line with our theoretical framework. The results in columns 2 and 4 of Table 1 also show that house price shocks have no significant effect on the probability of participating in the labour market for owner-occupiers or mortgagors but the probability of renters participating in the labour market falls by 0.3% in response to a 10% rise in house prices.[5] (Table 1 shows the effect of a doubling in house prices.) The results from the specification based on equation **(32)** are illustrated in Chart 11.

Table 2 reports the results from our estimation of equations **(29)** (1st column), **(30)** (second column), **(31)** (third column) and **(32)** (fourth column) for actual weekly hours worked and Table 3 reports the results for desired weekly hours. Charts 12-15 graphically present the implied responses for each group (with one standard error bands) to each shock based on the results for the specification given by equation **(32)**, our preferred specification.

Tables 2 and 3 suggest a similar qualitative response of labour supply measured by actual and desired weekly hours worked to a labour income shock. In response to involuntarily separating from their job, the results of our preferred specification (ie, that based on equation **(32)**), shown in Charts 12 and 13, suggest that mortgagor heads of household increase both their actual and desired weekly hours by 0.9 ($\approx 6.107 - 5.163$) and 1.5 ($\approx 6.542 - 5.049$), respectively, conditional on continuing to participate. There is no significant difference between the response of renters and mortgagors. We again see a discouraged worker effect for outright-owner heads of households, who decrease their actual weekly hours by 1.4 ($\approx 3.340 - 0.959 - (6.107 - 5.163)$), and their desired weekly hours by 0.9 ($\approx 3.283 - 0.864 - (6.542 - 5.049)$) as shown in Charts 12 and 13, respectively. These results are in line with the predictions of our theoretical framework.

In response to the same shock, non-heads of mortgage-holding households increase both their actual and desired weekly hours by 1.2 (according to our preferred specification) as shown in Charts 12 and 13, respectively. There is no statistically significant difference in the response of non heads of owner-occupying and renting households to that of mortgagors though the point estimates are 0.6 and 0.0, respectively, for actual weekly hours worked and 0.5 and 0.2 for desired weekly hours. And we can note that these point estimates are also all insignificantly different from zero.

[5] NB Table 1 shows the effect of a doubling (ie, 100% rise) in house prices.

Table 2: Estimation results for actual hours

Dependent Variable:	*1*	*2*	*3*	*4*
Job loss	0.952***	1.08***		
	[0.228]	[0.327]		
Tenure*Job loss				
Outright owner*1	-1.219***	-1.385**		
	[0.475]	[0.653]		
Renter*1	0.161	-0.245		
	[0.417]	[0.625]		
Job loss*HoH				
0*1			7.731***	5.163***
			[0.248]	[0.0369]
1*0			0.906***	1.223***
			[0.284]	[0.401]
1*1			8.727***	6.107***
			[0.426]	[0.631]
Job loss*HoH*Tenure				
0*1*Outright owner			-1.2***	-0.959***
			[0.257]	[0.355]
0*1*Renter			-3.326***	-2.867***
			[0.367]	[0.548]
1*0*Outright owner			-0.245	-0.633
			[0.562]	[0.763]
1*0*Renter			-0.571	-1.184
			[0.581]	[0.832]
1*1*Outright owner			-3.585***	-3.34***
			[0.804]	[1.133]
1*1*Renter			-2.765***	-2.437**
			[0.683]	[1.049]
Monetary shock		0.876***		0.865***
		[0.249]		[0.249]
Tenure*Monetary shock				
Outright owner		0.611		0.609
		[0.459]		[0.459]
Renter		1.56***		1.548***
		[0.47]		[0.47]
House prices		4.163**		4.027***
		[0.596]		[0.588]
Tenure*House prices				
Outright owner		0.621		0.609
		[0.511]		[0.507]
Renter		-0.107		-0.188
		[0.813]		[0.803]
Individual-specific controls[1]	Yes	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes
R squared	0.04	0.04	0.11	0.09
Observations	2,029,110	1,228,764	2,029,110	1,228,764

Note: Job loss captures heads of households being made redundant, involuntarily unemployed, or having to stop work due to illness or an accident.

[1]Household-specific controls: age, age squared, whether eligible for state pension, number of dependent children under 16, number of adults, control for change in tenure, wave of observation.

‡Demand controls: regional unemployment rate, regional real hourly wages.

*=10%, **=5%, ***=1%

Table 3: Estimation results for desired hours

Dependent Variable:	*1*	*2*	*3*	*4*
Job loss	1.107***	1.309***		
	[0.227]	[0.326]		
Tenure*Job loss				
Outright owner*1	-1.193**	-1.422**		
	[0.47]	[0.654]		
Renter*1	0.269	-0.375		
	[0.422]	[0.631]		
Job loss*HoH				
0*1			7.569***	5.049***
			[0.248]	[0.372]
1*0			0.908***	1.16***
			[0.287]	[0.405]
1*1			8.873***	6.542***
			[0.423]	[0.628]
Job loss*HoH*Tenure				
0*1*Outright owner			-1.122***	-0.864**
			[0.257]	[0.358]
0*1*Renter			-3.404***	-2.906***
			[0.371]	[0.562]
1*0*Outright owner			-0.272	-0.654
			[0.571]	[0.781]
1*0*Renter			-0.598	-1.001
			[0.599]	[0.86]
1*1*Outright owner			-3.407***	-3.283***
			[0.784]	[1.124]
1*1*Renter			-2.723***	-2.938***
			[0.686]	[1.058]
Monetary shock		0.78***		0.77***
		[0.252]		[0.251]
Tenure*Monetary shock				
Outright owner		0.663		0.661
		[0.465]		[0.465]
Renter		1.612***		1.6***
		[0.482]		[0.482]
House prices		4.163***		4.127***
		[0.602]		[0.594]
Tenure*House prices				
Outright owner		0.559		0.548
		[0.516]		[0.513]
Renter		-0.291		-0.374
		[0.828]		[0.818]
Individual-specific controls[1]	Yes	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes
R squared	0.04	0.04	0.1	0.09
Observations	2,029,106	1,228,762	2,029,106	1,228,762

Note: Job loss captures heads of households being made redundant, involuntarily unemployed, or having to stop work due to illness or an accident.

[1]Household-specific controls: age, age squared, whether eligible for state pension, number of dependent children under 16, number of adults, control for change in tenure, wave of observation.

‡Demand controls: regional unemployment rate, regional real hourly wages.

*=10%, **=5%, ***=1%

Chart 12: Impact of involuntary job loss on actual hours, by tenure

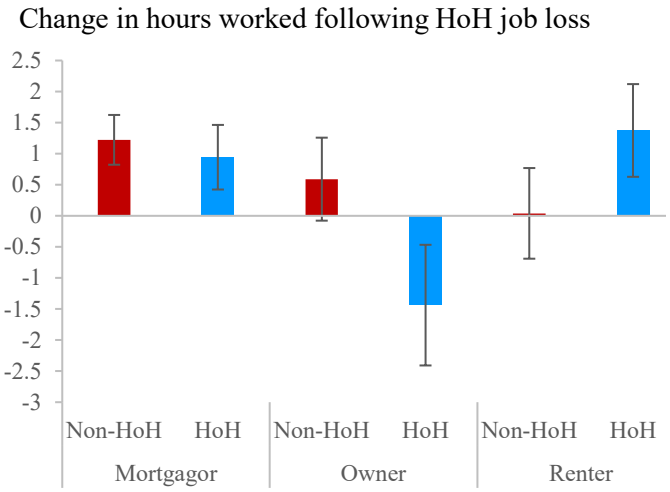
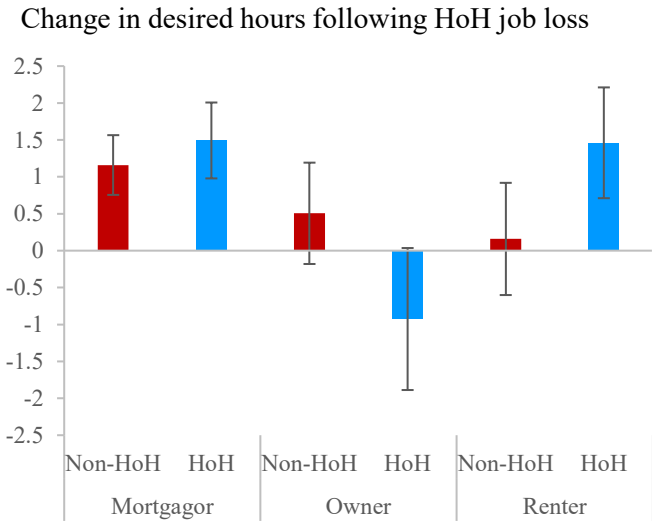


Chart 13: Impact of involuntary job loss on desired hours, by tenure



Tables 2 and 3 show that all tenure groups increase their actual and desired hours worked in response to an exogenous increase in interest rates. According to our preferred specification, as shown in Chart 14, a 100 basis point exogenous increase in interest rates corresponds to an increase in weekly hours worked of 0.9 for mortgagors, 1.5 for outright owners, and 2.4 for renters. Chart 15 shows that the same shock leads to an increase in desired weekly hours of 0.8 for mortgagors, 1.4 for outright owners, and 2.4 for renters. These responses are in line with the prediction of our theoretical framework that all groups would increase their labour supply in response to such a shock. All tenure groups also increase their labour supply in response to a negative house price shock. A 10% fall in real house prices leads to an increase in the hours worked of each household member by 0.4 hours per week for mortgagors. The response of outright owners and renters is insignificantly different from that of mortgagors.

Chart 14: Impact of interest rate and house price shocks on actual hours, by tenure

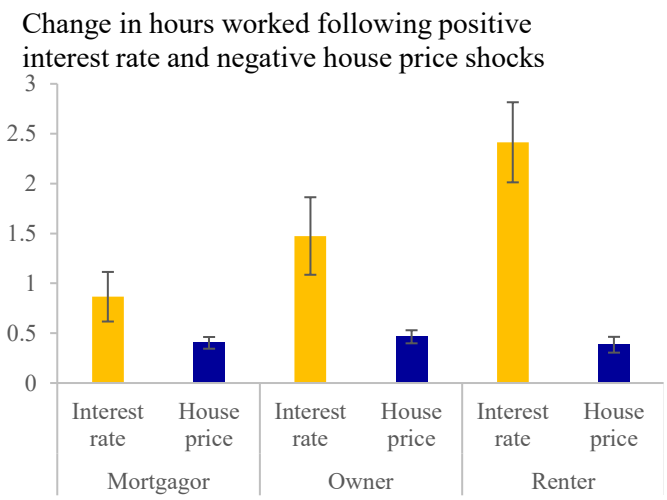
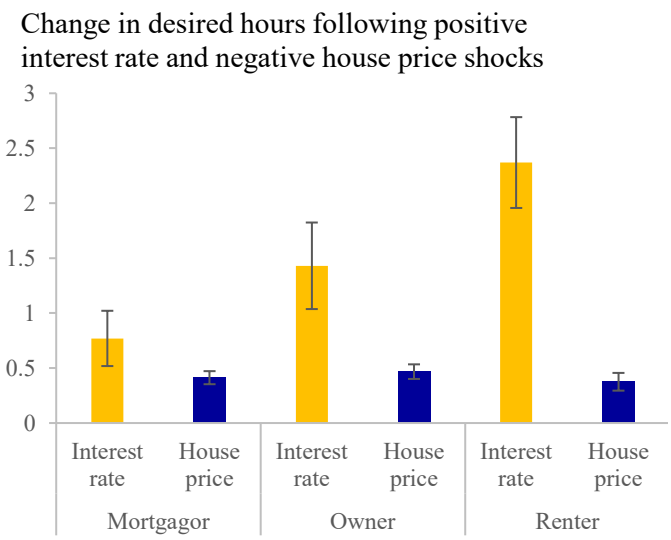


Chart 15: Impact of interest rate and house price shocks on desired hours, by tenure



7 Results using predicted debt metrics

We have shown above that there is significant heterogeneity in the response of households to income and interest rate shocks by tenure, with mortgagors generally the most responsive, and outright owners the least. To the extent that tenure can proxy for households' balance sheets, this suggests that higher debt (and lower asset) levels make households increase their labour supply by more in response to shocks that would increase the burden of servicing their debts, either by raising repayment costs, in the case of interest rate shocks, or by lowering their disposable income, in the case of income shocks.

However, given the considerable heterogeneity *within* mortgagors, the approach above will likely understate the impact of debt on the responsiveness of household labour supply for the most highly indebted and constrained households. In particular, our theoretical framework suggested that we might expect mortgagors with higher levels of debt to respond more to movements in interest rates as households with large outstanding balances will see a larger increase in their debt repayments for a given change in their mortgage interest rate. Outside of the framework, we might also expect mortgagors with higher LTVs to be more responsive, as they are most likely to be collateral constrained. And, they are also more likely to have higher DSRs, so may be more responsive to income shocks. One approach to try to capture these channels directly is to consider the responsiveness of different mortgagor groups, by debt level. In particular, we use debt metrics predicted from the WAS to examine whether mortgagors with higher LTVs or outstanding mortgage balances are more responsive than those mortgagors who are comparatively unconstrained.

7.1 Imputation procedure

We impute two different debt metrics: whether a mortgagor is high or low LTV, and whether they are high or low debt. We define a mortgagor household in the WAS as 'high LTV' if they have an LTV ratio greater than 75%, and low LTV otherwise, and 'high debt' if they have an outstanding balance of £150,000 and low otherwise. These figures were chosen so that approximately 25% of mortgagors are defined as 'high debt/LTV'.

We randomly split the WAS into a training and a test sample in order to assess the performance of the debt imputation procedure, with 19,900 mortgagor households in the training sample, and 2,210 in the test sample. We then classified households in the training sample as high or low debt and LTV using logit regression to predict the status of each mortgagor household in the WAS based on a number of household characteristics – crucially region and time at address:

$$Pr(high\ LTV_i, high\ debt_i) = year + \beta_1 gender_i * year + \beta_2(total\ adults_i) * year + \beta_3(time\ at\ address_i) * year + \beta_4 age_i * (time\ at\ address_i) * year + \beta_5(age\ squared_i) * (time\ at\ address_i) * year + \beta_6(NUTS2_i) * year + u_i \quad \textbf{(33)}$$

Having done this, we then use this estimated relationship to predict whether mortgagors in the LFS are high or low debt and LTV, assigning households with an estimated probability of greater than 0.2 to be either high debt or high LTV.

Comparing the original metrics to the predicted ones within the test sample of the WAS can allow us to assess the performance of the imputation. We can see from Table 4 below that across both metrics, approximately 80% of low debt/ LTV mortgagors are correctly predicted to be low, with a slightly lower proportion of high debt/LTV mortgagors correctly predicted. Given that this classification is out-of-sample, this is a fairly high success rate.

Table 4: Prediction success in the Wealth and Assets Survey

	Predicted: Low LTV	**Predicted: High LTV**
Low LTV	78.6%	21.4%
High LTV	30%	70%
	Predicted: Low debt	**Predicted: High debt**
Low debt	81.3%	18.7%
High debt	37.7%	62.3%

7.2 Exogenous income shock with imputed debt metrics

To see the impact of debt on the labour supply response of households, we return to our exogenous income shock specification above:

$$\begin{aligned} &Participation_{i,t},\ actual\ hours_{i,t},\ desired\ hours_{i,t} \\ &\quad = \beta_0 + \beta_1 income\ shock_{i,t} * HoH_i + \beta_2 income\ shock_{i,t} * tenure'_{i,t} * HoH_i \\ &\quad + \beta_3 interest\ rate\ shock_{i,t} + \beta_4 interest\ rate\ shock_{i,t} * tenure'_{i,t} \\ &\quad + \beta_5 house\ price\ shock_{i,t} + \beta_6 house\ price\ shock_{i,t} * tenure'_{i,t} + controls_{i,t} \\ &\quad + \nu_i + \alpha_t + u_{i,t} \end{aligned} \qquad \textbf{(34)}$$

Instead of having tenure split between mortgagors, outright owners and renters, we now have $tenure'_{i,t}$, which further splits mortgagors into high and low LTV or high and low debt (depending on the specification). As above, we present the results of these regressions graphically, (split by LTV in charts 16-21, and by debt in charts 22-27); the full regression output, including the other specifications given by the relevant versions of equations **(29)** to **(31)** can be found in Tables B-D in the Annex. The regressions were estimated over the shorter sample period 2006 Q3 to 2016 Q2, reflecting the availability of data within the WAS. From these results, we can see that being predicted to be more indebted has a significant impact on the labour supply responses of mortgagors.

Considering first the effect of the unexpected job loss shock, we can see that the heads of predicted high LTV and high debt mortgagor households reduce their participation by significantly less in response to job loss, on average, than mortgagors predicted to have low LTVs or outstanding balances (Charts 16 and 22). High LTV heads of households who unexpectedly lost their job are 4% less likely to participate in the labour market, compared with 8% for low LTV households. This is in line with the predictions of our theoretical model and suggests that the discouraged worker effect is only half as potent for mortgagors with high debt burdens, perhaps because of the pressure of meeting their mortgage obligations. The added worker effect is similar across low and high debt households, however – in part this reflects high debt households typically having at least two members participating to start with, so there is limited capacity for these households to add further workers to the labour market. The response of hours to the shock at the intensive margin is also similar across both high and low debt households, with the difference between them not statistically significant.

Chart 16: Impact of involuntary job loss on participation, by LTV

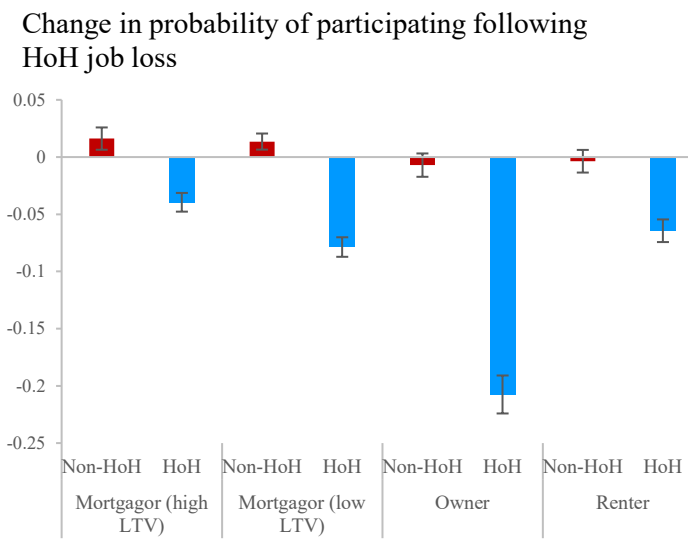


Chart 17: Impact of interest rate and house price shocks on participation, by LTV

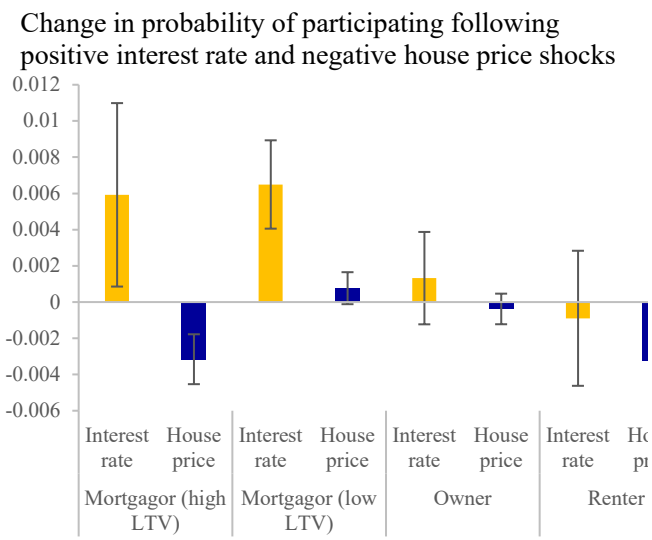


Chart 18: Impact of involuntary job loss on actual hours, by LTV

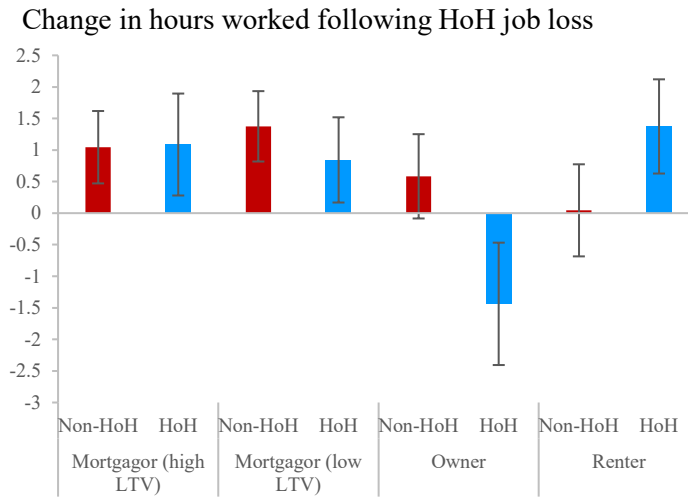


Chart 19: Impact of interest rate and house price shocks on actual hours, by LTV

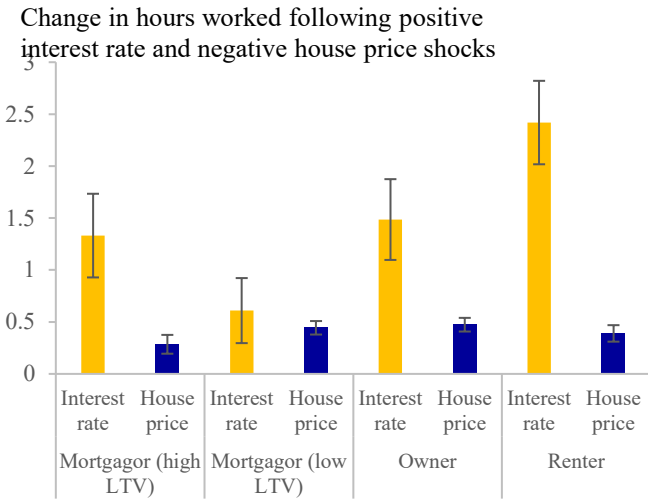


Chart 20: Impact of involuntary job loss on desired hours, by LTV

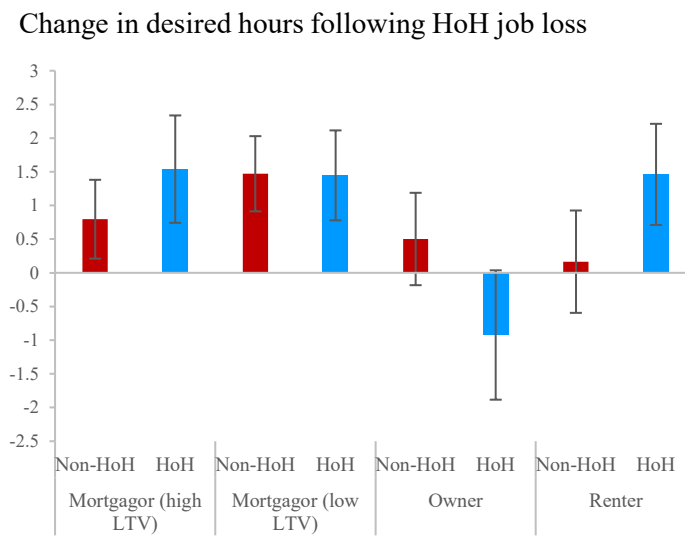


Chart 21: Impact of interest rate and house price shocks on desired hours, by LTV

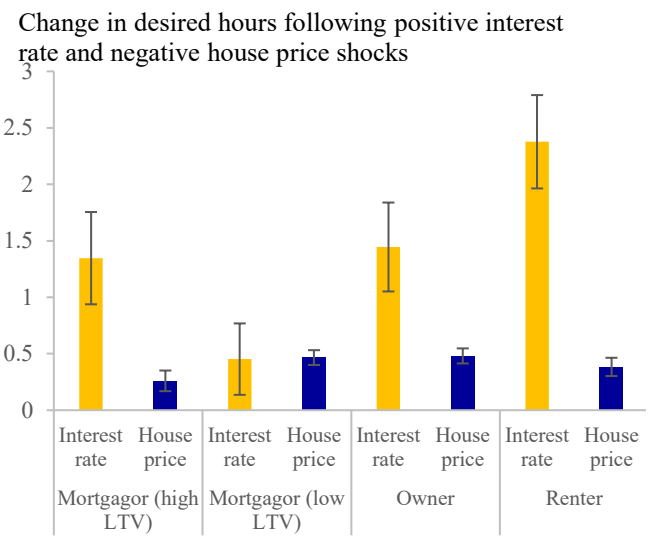


Chart 22: Impact of involuntary job loss on participation, by tenure

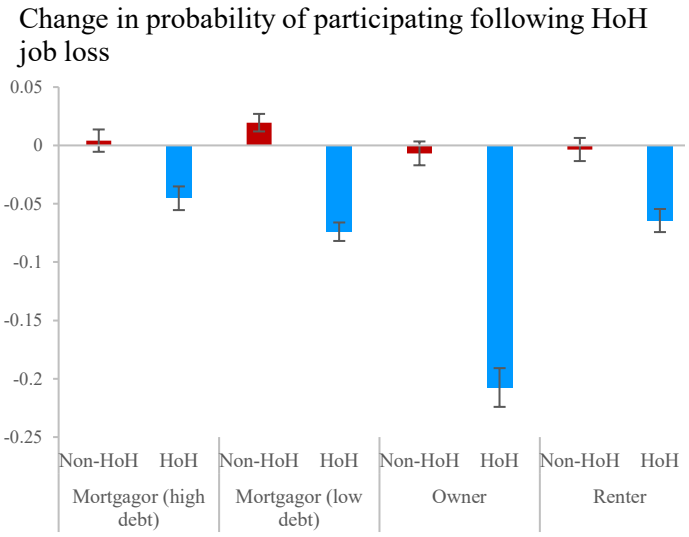


Chart 23: Impact of interest rate and house price shocks on participation, by tenure

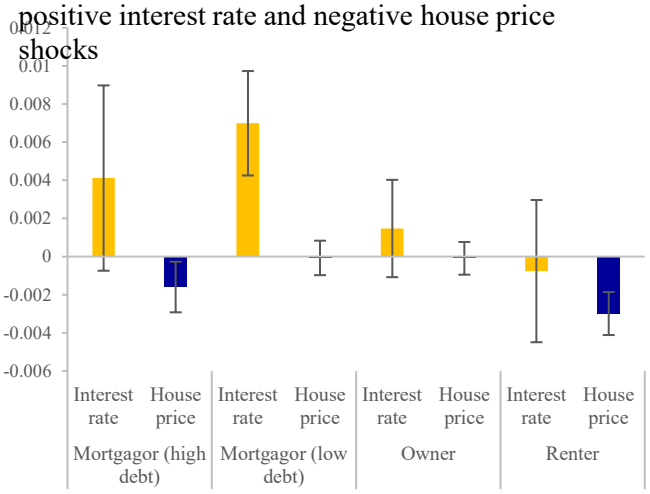


Chart 24: Impact of involuntary job loss on actual hours, by tenure

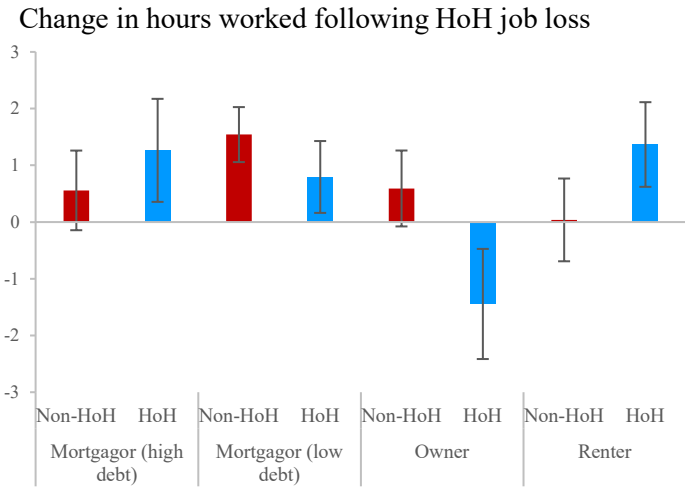


Chart 25: Impact of interest rate and house price shocks on actual hours, by tenure

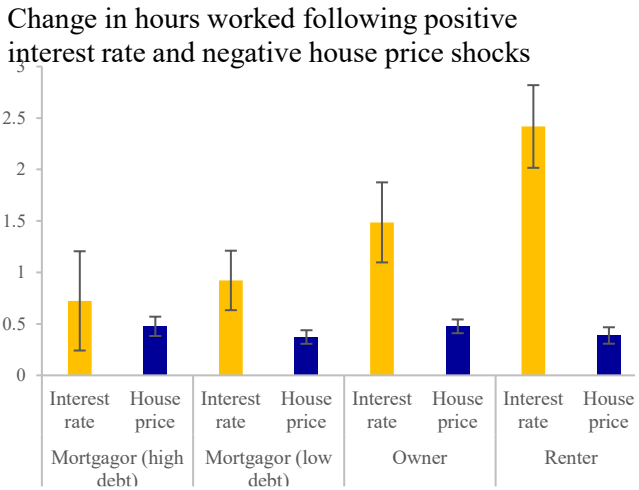


Chart 26: Impact of involuntary job loss on desired hours, by tenure

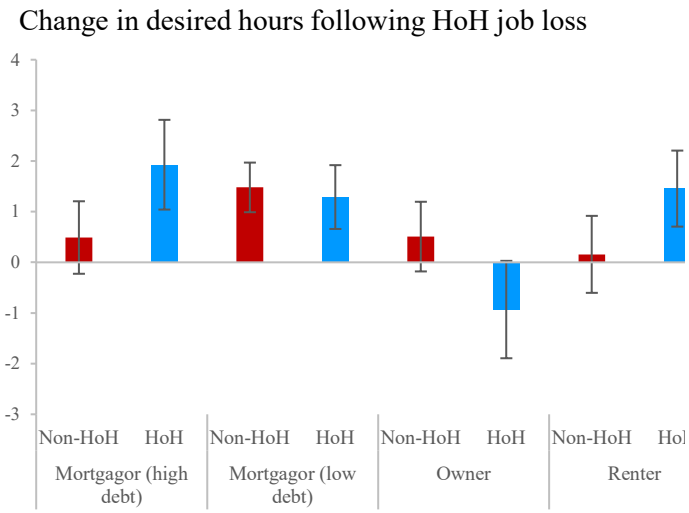
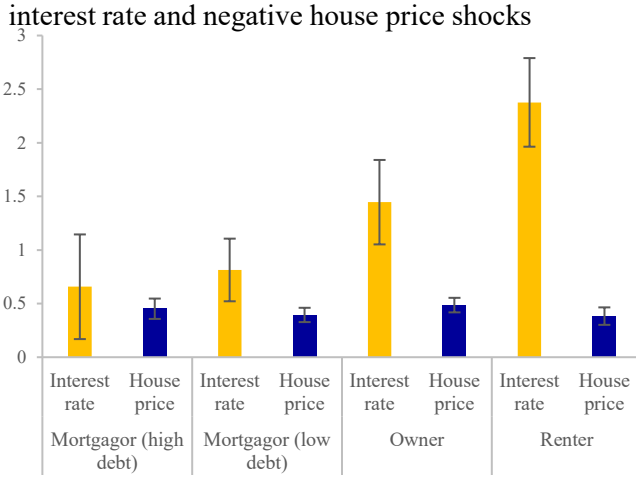


Chart 27: Impact of interest rate and house price shocks on desired hours, by tenure



As noted in section 6, the impacts of the house price and interest rate shocks on participation are very small. This remains true for both groups when we split mortgagors into high LTV and debt and low LTV and debt. As shown in Charts 17 and 23, all responses are insignificant apart from that of low debt and low LTV mortgagors, who increase their probability of participating by 0.6% in response to a 100 basis point interest rate shock. Chats 19, 21, 25 and 27, however, suggest that there is more evidence of an effect at the intensive margin. High-LTV mortgagors see a much larger increase in their actual and desired hours in response to an exogenous interest rate shock than low-LTV mortgagors, with actual hours worked increasing by 1.3 hours per week for high-LTV mortgagors on average in response to a 100bp rate shock, compared with 0.6 hours per week for low-LTV mortgagors. This is again in line with the predictions of our theoretical model.

The responses of high and low debt mortgagors, though, are insignificantly different from each other. Similar to the findings of the effect of a house price shock between tenure groups, both high and low debt and LTV households increase their labour supply in response to a negative house price shock, with no significant difference between the responses.

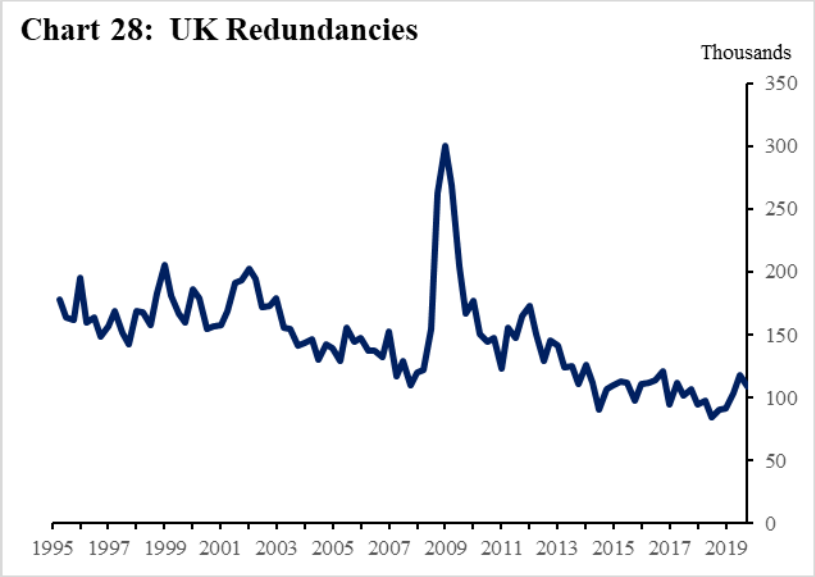
7.3 Estimating the implications for labour supply following the crisis

As we said in the introduction, household debt increased considerably as a proportion of household income in the lead-up to the financial crisis, and remains relatively high, while labour force participation and employment have consistently been higher during and since the recession than we might have expected. The question for this section is whether, given our empirical results, the rise in debt can provide a quantitatively significant explanation of the rise in labour supply following the financial crisis.

The mechanism we have in mind is the following. We think of the financial crisis as having brought about a fall in the current and expected future income of households. This leads to a fall in consumption and a rise in labour supply, assuming leisure is a normal good. But, the more indebted is a household, the more they will want to increase their labour supply, since the marginal value of an additional pound is higher for more 'credit-constrained' households. So an increase in average indebtedness ahead of the shock – for example, a rise in the proportion of highly-indebted households – would lead to a more positive response of labour supply to the financial crisis.

So, to assess the extent to which the rise in indebtedness might have affected the response of labour supply to the financial crisis, we first need to construct a proxy for the exogenous income shock brought about by the financial crisis. Unfortunately, our empirical results do not enable us to assess directly the effects of a fall in income on participation or hours worked. Nor do they enable us to assess the effects on employment. Instead, we can only use the results of the previous section to examine the effects of the immediate job losses caused by the crisis on labour supply after the crisis.

Chart 28 shows data on UK redundancies from the Labour Force Survey. As can be seen, redundancies were fairly flat between 2003 Q1 and 2013 Q1, except for 2008 Q3 to 2010 Q4, the period of the financial crisis and its immediate aftermath. We can note that in the average quarter over this period (but not including the financial crisis period), roughly 142,000 employees were made redundant. Assuming that had been the case over the 2008 Q3 to 2010 Q4 period, we would have seen 1.42 million employees made redundant over that period. In fact, over that period, 1.98 million employees were made redundant, which works out at as 6.3% of the 2008 Q3 labour force (31.42 million). These data suggest that the financial crisis led to 560,000 'excess' redundancies. We take this as our measure of the shock.



The results in Chart 16 suggest that if the Head of Household is made redundant, then high-LTV mortgagors are 4.1% less likely to participate whereas low-LTV mortgagors are 7.2% less likely to participate. Similarly, the results in Chart 22 suggest that if the Head of Household is made redundant, then high-debt mortgagors are 5.2% less likely to participate whereas low-debt mortgagors are 7.2% less likely to participate. A rise in the share of high-LTV and/or high-debt mortgagors would thus imply a smaller effect on participation of a given rise in redundancies.

As shown in Chart 9 in Section 4.3 above, the proportion of mortgagors with high LTV ratios (ie, LTV ratio greater than 75%) rose dramatically ahead of and during the financial crisis. Specifically, the British Household Panel Survey suggests that the proportion of mortgagors with high LTV ratios rose from 8% in 2004 to 22% in 2009. If we assume that it was 'heads of households' that were made redundant and that they were all mortgagors – which is clearly going to give us an 'upper bound' on our calculation – then putting these results together suggests that the fall in participation resulting from the global financial crisis shock would have been 560,000 * (0.08*0.04+0.92*0.08-0.22*0.04-0.78*0.08) = 3136 greater had we not seen the large increase in high-LTV mortgages between 2004 and 2009. This represents 0.01% of the 2008 Q3 labour force.

On first sight, this seems like a small number and, in particular, represents only a small fraction of the higher than expected employment in the United Kingdom during and after the crisis. This is despite the results being significant at the household level. Of course, given that almost all households with a mortgage need to participate in the labour force anyway (otherwise they will default on their mortgages), this is perhaps not surprising. To sum up, although we do find a significant effect of debt on labour supply at the level of the individual household, there are simply not enough high debt households who are faced by these shocks for the effects on participation to be large at a macro level.

That said, there are a number of reasons to think that these results may have substantially underestimated the effect of the increase in debt. First, it is likely that the number of job losses

resulting from the crisis was limited as a result of falls in wages. According to our theoretical framework, these wage falls would have had an effect on labour supply that would have been more positive as a result of the increase in debt. But, the calculation just described would have missed this completely. Second, if it is the case that 'fear of unemployment' causes an increase in labour supply among highly-indebted households rather than the actual shock of being unemployed (as has been shown in eg, Ravn and Sterk (2017) and Juelsrud and Wold (2019), to be the case for consumption), then it is possible that our mechanism could explain at least some of the positive labour supply response during and after the crisis, despite the relatively small number of additional redundancies seen during the crisis. Third, it is also possible that if the reduction in the flow of redundant workers into non-participation were to persist, the cumulative effect on labour supply could become significant over time. In support of this idea, we can note that Chart 9 suggests that the proportion of high-LTV households did not start to fall until 2013, five years after the global financial crisis.

Another element missing from this analysis is the response of labour supply to the tightening in financial conditions experienced by households at the time of the financial crisis. Our theoretical framework suggests that if households were experiencing tighter financial conditions at the time of the financial crisis they would likely have raised their hours, and done so by more the more indebted they were. Unfortunately, there is no easy way of translating the tightening in 'non price' credit conditions – that is, the fact that banks became much less likely to lend at any interest rate – into an interest rate 'shock' that we could put into our empirical results to obtain an estimated response for hours. And, although we could estimate the response of hours for individual households translating this into an aggregate effect would be difficult without an estimate of the aggregate labour supply elasticity.

8 Robustness

To assess the extent to which our results are robust to the shock measures and specifications chosen, we ran a number of robustness checks, the results of which are presented below. Even when we use a narrower measure of the income shock, and when we introduce age interactions on the income shocks, our key findings remain.

For our main specification, we considered all households whose head had either been made involuntarily unemployed, or had to leave employment due to health reasons, as this generated the largest sample size for us to work with. However, one might be concerned that this shock is not fully exogenous. For example, heads of households with poor health may feel more able to leave their job if they know their partner will be able to take on more work. As a robustness check we repeat our analysis, restricting our sample to only those households whose head was made redundant, arguably the most likely type of job loss to be exogenous with respect to the household's subsequent labour supply decisions.

The results of this analysis for specifications based on equations **(29)**, **(31)** and **(32)** and the narrower measure, of redundancies are shown in Tables E-G in the appendix. Even on this

narrower measure, although standard errors are generally larger due to the smaller sample size, our key findings still hold and remain significant. Considering Table E, for example, outright owners continue to see a much larger fall in their likelihood of participating than mortgagors following the shock and, in fact, that difference is actually larger when the shock is based on the narrower measure. Similarly to our previous results, Tables F and G suggest that mortgagors increase their actual and desired hours following the shock, whereas outright owners decrease their hours. Using the narrower measure of the income shock also has very little effect on the estimated impact of the interest rate and house price shocks, so again, these results are robust to the choice of job loss measure used.

Another possible concern is that the large differences we find here in labour supply responses between mortgagors and outright owners might be driven by the difference in ages between these two populations. The main specifications include age, age squared, and a dummy for whether the individual is eligible for the state pension to control for this, but we further consider robustness checks where we introduce interactions between age and age squared and the job loss shock, in case the results are being driven by older individuals being more likely to exit the labour market following redundancy.

The results for specifications based on equations **(29)**, **(31)** and **(32)**, including these additional interactions, are shown in Tables H-J in the appendix. Once again, the key findings are robust to the change in specification. Relative to our baseline results, all households see a smaller coefficient on the interaction terms between job loss and housing tenure, with mortgagors no longer seeing a statistically significant discouraged worker effect in specifications based on equations **(29)** and **(32)** (in line with our model predictions). And while the discouraged worker effect for outright owners is smaller with the addition of the interaction terms, it is still much larger than that seen for mortgagors, significant at the 1% level. This suggests that it is the difference in housing tenure (and balance sheets) between these groups, rather than demographic differences between the populations, that drive our findings.

9 Conclusions

In this paper, we have assessed the link between household debt and labour supply. We developed a theoretical framework within which we could examine the behaviour of three types of household: outright homeowners, mortgagors and renters. The framework suggested that lower wealth (both housing and financial) should be associated with higher labour supply and higher household debt with higher labour supply. In addition, the framework suggested that for mortgagors, a surprise fall in wages should lead to an increase in labour supply whereas for outright homeowners it should lead to a fall in labour supply. A surprise fall in house prices should lead to an increase in the labour supply of mortgagors. Finally, the framework suggested that surprise rises in interest rates (which we can think of as proxying a surprise tightening of financial conditions more generally) should be associated with increases in labour supply, with this effect rising in the initial level of household debt.

We then used microeconomic data from the Labour Force Survey and the Wealth and Assets Survey to see if the UK data supported these hypotheses. In line with the theory, we found that a negative shock to income led to a reduction in labour force participation among outright homeowners (ie, a discouraged worker effect) while increasing the desired hours of mortgage holders. We also found that a surprise rise in interest rates led to an increase in the desired hours of outright homeowners and a larger increase in the labour supply of mortgage holders. Finally, we found that a fall in house prices leads to a rise in the desired hours of mortgage holders.

Using the Wealth and Assets Survey, we were able to impute levels of debt and assets for the participants in the Labour Force Survey and examine how the *level* of debt matters for the response of households to income shocks. We found that heads of households predicted to have a low LTV ratio on their mortgage or low debt, decreased their participation by significantly more in response to job loss, on average, than mortgagors predicted to have high LTV ratios or outstanding mortgage balances. High debt mortgagors also subsequently increased their average hours significantly more than outright owners (conditional on being employed). Similarly, we saw a much stronger added worker effect for households predicted to have high LTV ratios relative to mortgagors with low LTV ratios, outright owners and renters. Essentially we find that higher debt (and lower asset) levels make households increase their labour supply by more in response to shocks that would increase the burden of servicing their debts, either by raising repayment costs, in the case of interest rate shocks, or by lowering their disposable income, in the case of income shocks.

These results suggest that the rise in debt leading up to the financial crisis in the United Kingdom has the potential, at least partly, to explain the subsequent behaviour of employment, hours and wages. Over time the high levels of debt may then have acted to push out overall labour supply. Looking forward, we would like to develop our framework into a fully-fledged macroeconomic model for the United Kingdom. We could then examine quantitatively the extent to which movements in aggregate household debt ahead of the global financial crisis can explain the recent evolution of wages, the labour force and employment. We leave this for future work.

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Appendix:

Table A: Household Surveys

	Summary	Frequency	Backrun	Sample size	Panel?	Conducted how?
Labour Force Survey (LFS)	A household survey with detailed information on economic activity and hours and a number of household characteristics. No debt or asset data available apart from tenure.	Quarterly	The quarterly LFS is available from 1992, and the household datasets are available from 2002.	40,000 households per quarter, covering 90,000 individuals.	The data consists of a series of overlapping 5 quarter long panels (as each household remains in sample for 5 quarters).	First quarter conducted face-to-face, follow-up interviews conducted over the phone.
Wealth and Assets Survey (WAS)	A household survey covering the level (and type) of assets, savings and debt held by households. The most granular and accurate source of debt and asset information. Participation data available for the full backrun, but family hours are only included from 2008.	Biennial	5 waves (with wave 1 covering July 2006-June 2008)	Wave 1 = 31,000; Wave 2 = 20,000; Wave 3 = 21,000; Wave 4 = 20,000; Wave 5 = 19,000	Yes	Face-to-face
Living Costs and Food Survey (LCFS)	A household survey covering households' income, consumption and cost of living. Very detailed expenditure information, with households asked to keep an expenditure diary for 2 weeks.	Annual	LCF from 2008 (but replaced the EFS, available from 2001, which replaced the FES and NFS, available from 1957).	Approximately 6,000 households.	No	Face-to-face
Bank of England/NMG Survey of Household Finances	A household survey, commissioned by the Bank of England, covering households' finances and expectations.	Biannual	Annual from 2004, biannual from 2014.	2,000 households per survey before 2012; 6,000 households per survey after 2012.	Panel element from 2012 (around 50% of households have responded to a previous survey).	Initially face-to-face, moved online in 2012.

Table B: Estimation results for participation with predicted debt

Dependent Variable:	*5*	*6*	*7*	*8*
Job loss*HoH				
0*1	0.082***	0.093***	0.051***	0.064***
	[0.006]	[0.008]	[0.008]	[0.009]
1*0	0.038***	0.009	0.016*	0.004
	[0.008]	[0.008]	[0.01]	[0.01]
1*1	0.043***	0.042***	0.011	0.019
	[0.009]	[0.011]	[0.011]	[0.014]
Job loss*HoH*Tenure				
0*1*Low LTV	0.006		0.016*	
	[0.007]		[0.009]	
0*1*Low debt		-0.005		-0.000
		[0.008]		[0.01]
0*1*Outright owner	-0.023***	-0.035***	-0.01	-0.026***
	[0.007]	[0.008]	[0.009]	[0.01]
0*1*Renter	-0.028***	-0.039***	-0.008	-0.022*
	[0.008]	[0.009]	[0.01]	[0.011]
1*0*Low LTV	-0.038***		-0.003	
	[0.01]		[0.015]	
1*0*Low debt		0.015		0.015
		[0.01]		[0.012]
1*0*Outright owner	-0.044***	-0.015	-0.023*	-0.011
	[0.012]	[0.012]	[0.014]	[0.014]
1*0*Renter	-0.041***	-0.012	-0.02	-0.008
	[0.011]	[0.011]	[0.014]	[0.014]
1*1*Low LTV	-0.029***		-0.023	
	[0.011]		[0.015]	
1*1*Low debt		-0.023*		-0.029*
		[0.013]		[0.016]
1*1*Outright owner	-0.184***	-0.185***	-0.178***	-0.188***
	[0.016]	[0.017]	[0.02]	[0.021]
1*1*Renter	-0.033***	-0.034**	-0.032**	-0.041**
	[0.012]	[0.013]	[0.016]	[0.018]
Monetary shock			0.006	0.004
			[0.005]	[0.005]
Tenure*Monetary shock				
Low LTV			0.000	
			[0.006]	
Low debt				0.0029
				[0.006]
Outright owner			-0.005	-0.003
			[0.006]	[0.005]
Renter			-0.007	-0.005
			[0.006]	[0.006]
House prices			-0.034**	-0.016
			[0.014]	[0.013]
Tenure*House prices				
Low LTV			0.04***	
			[0.015]	
Low debt				0.015
				[0.015]
Outright owner			0.028**	0.015
			[0.014]	[0.014]
Renter			-0.000	-0.014
			[0.000]	[0.017]
Individual-specific controls[1]	Yes	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes
R squared	0.39	0.39	0.39	0.38
Observations	3,443,726	3,443,726	2,098,246	2,098,246

Note: Job loss captures heads of households being made redundant, involuntarily unemployed, or having to stop work due to illness or an accident.

[1]Household-specific controls: age, age squared, whether eligible for state pension, number of dependent children under 16, number of adults, control for change in tenure, wave of observation.

‡Demand controls: regional unemployment rate, regional real hourly wages.

*=10%, **=5%, ***=1%

Table C: Estimation results for actual hours with predicted debt

Dependent Variable:	*5*	*6*	*7*	*8*
Job loss*HoH				
0*1	6.25***	7.738***	3.682***	5.704***
	[0.392]	[0.505]	[0.55]	[0.702]
1*0	1.322***	0.289	1.042*	0.558
	[0.416]	[0.493]	[0.573]	[0.709]
1*1	7.853***	7.904***	4.764***	6.969***
	[0.667]	[0.78]	[0.969]	[1.14]
Job loss*HoH*Tenure				
0*1*Low LTV	2.076***		2.137***	
	[0.456]		[0.644]	
0*1*Low debt		0.019		-0.68
		[0.54]		[0.747]
0*1*Outright owner	0.527	-1.157**	0.823	-1.505**
	[0.444]	[0.53]	[0.622]	[0.726]
0*1*Renter	-1.835***	-3.357***	-1.351*	-3.417***
	[0.486]	[0.579]	[0.7]	[0.822]
1*0*Low LTV	-0.595		0.341	
	[0.571]		[0.799]	
1*0*Low debt		1.048*		0.984
		[0.604]		[0.859]
1*0*Outright owner	-0.662	0.382	-0.459	0.034
	[0.641]	[0.699]	[0.871]	[0.977]
1*0*Renter	-0.99	0.042	-0.995	-0.52
	[0.655]	[0.705]	[0.926]	[1.0147]
1*1*Low LTV	1.047		1.906	
	[0.839]		[1.223]	
1*1*Low debt		1.171		-1.149
		[0.911]		[1.1325]
1*1*Outright owner	-2.479**	-2.714***	-1.699	-4.214***
	[0.979]	[1.052]	[1.392]	[1.493]
1*1*Renter	-1.882**	-1.967**	-1.063	-3.314**
	[0.859]	[0.949]	[1.292]	[1.424]
Monetary shock			1.219***	0.723
			[0.404]	[0.482]
Tenure*Monetary shock				
Low LTV			-0.733	
			[0.508]	
Low debt				0.199
				[0.561]
Outright owner			0.146	0.763
			[0.558]	[0.618]
Renter			1.075	1.694***
			[0.567]	[0.626]
House prices			3.442***	4.761***
			[0.931]	[0.938]
Tenure*House prices				
Low LTV			1.454	
			[0.972]	
Low debt				-1.037
				[1.029]
Outright owner			1.776**	0.001
			[0.906]	[0.972]
Renter			0.865	-0.889
			[1.092]	[1.147]
Individual-specific controls[ı]	Yes	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes
R squared	0.11	0.11	0.09	0.09
Observations	1,985,135	1,985,135	1,228,420	1,228,420

Note: Job loss captures heads of households being made redundant, involuntarily unemployed, or having to stop work due to illness or an accident.

[ı]Household-specific controls: age, age squared, whether eligible for state pension, number of dependent children under 16, number of adults, control for change in tenure, wave of observation.

‡Demand controls: regional unemployment rate, regional real hourly wages.

*=10%, **=5%, ***=1%

Table D: Estimation results for desired hours with predicted debt

Dependent Variable:	*5*	*6*	*7*	*8*
Job loss*HoH				
0*1	6.086***	7.644***	3.663***	5.588***
	[0.396]	[0.509]	[0.56]	[0.713]
1*0	1.317***	0.363	0.793	0.490
	[0.425]	[0.496]	[0.585]	[0.716]
1*1	8.003***	8.217***	5.198***	7.515***
	[0.664]	[0.772]	[0.967]	[1.129]
Job loss*HoH*Tenure				
0*1*Low LTV	2.067***		1.988***	
	[0.459]		[0.653]	
0*1*Low debt		-0.071		-0.678
		[0.544]		[0.758]
0*1*Outright owner	0.617	-1.146**	0.819	-1.404*
	[0.447]	[0.534]	[0.631]	[0.736]
0*1*Renter	-1.892***	-3.487***	-1.488**	-3.453***
	[0.492]	[0.585]	[0.717]	[0.839]
1*0*Low LTV	-0.588		0.685	
	[0.577]		[0.808]	
1*0*Low debt		0.937		0.989
		[0.608]		[0.867]
1*0*Outright owner	-0.87	0.277	-0.292	0.018
	[0.653]	[0.707]	[0.892]	[0.994]
1*0*Renter	-1.012	-0.06	-0.626	-0.332
	[0.676]	[0.722]	[0.957]	[1.041]
1*1*Low LTV	1.074		1.908	
	[0.835]		[1.217]	
1*1*Low debt		0.980		-1.317
		[0.903]		[1.314]
1*1*Outright owner	-2.299**	-2.707***	-1.642	-4.264***
	[0.961]	[1.032]	[1.382]	[1.478]
1*1*Renter	-1.828**	-2.079**	-1.564	-3.925***
	[0.861]	[0.946]	[1.299]	[1.423]
Monetary shock			1.242***	0.657
			[0.410]	[0.488]
Tenure*Monetary shock				
Low LTV			-0.904*	
			[0.515]	
Low debt				0.157
				[0.567]
Outright owner			0.091	0.789
			[0.566]	[0.626]
Renter			1.019	1.719***
			[0.58]	[0.638]
House prices			3.146***	4.52***
			[0.94]	[0.949]
Tenure*House prices				
Low LTV			1.937	
			[0.982]	
Low debt				-0.578
				[1.04]
Outright owner			2.105**	0.340
			[0.916]	[0.984]
Renter			1.067	-0.687
			[1.11]	[1.167]
Individual-specific controls[1]	Yes	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes	Yes
R squared	0.1	0.1	0.08	0.09
Observations	1,985,132	1,985,132	1,228,418	1,228,418

Note: Job loss captures heads of households being made redundant, involuntarily unemployed, or having to stop work due to illness or an accident.

[1]Household-specific controls: age, age squared, whether eligible for state pension, number of dependent children under 16, number of adults, control for change in tenure, wave of observation.

‡Demand controls: regional unemployment rate, regional real hourly wages.

*=10%, **=5%, ***=1%

Table E: Estimation results for participation, redundancy only

Dependent Variable:	*1*	*3*	*4*
Job loss	-0.0438***		
	[0.005]		
Tenure*Redundancy			
Outright owner*1	-0.116***		
	[0.011]		
Renter*1	-0.031***		
	[0.01]		
Redundancy*HoH			
0*1		0.089***	0.064***
		[0.004]	[0.005]
1*0		0.021***	0.021***
		[0.006]	[0.008]
1*1		-0.018***	-0.046***
		[0.008]	[0.01]
Redundancy*HoH*Tenure			
0*1*Outright owner		-0.033***	-0.027***
		[0.004]	[0.005]
0*1*Renter		-0.036***	-0.021***
		[0.006]	[0.008]
1*0*Outright owner		-0.028**	-0.03**
		[0.01]	[0.014]
1*0*Renter		-0.028**	-0.03
		[0.009]	[0.016]
1*1*Outright owner		-0.222***	-0.216***
		[0.018]	[0.023]
1*1*Renter		-0.047***	-0.05**
		[0.01]	[0.018]
Monetary shock			0.006***
			[0.002]
Tenure*Monetary shock			
Outright owner			-0.005
			[0.003]
Renter			-0.008
			[0.004]
House prices			-0.002
			[0.008]
Tenure*House prices			
Outright owner			-0.004
			[0.007]
Renter			0.031***
			[0.012]
Individual-specific controls[ı]	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes

Table F: Estimation results for actual hours, redundancy only

Dependent Variable:	*1*	*3*	*4*
Redundancy	0.569*		
	[0.295]		
Tenure*Redundancy			
Outright owner*1	-1.597***		
	[0.589]		
Renter*1	0.034		
	[0.628]		
Redundancy*HoH			
0*1		7.733***	5.166***
		[0.248]	[0.369]
1*0		1.008***	1.463***
		[0.35]	[0.478]
1*1		7.738***	4.644***
		[0.544]	[0.796]
Redundancy*HoH*Tenure			
0*1*Outright owner		-1.2***	-0.956***
		[0.257]	[0.355]
0*1*Renter		-3.311***	-2.854***
		[0.367]	[0.548]
1*0*Outright owner		-0.237	-1.065
		[0.667]	[0.869]
1*0*Renter		-0.328	-1.571
		[0.807]	[1.068]
1*1*Outright owner		-5.16***	-4.637***
		[1.078]	[1.524]
1*1*Renter		-2.827***	-2.299
		[1.023]	[1.438]
Monetary shock			0.864***
			[0.249]
Tenure*Monetary shock			
Outright owner			0.616
			[0.459]
Renter			1.547***
			[0.47]
House prices			4.01***
			[0.588]
Tenure*House prices			
Outright owner			0.631
			[0.507]
Renter			-0.183
			[0.802]
Individual-specific controls[ı]	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes

Table G: Estimation results for desired hours, redundancy only

Dependent Variable:	*1*	*3*	*4*
Redundancy	0.796***		
	[0.293]		
Tenure*Redundancy			
Outright owner*1	-1.58***		
	[0.585]		
Renter*1	-0.003		
	[0.63]		
Redundancy*HoH			
0*1		7.571***	5.054***
		[0.248]	[0.372]
1*0		0.983***	1.407***
		[0.35]	[0.484]
1*1		8.128***	5.384***
		[0.54]	[0.789]
Redundancy*HoH*Tenure			
0*1*Outright owner		-1.11***	-0.857**
		[0.257]	[0.358]
0*1*Renter		-3.387***	-2.899***
		[0.371]	[0.562]
1*0*Outright owner		-0.099	-0.978
		[0.676]	[0.89]
1*0*Renter		-0.362	-1.55
		[0.822]	[1.082]
1*1*Outright owner		-5.176***	-4.973***
		[1.054]	[1.538]
1*1*Renter		-3.023***	-2.823**
		[1.021]	[1.428]
Monetary shock			0.77***
			[0.251]
Tenure*Monetary shock			
Outright owner			0.669
			[0.465]
Renter			1.6***
			[0.482]
House prices			4.127***
			[0.594]
Tenure*House prices			
Outright owner			0.571
			[0.512]
Renter			-0.364
			[0.817]
Individual-specific controls[ı]	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes

Table H: Estimation results for participation, including age interactions

Dependent Variable:	*1*	*3*	*4*
Job loss	0.045		
	[0.031]		
Job loss*Age	0.001	0.003**	0.01**
	[0.002]	[0.002]	[0.002]
Job loss*Age²	-0.000***	-0.000***	-0.000***
	[0.000]	[0.000]	[0.000]
Tenure*Job loss			
Outright owner*1	-0.037***		
	[0.009]		
Renter*1	-0.02		
	[0.007]		
Job loss*HoH			
0*1		0.089***	0.064***
		[0.004]	[0.005]
1*0		0.016	-0.109**
		[0.03]	[0.042]
1*1		0.039	-0.117**
		[0.032]	[0.044]
Job loss*HoH*Tenure			
0*1*Outright owner		-0.034***	-0.027***
		[0.004]	[0.005]
0*1*Renter		-0.036***	-0.022***
		[0.006]	[0.008]
1*0*Outright owner		0.014	-0.02
		[0.01]	[0.013]
1*0*Renter		-0.034***	-0.025**
		[0.01]	[0.012]
1*1*Outright owner		-0.123***	-0.114***
		[0.014]	[0.018]
1*1*Renter		-0.029***	-0.025*
		[0.01]	[0.014]
Monetary shock			0.006***
			[0.002]
Tenure*Monetary shock			
Outright owner			-0.005
			[0.003]
Renter			-0.008*
			[0.004]
House prices			-0.002
			[0.008]
Tenure*House prices			
Outright owner			-0.004
			[0.007]
Renter			0.031***
			[0.012]
Individual-specific controls[ı]	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes

Table I: Estimation results for actual hours, including age interactions

Dependent Variable:	*1*	*3*	*4*
Job loss	1.287		
	[1.728]		
Job loss*Age	0.059	0.022	0.167
	[0.092]	[0.093]	[0.132]
Job loss*Age²	-0.002	-0.001	-0.003
	[0.001]	[0.001]	[0.002]
Tenure*Job loss			
Outright owner*1	-0.56		
	[0.503]		
Renter*1	-0.134		
	[0.423]		
Job loss*HoH			
0*1		7.73***	5.161***
		[0.248]	[0.0369]
1*0		1.844	-0.999
		[1.735]	[2.483]
1*1		9.926***	3.945
		[1.854]	[2.664]
Job loss*HoH*Tenure			
0*1*Outright owner		-1.202***	-0.96***
		[0.257]	[0.355]
0*1*Renter		-3.326***	-2.867***
		[0.367]	[0.548]
1*0*Outright owner		0.317	-0.123
		[0.586]	[0.806]
1*0*Renter		-0903	-1.289
		[0.584]	[0.834]
1*1*Outright owner		-2.88***	-2.674**
		[0.823]	[1.172]
1*1*Renter		-3.135***	-2.568**
		[0.689]	[1.055]
Monetary shock			0.866***
			[0.249]
Tenure*Monetary shock			
Outright owner			0.609
			[0.459]
Renter			1.546***
			[0.47]
House prices			4.032***
			[0.588]
Tenure*House prices			
Outright owner			0.611
			[0.507]
Renter			-0.194
			[0.803]
Individual-specific controls[ı]	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes

Table J: Estimation results for desired hours, including age interactions

Dependent Variable:	*1*	*3*	*4*
Job loss	1.356		
	[1.742]		
Job loss*Age	0.051	0.001	0.194
	[0.092]	[0.093]	[0.133]
Job loss*Age²	-0.001	-0.001	-0.003*
	[0.001]	[0.001]	[0.002]
Tenure*Job loss			
Outright owner*1	-0.634		
	[0.499]		
Renter*1	0.021		
	[0.428]		
Job loss*HoH			
0*1		7.568***	5.048***
		[0.248]	[0.372]
1*0		2.094	-1.788
		[1.749]	[2.498]
1*1		10.304***	3.596
		[1.864]	[2.669]
Job loss*HoH*Tenure			
0*1*Outright owner		-1.123***	-0.864**
		[0.257]	[0.358]
0*1*Renter		-3.404***	-2.905***
		[0.371]	[0.562]
1*0*Outright owner		0.209	-0.19
		[0.595]	[0.825]
1*0*Renter		-0.904	-1.038
		[0.603]	[0.864]
1*1*Outright owner		-2.81***	-2.671**
		[0.804]	[1.162]
1*1*Renter		-3.062***	3.006***
		[0.693]	[1.066]
Monetary shock			0.77***
			[0.251]
Tenure*Monetary shock			
Outright owner			0.66
			[0.465]
Renter			1.6***
			[0.482]
House prices			4.131***
			[0.594]
Tenure*House prices			
Outright owner			0.55
			[0.513]
Renter			-0.379
			[0.818]
Individual-specific controls[ı]	Yes	Yes	Yes
Demand controls‡	Yes	Yes	Yes
Individual fixed effects	Yes	Yes	Yes