Labour market participation and mortgage-related borrowing constraints

Renata Bottazzi
University College London and Institute for Fiscal Studies, London

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Abstract

This paper analyses the relationship between female labour market participation and mortgage commitments in a life-cycle set up. In particular, it examines whether a mortgage qualification constraint has any effect on female labour market participation. This is done by conditioning on the mortgage decision in a labour market participation equation for married women. Endogeneity of the mortgage variable is tested using house price data. Panel data from the British Household Panel Study is used in order to control for unobserved heterogeneity in participation.

Keywords: female labour market participation, mortgage commitments

JEL classification: J22, D10, R20

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e-mail address: r.bottazzi@ucl.ac.uk

1 Introduction

This paper analyses the relationship between female labour market participation and mortgage commitments in a life-cycle setting.

Most of the literature concerning life-cycle models and borrowing constraints has focused on the impact of borrowing constraints on consumption, assuming labour supply to be exogenous. However, it is worth investigating whether this is a plausible assumption. In fact, labour supply may be thought of as a way to circumvent or to reduce the impact of borrowing constraints, and so assuming that it is exogenous would produce biased estimates of the impact of borrowing constraints on consumption.

The importance of mortgages in the context of borrowing constraints and labour supply decisions derives from two sources. The first is that housing is usually the most substantial component of assets for home owners. The second is that there is an explicit mortgage qualification constraint, based on household annual income and assets, when the mortgage is taken out.

The ways in which mortgage commitments can be interpreted , will now be analysed in turn.

When taking out a mortgage individuals normally face two types of constraints: a wealth constraint, typically in the form of a minimum downpayment, and an income constraint, typically in the form of a maximum ratio of mortgage payment to household earned income. In the UK, it is theoretically possible to borrow up to 100% of the property's value (although a higher lending fee, the so-called MIG -Mortgage Indemnity Guarantee-, normally applies for mortgages of more than around 90% of the property value) and the effective qualification constraint is the one related to the household income. The Financial Service Authority reports that "typically, the maximum mortgage a lender offers is three times the main earner's income plus one times any second earner's income, or two-and-a-half times the [households] joint income". Hence, there exists an explicit mortgage qualification constraint that is a function of household earned income.

Although it formally applies when the mortgage is taken out, it is possible to consider an income constraint as holding at every period during which the mortgage is being repaid as long as remortgaging is a possibility. Fortin (1995) justifies the presence of such a constraint at every period on the basis of the Canadian institutional setting, where people remortgage very frequently[1] or, alternatively, in the light of allocational inflexibilities

[1] In the selected sample used in this work, 20.5% of households take out additional mortgage on their home at least once during the observation period.

introduced by mortgage payments in the household decision process. In other words, it is explicitly taken into account that mortgage payments might alter household consumption and leisure decisions due to the fact that they must be met at every period and that they normally constitute a substantial part of households' total income.

Moreover, a more general earnings-related borrowing constraint (see Alessie, Melenberg and Weber (1988) and Aldershof et al. (1997)) may apply to households that have taken out a mortgage. If capital markets are imperfect, people might not be able to borrow as much as they would like to, and one way to express the borrowing constraint is in terms of earned income. In particular, individuals who earn more can borrow up to a higher sum than people who earn less, on the basis that their higher earnings reflect higher human capital to be used as collateral. Households with mortgages might be particularly subject to this type of constraint if their home equity is still low and they do not have other assets to offer as collateral. However, it might be the case that individuals with higher earnings, together with a mortgage, hold assets of various forms, hence rendering this type of borrowing constraint binding only for households at the bottom of the income distribution.

An important issue that follows from the existence of a mortgage-related qualification constraint is that mortgage commitments are potentially endogenous in labour supply decisions. Most of the literature that addresses the relationship between mortgage commitments and labour supply decisions takes mortgage choice (whether to take out a mortgage, its size) as exogenous (see Fortin (1995), Aldershof et al (1997)). In other words, the borrowing constraint is considered to hold at every period but the amount of the mortgage payment is assumed to be exogenous. This will be the implicit assumption in the first part of this analysis as well. That is, it will be assumed that the direction of causality in the relationship between mortgage commitments and labour market participation runs from the former to the latter. The hypothesis of exogeneity is then tested in the second part of the paper.

Most of the studies that have been carried out so far have analysed a single cross-section of the data set of interest and have thus relied on a static-level analysis. In this work, panel data from the British Household Panel Study will be used. Although a static model will be estimated, unlike static models based on a single cross-section, individual unobserved heterogeneity will be controlled for.

The paper is organised as follows. Section 2 presents a survey of the related literature. Section 3 contains the theoretical framework that is used as a guide in the interpretation of the empirical results. Section 4 describes the data set as well as sample selection issues and the variables used in the analysis. It also contains a descriptive section on the relationship between participation and mortgage commitments. Section 5 presents the empirical model and the estimation methods, a description of the empirical results and a discussion of endogeneity of mortgage choice. Section 6 concludes.

2 The literature review

The effect of mortgage market constraints has been analysed in relation to different types of household decisions such as tenure, savings and labour supply. Either the institutional borrowing constraints regarding the downpayment or the ratio of mortgage payments to household income, or both, have been considered. Some works have instead adopted a more general borrowing constraint.

Yoshikawa and Ohtake (1989) examine housing demand and female labour supply in the context of a three-period life-cycle model in which households choose the type of tenure (renting/owning), consumption of other goods and female labour supply, subject to a life-time budget constraint and to an additional constraint related to the downpayment for those who choose to own. They estimate the savings function and the female labour supply function for the two tenure types from a cross-section of the Japanese National Survey of Family Income and Expenditure, by using a two-step Heckman procedure. Tenure choice and savings are made to depend, among other variables, on permanent income of the household head, total net assets and price of land. It is found that changes in husbands' permanent income and/or the price of land affect the tenure decision and that this switching effect makes the price of housing affect the savings rate in two opposite directions. Whether the switching effect affects female labour supply as well, is not examined.

Fortin (1995) analyses the relationship between household labour supply and the mortgage qualification constraint expressed in terms of a maximum gross debt service ratio (mortgage payments/gross household income). The theoretical setting is that of a multiperiod life-cycle model with utility maximization over leisure and consumption, subject to the current period allocation of life-time wealth and to the additional mortgage qualification constraint based on earnings. It is assumed that this mortgage qualification constraint holds at every period on the basis of the Canadian institutional setting, where people remortgage very frequently. Using 1986 data from the Canadian Family Expenditure Survey, the first estimate is of a reduced form model of female labour supply in relation to a set of housing variables that include the value of the house owned, the balance of mortgage and dummy variables for different levels of the ratio of mortgage charges to gross family income (exclusive of wife's labour income). Both a higher balance of mortgage and a higher ratio of mortgage charges to other family income positively affect female labour market participation and hours of work. Subsequently, two labour earnings equations are estimated in relation to the theoretical model. In order to test whether binding constraints for mortgage qualification influence wives' participation, one equation relates to the case in which the housing constraint applies to both the husband and the wife, and the other equation relates to the case in which it applies only to husband's earnings. It emerges that the housing constraint should apply to both spouses but the husband's earnings should be given a greater weight than the wife's.

Aldershof et al. (1997) analyse the relationship between female labour supply and housing consumption by developing a life-cycle consistent model in which households maximise expected lifetime utility over female leisure, housing consumption and non-housing consumption, subject to a housing production function, to the standard lifetime budget constraint and to an earnings-related liquidity constraint.[2] Hence, labour supply and housing consumption are jointly determined. Separability of preferences between these two choices is tested by estimating the female labour supply function conditional on housing consumption and it is not rejected. Estimation is based on the 1989 wave of the Dutch Socio-Economic Panel. Moreover, it is found that female labour supply is positively affected by the ratio of mortgage interest payments to total family income (exclusive of the woman's earnings), which is considered to be a proxy for the presence of binding liquidity constraints.

Del Boca and Lusardi (2001) examine whether imperfections in the credit market, and in particular in the mortgage market, spill over to the labour market by using the 1989 and 1993 cross-sections from the Italian Survey of Household Income and Wealth. Exogenous changes in the mortgage market, such as the reduction of the down payment and wider access to the mortgage market (due both to the financial liberalization brought by the European unification in 1992 and to the Amato Act of 1990), are considered to be an important source of variation to identify these effects. The decision to participate in the labour market and to obtain a mortgage are modelled in terms of a latent variables simultaneous equation model. Mortgage debt is introduced in the empirical estimation using a dummy and a continuous variable for the amount outstanding. It is found that

[2] It is through this earnings dependent liquidity constraint that mortgage commitments are expected to relate to female labour supply. It is argued that the constraint is more likely to be binding in cases where the household has high mortgage commitments.

it has a positive and significant effect on female labour participation. A dummy and the outstanding value owed are also used for family debt and for other types of debt (car, appliances) to check whether mortgage commitment is different from other types of debt. The direction of causality between borrowing constraints and labour supply is assessed by relying on variables proxing for the credit system[3] and the changes in the mortgage market over time.

3 The theoretical framework

The theoretical framework that is adopted as a guide for the empirical specification is one of dynamic programming where individuals choose labour supply (participation) and consumption according to the value function

$$V_t(A_t) = \max_{P_t, c_t} [u_t(P_t, c_t, Z_t) + \beta E_t V_{t+1}(A_{t+1})] \tag{1}$$

subject to the standard asset accumulation rule and to a mortgage-related liquidity constraint,[4] as follows:

$$\begin{aligned} A_{t+1} &= (1 + r_{t+1})[A_t + (y_t + w_{ft}P_t - c_t - m_o)] \\ k(y_t + w_{ft}P_t) &\geq m_o \end{aligned} \tag{2}$$

where

A_t = assets at the beginning of period t

$u_t(\cdot)$ = intra-temporal utility function at period t

P_t = hours of work (participation)

c_t = consumption

Z_t = demographic variables

E_t = expectation operator based on information at time t

[3] They include whether people have a checking account, how many banks they have been using and how many credit cards they use

[4] The mortgage- related borrowing constraint has been introduced following Fortin (1995). Also if thought of in terms of allocational inflexibility, it is meant to be relevant for homeowners with mortgage but not for renters. In fact, it could be argued that homeowners with mortgage who are incapable of keeping up with mortgage payments could always move to a smaller house in the same way as renters could move to a cheaper accommodation. However, as opposed to renters, in order to do that, they would be subject to a mortgage qualification constraint based on earnings. Alternatively, by staying in the same accommodation, they would be subject to allocational inflexibilities (captured by the mortgage-related borrowing constraint) in a way that renters would not be.

β = consumer's discount factor

r_t = rate of return between period $t-1$ and period t

y_t = unearned (non-asset) income (husband's income)

w_{ft} = female wage (earned income if P_t represents participation)

m_o = mortgage payment at period t (assumed to be constant, i.e. non depending on the interest rate)

k = proportion of total household income to be allocated to mortgage payments

Utility is assumed to be intertemporally separable and the intra-temporal utility function, $u_t(\cdot)$, is assumed to be strictly concave and monotonically increasing in c and decreasing in P (there is no presumption regarding Z). Moreover, the amount of the mortgage is assumed to be exogenous so that the mortgage payment at period t is assumed as given.

First-order conditions are obtained from standard dynamic programming techniques and are represented by the following:

$$u_{ct} = \beta E_t[(1 + r_{t+1})\lambda_{t+1}] \tag{3}$$

$$u_{Pt} = \beta E_t[(1 + r_{t+1})\lambda_{t+1}]w_{ft} - \mu_t k w_{ft} \tag{4}$$

$$\lambda_t = \beta E_t[(1 + r_{t+1})\lambda_{t+1}] \tag{5}$$

$$\mu_t[k(y_t + w_{ft}P_t) \geq m_o] = 0, \quad \mu_t \geq 0 \tag{6}$$

where u_{ct} and u_{Pt} denote the first-order derivatives of the utility function with respect to consumption and hours of work, μ_t represents the Kuhn-Tucker multiplier associated to the mortgage-related constraint and λ_t is the marginal utility of wealth ($\partial V_t/\partial A_t$).

When constraint (6) is binding, $\mu_t > 0$ and $P_t = \frac{m_o/k - y_t}{w_{ft}}$. Hence,

$$\mu_t = f(m_o, y_t, w_{ft}) \tag{7}$$

The effect of the mortgage constraint, when binding, is that participation becomes a function of mortgage payment, other family income and female wage. By contrast, when it is not binding, $\mu_t = 0$ and participation does not depend on mortgage payment.

Using first-order conditions (3)-(5), optimal consumption and labour supply equations are defined as follows:

$$c_t = c_t(\lambda_t, w_{ft}, Z_t, \mu_t) \tag{8}$$

$$P_t = P_t(\lambda_t, w_{ft}, Z_t, \mu_t) \tag{9}$$

The equations derived for consumption and participation are the so-called *Frisch equations.*[5] In this framework, λ is interpreted as capturing all the information from other periods that is required in order to obtain the optimal choice in the current period (e.g. it could be thought of as reflecting household permanent income).[6]

In the theoretical framework presented so far, optimization is carried out over hours of work. However, the empirical specification that will be introduced later is expressed in terms of a participation rather than hours equation as a function of other family income, demographics, ratio of mortgage payment to other family income (also interacted with demographic variables). This discrepancy is purely due to the easier analytical tractability of a continuous variable rather than a discrete one, and the model is meant to be just an indication of the way in which the mortgage-related constraint affects labour supply decisions. Finding a positive effect of the mortgage variable on participation is taken as evidence that the mortgage borrowing constraint is binding, and hence that having a mortgage distorts households participation decisions.

4 The data

The data used for this work is the British Household Panel Study (BHPS), waves 3-10 (1993-2000).[7] It reports information on British households on the basis of yearly interviews conducted on an original sample of approximately 5,000 households (circa 10,000 individuals).[8] The panel nature of the data set means that the same individuals are interviewed each year.[9]

The data contains both household and individual level information. At the individual level, apart from demographic characteristics such as age, region, number of children and education, there is detailed information concerning current labour force status, labour force history, health and personal finances (including different sources of income and of investment). Moreover, detailed wealth data is collected every five years.

At the household level, there is detailed information regarding household composition, household expenditure and tenure type of the home lived in, and details on rent or mortgage payments and on loan repayments. In particular, housing information is provided

[5] Demand functions derived by holding the marginal utility of wealth constant.

[6] In an empirical specification, λ would then be modelled as an individual fixed effect.

[7] Waves 1 and 2 are not being used since wave 2 reports many missing observations on housing variables.

[8] Children are interviewed if above 16.

[9] In fact, the selected sample that is being analysed in this work reports on average 4.3 observations per individual over 8 years. This is partly due to attritrion and partly to sample selection (see next section).

with different degrees of detail according to whether households own the accommodation, are paying a mortgage or are renting. Each year, all respondents are asked about the type of accommodation and the number of rooms. Homeowners, including those with a mortgage, also provide their estimate of the value of the house (based on current prices). Further, owners with mortgage are asked to provide some information every year and some additional information the first time they are interviewed at their current address. Among the information which is provided only by people being interviewed for the first time (or who have moved address since previous interview), there is the following: the year in which the mortgage was taken out, the original cost of the house, the original amount of the mortgage (excluding later additions), the number of years the mortgage has still to run and the type of mortgage (whether a repayment mortgage, an endowment mortgage, a mixture of the two or some other type). Every year homeowners with a mortgage are asked whether any additional mortgage has been taken out, its amount, the destination use of it (home extension/ improvement, car purchase, other consumer goods, other). They are also asked to provide the last total monthly instalment on the mortgage or loan.[10] Finally, there are three direct questions on liquidity constraints related to either rent or mortgage payments. In particular, respondents are asked whether there have been any difficulties paying for the accommodation in the last twelve months, and, in case of affirmative answer, whether this has resulted in borrowing money or in cutting back on other household spending. Respondents are also asked whether or not the household has been more than two months behind with the rent or mortgage payment.

4.1 Sample selection

Since the purpose of this work is to analyse whether mortgage-related borrowing constraints affect households' labour participation, the focus will be on female participation on the ground that males normally work full time and so their labour supply behaviour is already constrained. Only people who are in couples (either married or cohabiting) and of different sex will be taken into account and, in line with Fortin (1995), it will be people who are in couples in which the husband works full time and so receives a regular salary. The number of observations drops from 90998 to 45082.

Self-employed are selected out on the basis of the assumption that their labour supply behaviour is different from employed people.[11] Moreover, renters are removed from the

[10] It includes life insurance payments if they are paid together with the mortgage, and it includes both the premium and the interests if it is an endowment mortgage.

[11] In particular, self-employed people do not receive a fixed wage as is assumed in this analysis.

sample as it is assumed that the tenure decision is exogenous and the focus is on homeowners either with or without a mortgage. Finally, only women in the age range 25-45 are kept for the analysis. This is based on the assumption that above this range the mortgage qualification constraint is unlikely to be binding, moreover it is in this range that interactions with the presence of children are more likely to take place. The final working sample is of 12510 observations, that is, 6255 households. Since we have an unbalanced panel, the number of households is in fact 1475, of which 281 are only observed once over 8 periods and 258 are observed over the whole period (8 times). A varying number of 120 and 200 households are observed 2-7 times. On average, people are observed 4.3 times out of 8 periods. The sample selection plays an important role in this apparent high attrition, both through selection of people in couples and through the choice of the age range.

4.2 Description of variables

Female participation

It is a dummy variable defined on the basis of whether the female did any paid work the week before the interview and, in case of negative answer, whether she had a job that she was away from in the same week.[12] Since this definition may assign women who did casual work and who were on maternity leave to the group of participants in the labour market,[13] two alternative definitions of participation have been used to check the sensitivity of the results. One is based on whether the number of weeks of employment during the year before the interview was positive and the other is based on whether the declared current employment status is that of being in paid employment. None of these alternative definitions change the pattern of the results.

Demographic information

The BHPS includes all the standard demographic information such as age, education, number of children, age range of children and region of residence.

In the analysis that follows female's age has been rescaled, so that the youngest females in the selected sample (25 years old) are the reference group. Its square has also been included in order to take into account non-linearities in the relationship between participation and age.

Children possibly play a central role as the focus of the analysis is on female par-

[12] "Any paid work" includes any number of hours, including Saturday jobs and casual work. The reasons of being away from work include those on maternity leave, on holiday, on strike and on sick leave.

[13] It turns out that only 8 observations register the female as participating while she is in fact on maternity leave.

ticipation at early/middle stage of the life cycle. The number of children is controlled for, as is age of the youngest child using dummies which indicate whether the youngest child is either between 0 and 2 years of age or between 3 and 4 years of age. As long as this adds information to the analysis, a dummy for the youngest child being above 5 years of age will be included. Female's education and the region of residence are used as additional control variables whenever the estimation method does not eliminate the fixed effect. Education is summarised by four dummy variables: no education, O level, A level, degree or higher. Dummies are defined for each of nineteen regions.

Income measures

Since the focus of this analysis is on female labour participation, it is necessary to control for income effects related to unearned income. Hence, the log of other family income defined as all household income but female's earned income (i.e. husband's earned and non-earned income and the female non-earned income) is included as explanatory variable. In particular, monthly non-labour income is recovered from the sum of all non-labour income in the year prior the start of the interview period, whereas labour income is given by the usual gross pay per month.[14]

Mortgage and housing information

Of all the housing information described in the previous section, the main variable that has been used in this context is the monthly mortgage payment. The ratio between the monthly mortgage payment and the other family income is the so-called *obligation ratio* (or). As opposed to the ratio that enters the mortgage qualification constraint, this ratio has other family income rather than total family income in the denominator, the difference between the two being the female earned income.

The obligation ratio is expected to capture the effect on household labour market participation of the variation in the burden of mortgage commitments relative to household income. In other words, it is expected to capture the effect of mortgage-related borrowing constraints on labour market participation. Although the institutional mortgage qualification constraint should hold only when the mortgage is taken out, it is plausible to think that it may hold also in subsequent periods. In fact, a positive correlation between the obligation ratio and female participation may be taken as evidence of this hypothesis. Fortin (1995) suggests that the mortgage qualification constraint may hold after the mortgage has been taken out as people may remortgage quite frequently. On the other hand, variation in interest rates may provide another reason for variation in participation

[14] It is gross payment in the month before interview as long as this is the usual payment; when only the net monthly income was available, BHPS imputed values have been used.

related to mortgage commitments. For instance, assuming that the constraint binds, a household that obtained a mortgage on the basis of only male's income and then faces an increase in the obligation ratio due either to higher interest rates or to a decline in male's earnings, would probably have to increase its labour market participation in order to lessen the effect of the underlying mortgage-related borrowing constraint. Alternatively, it could re-mortgage but in that case it would face the institutional mortgage qualification constraint. Hence, either implicitly or explicitly, the earnings-related mortgage constraint would hold not only when the mortgage is taken out but also in subsequent periods.

4.3 Descriptive statistics

Table 1.a and Figure 1.a illustrate female labour market participation behaviour by different types of tenure and age as obtained from the pooled selected sample (years 1993-2000).[15] Both document a strikingly higher participation rate for females in households that have a mortgage, particularly in the age range 30-35, when presumably labour supply decisions are strongly related to the presence and the age of children. Whereas participation for women without a mortgage shows a definite U-shaped pattern with its minimum at the age of 32-33, participation for those with a mortgage only decreases slightly from 84% to 80%. The participation rates of renters appear to be in between the participation rate of owners with no mortgage and owners with a mortgage for any age after 29 and it is the lowest before age 29.

Since households that own the house outright are less than 4% of the sample that includes renters,[16] and since 80% of households in the same sample own with a mortgage, it is necessary to rule out the possibility that the above result is driven by the small number of observations for the group of outright owners, particularly for age below 35. Rather than dividing the group of owners into those who own outright and those who have a mortgage, the two groups are defined according to whether the monthly mortgage payment is below or above the 33rd percentile of the distribution of the monthly mortgage payment (dummy for low/high mortgage payment), where the group with low mortgage payment includes those that own outright. As documented in Table 1.b and in Figure 1.b, up to the age of 36 the participation rate of these two groups presents the same features as the groups of owners outright and owners with mortgage, with a definite U-shaped pattern for those with low monthly mortgage payment (although, as expected,

[15] The figures have been obtained by running mean least-squares smoothing and confidence intervals have been constructed from pointwise standard errors of smoothed values of participation.

[16] 4.5% of the sample with no renters.

the average participation rate for the group of owners with low mortgage is now higher than before). After the age of 36 the two patterns are very similar, possibly due to the fact that the mortgage-related constraint is no longer binding. The participation rate of renters, on the other hand, is now lower than the one of both groups of home owners.

In what follows it is then further explored the relationship between the participation rate of home owners (with and without a mortgage) by focusing on a sample that excludes renters. The obligation ratio is used instead of the mortgage monthly payment in order to net out the effect of household income (excluding female labour income) from a measure of allocational inflexibilities imposed by the mortgage.[17] Figure 2 follows the same logic as Figure 1 but is based on the obligation ratio rather than the level of mortgage monthly payment. It illustrates the pattern of female participation according to whether the obligation ratio is below or above its 33rd percentile level. As for the mortgage level, the pattern of female participation for the group with low obligation ratio is U-shaped, with a minimum at the age of 32-33, whereas participation for the group with high obligation ratio stays at a significant higher level and has only a slight decline at the age of 35. This indicates that other household income is positively related to monthly mortgage payment (otherwise the relative and the absolute mortgage payments would have different effects on labour participation) and that there is a positive correlation between mortgage-related allocational inflexibilities (as represented by the obligation ratio) and female labour market participation.

This latter feature is explored further in Figure 3 by controlling for the presence of young children in the household. In fact, it might be argued that mortgage decisions and fertility decisions are not separable. It turns out that even when the youngest child is between 0 and 2 year old a high obligation ratio significantly increases the probability that females work more than in cases where the obligation ratio is low, at least after the age of 32. When the youngest child in the household is between 3 and 4 year old, the same result holds in the age range 32-37.

Tables 2 and 3 report female labour market participation by 5-year-age groups and obligation ratio quartiles (the lower quartile is defined for $or \leq 0.104$ and the upper

[17] In fact, the institutional mortgage borrowing constraint imposes an upper bound on the mortgage level in terms of household income. Hence, if household income does not change significantly over time, and mortgage payments do not decrease (for instance due to decreasing interest rates) it is plausible to expect that mortgage payments are positively related to household income. Hence, the effect of the burden imposed by the mortgage on female labour supply must be measured in relative terms (relative to household income, excluding female labour income) rather than in absolute ones.

one for $or \geq 0.219$). In table 2 children are not controlled for. It emerges that female labour market participation is higher the higher the obligation ratio for any age group. Particularly in the age range 25-35, labour market participation for the group with the highest obligation ratio is about 20 percentage points higher than for the group with the lowest participation ratio: female participation is 72% for those aged 25-30 with an obligation ratio below 10.4%, it is 93% if their obligation ratio is above 21.9%, and it is 78.7% and 83.8% if their obligation ratio is in between 10.4% and 21.9%. For females aged 30-35, participation goes from 66% to 86% when switching from the lowest to the highest obligation ratio.

When controlling for the presence of the youngest child in the age range 0-2 (Table 3), it is still true that females with the highest obligation ratio have a higher participation rate than those with the lowest obligation ratio. However, for the age group 25-30, the participation pattern is no longer increasing for intermediate levels of the obligation ratio. Whereas those having an obligation ratio below 10.4% have a participation rate of 65%, those having an obligation ratio between 10.4% and 21.9% have a participation rate of, respectively, 59% and 61%. Also when controlling for the presence of the youngest child in the age range 3-4 some non-linearities are present for the age group 25-30. It is noteworthy that participation is around 50% for all the females between 25 and 40 year of age with an obligation ratio below 10.4% whereas it is well above 80% for those with an obligation ratio above 21.9%.

Of course these results are obtained ignoring the panel structure of the data set and hence they can only be taken as a rough indication of a positive relationship between mortgage-related allocational inflexibilities and female labour market participation. The analysis of this relationship in a regression framework that accounts for unobserved heterogeneity in labour market participation will be carried out in the next sections using the panel structure.

5 The empirical model

A static female participation equation with unobserved heterogeneity is estimated. Specifically, the form of the estimated equation is:[18]

$$P_{it} = 1\{\beta \ln y_{it} + \gamma Z_{it} + \delta H_{it} + \theta_1 age_{it} * or_{it} + \theta_2 yoch02_{it} * or_{it} + \alpha_i + \varepsilon_{it} \geq 0\} \quad (10)$$

where P is a binary variable indicating whether the female participates in the labour market.

ln$y$ is the log of other family income and Z is a vector of variables that capture demographic characteristics. Typically it includes (a polynomial in) age and the number of children as well as the age of youngest child. H is a vector of mortgage and housing variables. In the analysis that follows, it includes the obligation ratio (or), that is, the ratio of mortgage monthly payment to other family income and, possibly, the value of the house (in logs, to capture an income effect), the remaining mortgage life, the total mortgage outstanding.

The variable of interest is or and its interactions with age and with the number of children. Interactions with age are meant to capture a different effect of the mortgage-related borrowing constraint at different stages of the life-cycle. In fact, for people who take out a mortgage when they are 25, this interaction captures the effect related to the remaining life of the mortgage. The interaction with a dummy for the presence of young children in the household is meant to control for the possibility that the effect of mortgage commitments is different for people with and without young children.

α_i is the individual specific effect and ε_{it} is the time-varying error term.

5.1 Estimation method

The equation that is estimated in this work belongs to the class of non-linear panel data models with individual specific effect, and in particular to the class of discrete choice panel data models, as represented by the following:

$$y_{it} = 1\{x_{it}\beta + \alpha_i + \varepsilon_{it} \geq 0\} \quad t = 1, 2, ..., T \quad i = 1, 2, ..., n$$

[18] It is worth noticing that as long as mortgage monthly payment is small relative to household's other income, a specification including the the log of other household income and the level of obligation ratio (and no interactions) as explanatory variables represents an approximation (a first order Taylor expansion) of a specification containing only the log of *net* income (other family income net of mortgage payment). In that case, the effect of the mortgage variable would be interpreted in terms of income effect.

As a special case, if it is further assumed that ε_{it}'s are independent and logistically distributed conditional on $\alpha_i, x_{i1}, x_{i2}, ..., x_{iT}$, it follows that

$$\Pr(y_{it} = 1 | x_{i1}, x_{i2}, ..., x_{iT}, \alpha_i) = \frac{\exp(x_{it}\beta + \alpha_i)}{1 + \exp(x_{it}\beta + \alpha_i)}$$

as in the standard logit model,[19] with the only difference being the individual specific effect, α_i.

Estimating β requires dealing with the individual specific effect, α_i. There are basically two methods for doing this, and they will be surveyed in this section. Essentially, one approach, which defines the so-called *fixed effects* model, imposes no assumptions on the relationship between α_i and the explanatory variables and uses instead a method that "eliminates" the individual specific effect on the basis of the same idea that informs differencing in the linear panel data model with fixed effects. A second approach, which defines the so-called *random effects* model, assumes that both the individual specific effect and the idiosyncratic shock are independent of observable characteristics $(x_{i1}, x_{i2}, ..., x_{iT})$. The distribution of α_i conditional on $x_{i1}, x_{i2}, ..., x_{iT}$ is specified parametrically (semiparametrically) so that the individual specific effect is then integrated out.

In the *fixed effects* model the idea is to "eliminate" the individual specific effect by allowing it to be correlated in any form with the explanatory variables. A consistent estimator for β can be obtained by conditional maximum likelihood, where conditioning occurs with respect to the data $(x_{i1}, x_{i2}, ..., x_{iT})$ and to a sufficient statistic for the fixed effect.[20] If the sufficient statistic depends on β, the parameter to be estimated, then the conditional distribution of the data given the sufficient statistic depends on β, and not on α_i, and so β can be estimated by maximum likelihood. The problem with this method is that there is no common sufficient statistic for the non-linear panel data models such that the conditional distribution of the data given the sufficient statistic depends on β. It follows that the method for constructing a likelihood function that does not depend upon the fixed effect is strictly related to the specific non-linear functional form that is chosen as a representation of the data.

[19] Similarly, if ε_{it}'s are independent and normally distributed conditional on $\alpha_i, x_{i1}, x_{i2}, ..., x_{iT}$, then

$$\Pr(y_{it} = 1 | x_{i1}, x_{i2}, ..., x_{iT}, \alpha_i) = \Phi(x_{it}\beta + \alpha_i)$$

where $\Phi(\bullet)$ is the standard normal cumulative distribution.

[20] A *sufficient statistic* for α_i is a function of the data such that the distribution of the data given the sufficient statistic does not depend on α_i.

One case in which the conditional maximum likelihood method can be successfully applied is the one outlined above, where ε_{it}'s are independent and logistically distributed conditional on α_i, $x_{i1}, x_{i2}, ..., x_{iT}$ (Conditional ML Logit). Here, the sufficient statistic that "eliminates" the individual specific effect and lets the conditional distribution depend on β is given by $\Sigma_{t=1}^{T} y_{it}$, i.e. the number of times that $y_{it} = 1$ for the individual. Hence, in this application a sufficient statistic is given by the number of times that each female participates in the labour market over the observation period (1993-2000).[21] The drawback of "eliminating" the unobserved fixed effect in this fashion is that also observed fixed effects do not enter the conditional likelihood function and hence cannot be used as controls. In fact, identification requires that right hand side variables vary over time within individuals. Moreover, the explanatory variables must be strictly exogenous, that is, current shocks, ε_{it}, must be uncorrelated with past, present and future values of the the explanatory variable x: $E(\varepsilon_{it}|x_{i1}, x_{i2}, ..., x_{iT}) = 0,\ t = 1, 2, ..., T.$ [22]

This is a very strong identification assumption. In this work, a violation of strict exogeneity may occur if ε_{it} is correlated with or_{it}, the obligation ratio (i.e. if current mortgage payment is driven by a shock in the female's participation, such as an unexpected lay-off that makes the household obtain a low mortgage, or if current mortgage payment is correlated with past participation and the "true" model is one with lagged particpation but the estimated model ignores the lags). Moreover, assuming also children as strictly exogenous means that labour supply decisions do not affect fertility decisions.

As a further point, in these types of models the parameter(s) of interest are identified

[21] Since cases in which the female does not switch between participation and non-participation (i.e. cases in which she participates at every period and cases in which she never participates) do not contribute to the likelihood function, β is in fact estimated on the basis of females that switch status at least once between period 1 and period T. This means that the only relevant information for the conditional distribution is given by the cases in which $\Sigma_{t=1}^{T} y_{it} \neq 0, T$.

[22] As pointed out by Honoré (2002), this assumption is probably unrealistic in most economic context in which t represents time and particularly in cases in which y_{it} is the outcome of an individual's optimization problem so that it is expected that y_{it} enters as an explanatory variable in the equation for $y_{i,t+1}$. This is very likely to be the case for females labour force participation decisions.

In a model with lagged participation as explanatory variable, a weaker assumption than strict exogeneity would be prederminedness. In other words, given a model like the following:

$$y_{it} = \gamma y_{it-1} + \beta_0 x_{it} + \beta_1 x_{it-1} + \alpha_i + \varepsilon_{it}$$

x would be predermined if $E(\varepsilon_{it}|x_{i1}, x_{i2}, ..., x_{it,} y_{i1}, y_{i2}, ..., y_{it-1}) = 0$, i.e. if current shocks were uncorrelated with past values of y and with past and current values of x.

only up to scale[23] and conditional on the individual specific effect. As pointed out by Honoré (2002), by knowing the coefficient of the explanatory variable in a fixed effects logit model it is possible to judge the relative importance of different time-varying explanatory variables as well as to calculate the effect of the explanatory variables on the probability that the dependent variable takes the value 1 conditional on a particular value for the individual specific effect. However, it is not possible to calculate the average effect of the explanatory variable(s) on the same probability taken across the distribution of the individual specific effect in the population.

The *random effects* model "eliminates" the individual specific effect by assuming a parametric distribution for α_i conditional on $x_{i1}, x_{i2}, ..., x_{iT}$ so that α_i can be integrated out of the conditional distribution of the data.

For the Probit model, the traditional assumption is that of independence between α_i and $x_{i1}, x_{i2}, ..., x_{iT}$, although Chamberlain (1984) in fact allows for some correlation between them. Using Wooldridge (2002) definition, the "traditional random effects probit model" assumes that the distribution of the individual specific effect, α_i, conditional on the observables is as follows: $\alpha_i | x_{i1}, x_{i2}, ..., x_{iT} \sim N(0, \sigma_\alpha^2)$, which implies that α_i and the vector $(x_{i1}, x_{i2}, ..., x_{iT})$ are independent and that α_i is normally distributed.

As already mentioned, a particular case is that of Chamberlain (1984)'s random effects probit model, where the conditional distribution of the individual specific effect is allowed to depend linearly on the observables (assumption 2 below). More formally, Chamberlain's random effects probit model is obtained under the following assumptions:

1. $(\varepsilon_{i1}, \varepsilon_{i2}, ..., \varepsilon_{iT})$ is independent of α_i and of $(x_{i1}, x_{i2}, ..., x_{iT})$, with a multivariate normal distribution: $(\varepsilon_{i1}, \varepsilon_{i2}, ..., \varepsilon_{iT}) \sim N(0, \Sigma)$, $\Sigma = \begin{bmatrix} \sigma_1^2 & & & 0 \\ & \sigma_2^2 & & \\ & & ... & \\ 0 & & & \sigma_T^2 \end{bmatrix}$

so that $\Pr(y_{it} = 1 | x_{i1}, x_{i2}, ..., x_{iT}, \alpha_i) = \Phi\left(\frac{x_{it}\beta + \alpha_i}{\sigma_t}\right)$, where $\Phi(\cdot)$ is the standard normal distribution;

2. the distribution for the individual specific effect conditional on $(x_{i1}, x_{i2}, ..., x_{iT})$ is linear in the xs and normally distributed:

$\alpha_i = \lambda_0 + \lambda_1 x_{i1} + \lambda_2 x_{i2} + ... + \lambda_T x_{iT} + \nu_i$ where $\nu_i \sim N(0, \sigma_\nu^2)$ and independent of the xs.

[23] Arellano (2000) recalls that in the logit case the scale normalization is imposed through the variance of the logistic distribution (and, in general, by the form of the cumulative distribution of $\varepsilon_{it} | x_{i1}, ..., x_{iT}, \alpha_i$, if known).

Given assumptions 1. and 2., the distribution for y_{it} conditional on $(x_{i1}, x_{i2}, ..., x_{iT})$ has a probit form:

$$\Pr(y_{it} = 1 | x_{i1}, x_{i2}, ..., x_{iT}) = \Phi\left(\frac{x_{it}\beta + \lambda_0 + \lambda_1 x_{i1} + \lambda_2 x_{i2} + ... + \lambda_T x_{iT}}{(\sigma_t^2 + \sigma_\nu^2)^{1/2}}\right)$$

A more parsimonious version of Chamberlain's model allows the individual specific effect to depend on the average of x_{it}, $t = 1, 2, ..., T$, which we call $\bar{x}_i$, rather than on each single x_{it}, as follows:[24]

$$\alpha_i = \lambda_0 + \lambda_1 \bar{x}_i + \nu_i \text{ , where } \nu_i \sim N(0, \sigma_\nu^2) \text{ and independent of the } x\text{s.}$$

The distribution for y_{it} conditional on $(x_{i1}, x_{i2}, ..., x_{iT})$ then takes the following form:

$$\Pr(y_{it} = 1 | x_{i1}, x_{i2}, ..., x_{iT}) = \Phi\left(\frac{x_{it}\beta + \lambda_0 + \lambda_1 \bar{x}_i}{(\sigma_t^2 + \sigma_\nu^2)^{1/2}}\right)$$

Alternatively, a random effects logit model is defined under the assumption that the distribution of the time-varying disturbances conditional on the individual specific effect, $\varepsilon_{it}|\alpha_i$, are independently distributed according to a logistic *cdf* and that the individual specific effect, α_i, conditional on $(x_{i1}, x_{i2}, ..., x_{iT})$ is normally distributed.

More generally, the joint distribution of the data conditional on observables is defined as follows:

$$\Pr(y_{i1}, y_{i2}, ..., y_{iT} | x_{i1}, x_{i2}, ..., x_{iT}) = \int \Pr(y_{i1}, y_{i2}, ..., y_{iT} | x_{i1}, x_{i2}, ..., x_{iT}, \alpha_i) dF(\alpha_i | x_{i1}, x_{i2}, ..., x_{iT})$$

and $F(\alpha_i | x_{i1}, x_{i2}, ..., x_{iT})$, the *cdf* of the individual specific effect conditional on observables, has some specified parametric (or semiparametric) form.

This makes the model fully parametric and so, if the explanatory variables are strictly exogenous, maximum likelihood or methods of moments estimation can be applied.[25]

In this work both maximum likelihood random-effects logit and maximum likelihood random-effects probit are estimated. The comparison between these two models, which rely on a different parametric specification of the individual specific effect, and of these two models with the conditional maximum likelihood estimator, should give us an indication of the nature of unobserved heterogeneity.

Finally, estimation of a logit model is performed on the pooled sample by ignoring the panel structure of the data. In other words, it is assumed that observations are i.i.d.

[24] See Wooldridge (2002), Chapter 15.

[25] Arellano and Honoré (2000) recall that there exists a practical issue in using maximum likelihood, in terms of the speed and the accuracy in the calculation of a multinomial normal cumulative distribution.

and follow a logit distribution and so the fact that observations may be correlated over time within individuals due to the presence of unobserved individual heterogeneity is not taken into account. Hence, the individual specific effect is assumed to be zero. Moreover, the error term, ε_{it}, is assumed to be uncorrelated over time and with the explanatory variables, x_{it}.

$$\begin{aligned} y_{it} &= x_{it}\beta + \varepsilon_{it} \ , \ \ \varepsilon_{it} \sim iid \\ \Pr(y_{it} &= 1|x_{it}) = \Lambda(x_{it}) = \frac{\exp(x_{it}\beta)}{1+\exp(x_{it}\beta)} \end{aligned}$$

The comparison between the pooled logit and the conditional logit estimators should give an indication of the importance of unobserved heterogeneity that can be taken into account by using the panel structure of the data.

5.2 Empirical results

As emphasised in the previous section, one of the main identifying assumptions underlying the estimates obtained here is that the explanatory variables are strictly exogenous. Hence, both feedback effects from lagged participation to current and future values of the obligation ratio and to current and future fertility decisions (predetermination) and simultaneous decision about the mortgage and participation are assumed away.

The conditional ML logit, by allowing the individual specific effect to depend upon the explanatory variables, and by allowing this dependence to hold in an unspecified manner, is the least restrictive estimation method adopted here. Since only observations where at least one transition in participation has occurred over the observation period contribute to the likelihood function in a conditional logit, from the sample of 6255 observations, 4598, corresponding to 1186 individuals, are dropped and 1657 are used in the estimation.

Estimation results from a conditional logit are reported in Table 5, column 1. The variable of interest, the obligation ratio (*or*), has a positive and significant effect on participation for the reference group of 25 year olds. The interaction of *or* with age shows a negative sign, and significant at the 1% level, suggesting that the mortgage-related constraint has a decreasing impact on participation over the life cycle. It takes approximately 9 years (i.e. until the age of 34) to offset the positive effect of the obligation ratio on the participation of a female with no children.

As expected, children have a strong impact on female participation. In particular, having a youngest child aged either 0-2 or 3-4 has a negative and significant effect on participation, as does the presence of any additional child in the household. Whether it is the negative effect of children or the positive effect of mortgage commitments that dominates depends on the stage of the life cycle in which children enter. In fact, since the coefficient on the interaction between the dummy for having the youngest child in age 3-4 is not significant, the only relevant interaction between the obligation ratio and children is the one involving the dummy for having a youngest child aged 0-2. So, for instance, for a 25 year old female in a household with mortgage constraints and with the youngest child between 0 and 2 years of age the net effect on participation is positive, whereas for a female in the same situation but with no mortgage constraints the effect on participation is negative. However, when the youngest child in the household is aged 0-2, the positive effect of mortgage commitments on participation dominates the negative one deriving from children only for women 28 or younger. In other words, a 30 year old female with the youngest child aged 0-2 has a higher probability of participating if she has no mortgage commitments.

Other family income, in logs, has the expected negative sign.

The conditional logit estimation results are compared with estimates from a random effects logit model in Table 5, column 2. As opposed to the conditional (fixed effects) logit, all the observations are used (rather than just those in which there is a transition). Identification requires the *cdf* of the idiosyncratic shock conditional on the individual specific effect be logistic and the individual specific effect be normally distributed as well as independent of the explanatory variables. Moreover, as for the conditional logit model, strict exogeneity is assumed throughout. Both a specification that includes controls for education and region of residence and one that omits them are reported. In both specifications, all coefficients retain the same sign as in the conditional logit estimation.[26] However, the magnitude of both the obligation ratio and the age/obligation ratio interaction changes substantially, being, respectively, 5.843 and -0.679 according to the conditional logit and 8.023 and -0.335 according to the random effects logit. This casts doubts on the validity of the assumption underlying the random effects model, that the unobserved individual-specific effect be uncorrelated with the explanatory variables. In this case, it would mean assuming that preference towards work be uncorrelated with the obligation ratio. This appears to be very unlikely since the mortgage is given according to total family income, including female labour income (hence, participation).

[26] Most of the coefficients on the time-varying explanatory variables do not change noticeably according to whether these "fixed" effects are or are not included. The coefficients that show the biggest change are those for the log of other household income, the obligation ratio and the dummy for the youngest child being 0-2.

The random effects probit model (see Table 6) produces substantially the same results as the random effects logit, both in terms of significance and in terms of magnitude, once the rescaling factor (of approximately 1.8) is taken into account. This result suggests that the estimation results obtained under the random effects model are not driven by the functional form (probit or logit) assumed for the individual specific effect. What seems to play the major role is the assumption of independence between the individual specific effect and the explanatory variables that underlies the random effects model but does not need to hold for the fixed effects estimation.

One can test whether or not the data support the assumption of independence between the individual specific effect and the explanatory variables by estimating a "Chamberlain random effects probit". This involves defining the individual specific effect as a linear function of a vector of explanatory variables (or their average over time) and adding these variables into the probit model. The null hypothesis is that the coefficients on the variables that define the individual specific effect are jointly zero and this is tested against the alternative that there is some correlation taking the form of a conditional normal distribution with linear expectation and constant variance. In Table 6, column 3, we report the results obtained by adopting, as conditioning variables for the individual fixed effect, the individual average over time of both the obligation ratio and of the interaction between age and the obligation ratio.[27] The test on the joint significance of these two coefficients makes us reject the null hypothesis ($\chi^2(2) = 39.60$), so that the usual random effects probit is rejected in favour of a random effects probit that allows for some correlation between the individual specific effect and the explanatory variables. We take these results as further supporting the choice of a fixed effects logit since this estimator remains consistent whether or not there is any correlation (of whatever form) between the individual effect and the explanatory variables of the model.

Finally, estimation of a logit model is performed on the pooled sample and is reported in table 5, column 3. Comparison with the conditional logit estimates is expected to inform on the gain arising from acknowledging the panel structure of the data, i.e. from

[27] This is to say that we run a standard random effects probit on our usual set of explanatory variables augmented with the individual mean of the obligation ratio over time and with the product of the individual means of age and of the obligation ratio over time. This corresponds to assuming that the conditional distribution of the individual specific effect has the following form:

$$\alpha_i | x_{i1}, x_{i2}, ..., x_{iT} \sim N(\lambda_0 + \lambda_1 \overline{or}_i + \lambda_2 \overline{or}_i * \overline{age}_i, \sigma_\nu^2)$$

taking into account that observations may be correlated over time within individuals due to the presence of unobserved individual heterogeneity. As for the random effects models, education and region of residence are controlled for. The coefficients on all variables of interest retain the sign that was found by conditional logit estimation method and most of them are significant. However, the interaction between age and the obligation ratio is now insignificant. Moreover, the magnitude of the interaction term changes considerably relative to the conditional logit (from -0.679 to -0.130, when education and region are controlled for, and -0.117 when they are not). This perhaps suggests once again that unobserved preference towards work is in fact relevant in modelling participation and that it is correlated with age and with mortgage commitments.

5.3 Endogeneity

The variable of interest in this analysis, the obligation ratio, is likely to be endogenous for a number of reasons. One way in which the error term of our model could be correlated with the obligation ratio is through reverse causality between the mortgage and female labour market participation. So far, we have assumed the mortgage choice is given and consequently we have analysed the relationship as running from mortgage choice to labour market participation. Due to the existence of the institutional mortgage qualification constraint (whether and how much one can borrow is a function of household labour earnings, hence also of female labour participation prior to taking out the mortgage), it is plausible to think of the causality as running from participation to the mortgage. As long as participation is a fixed individual effect over the period analysed here, this should not be a problem for our estimation. In fact, conditional logit estimation deals with the individual specific effect by allowing it to be correlated with the obligation ratio and the other explanatory variables in any unspecified way. Our estimation would be biased and inconsistent if, instead, today's participation in the labour market were a function of future mortgage payments in a way that is not "fixed".[28] This would be the case, for instance, if participation today were driven by changes in the expectation of future mortgage commitments.

Another potential source of endogeneity lies in simultaneous decisions about the mortgage and labour market participation. Even after controlling for the individual specific effect, it could be the case that the idiosyncratic shock (ε_{it} in equation (10)) is correlated

[28] Recall that conditional logit estimation requires that the explanatory variables are strictly exogenous. Focussing on the obligation ratio, this requirement translates into the following condition:

$\Pr(P_{it} = 1 | or_{i1}, ..., or_{it}, ..., or_{iT}; \alpha_i) = \Pr(P_{it} = 1 | or_{it}; \alpha_i)$

with the obligation ratio if, for instance, a common shock hit the obligation ratio and participation in the labour market simultaneously.

In order to test for endogeneity, we use house price data as an excluded variable in a control function framework. House prices are presumably correlated with the obligation ratio but uncorrelated with labour market participation, which makes them a suitable instrument. We use two different data sets for house prices, which we will briefly outline hereafter. A discussion of the method and results of the test will follow.

5.3.1 The data

We first use data on house prices that contains quarterly information on residential property transactions by house type (flat, detached, semi-detached, terraced) at the Postal Sector level between 1995 and 2000.[29] In order to match it with the BHPS, we have aggregated it at the Local Authority District level,[30] which is the minimum geographical area recorded for each individual. Then, we have taken annual average prices (ratio between annual volume of transactions and annual number of transactions), RPI adjusted, by house type and Local Authority District (LAD). Therefore, the vector of the mortgage variable, the obligation ratio for the years 1995-2000, is instrumented with a vector of house prices for the corresponding years, appropriate for the Local Authority District and the house type of the household. The BHPS sample includes years 1993 and 1994 but house prices are collected only from 1995 onwards. 1500 observations (of the 6255) are missing due to this. A futher 555 observations are dropped due to missing house prices mostly in Scottish LADs.[31]

Since it might be argued that current house prices are not suitable instruments for a mortgage that could have been taken out several years before, we also collect information on house prices at the time the mortgage was taken out (RPI adjusted). Unfortunately, we are not aware of any data set that collects house prices at Local Authority District level

[29] Residential property transaction data were built by Experian, and made available through MIMAS, using information supplied by HM Land Registry.

[30] Conversion has been done at the MIMAS webpage (http://convert.mimas.ac.uk), within the Updated Area Master Files project (based on the ONS All-Fields Postcode Directory (AFPD)). In some cases, the Local Authority Districts as defined in the BHPS did not match with the Census definition as of 1998, particularly for Scotland and Wales. As a consequence, the match is not always 1:1. If more Census districts form a BHPS district, the price index of the latter is the result of a weighted average of the prices of the contributing districts, each of which with equal weights.

[31] See Appendix for a detailed list of LADs and corresponding number of missing observations.

as far back in time as mortgages were taken out by households in our sample (the earliest dates back to 1968 although 95 percent of households took out the mortgage in 1980 or after). We then use house prices at regional level.[32] Unlike the data at LAD level, house prices are now the average dwelling price for all dwellings. We had to sacrifice geographic and house type detail in order to find earlier data. Since the mortgage is taken out at one point in time, in order to capture the variability over time within individuals we interact the house price measure with current (annual) mortgage interest rates.[33] That is, the vector of obligation ratio between 1993 and 2000 is instrumented with a vector of the interactions between the average house price in the region of residence at the time the mortgage was taken out and mortgage interest rates between 1993 and 2000.[34]

5.3.2 The test

The test of endogeneity for the mortgage variable (the obligation ratio) in our regression is performed within a control function approach. We write our binary model as follows:

$$\begin{aligned} P_{it} &= 1\{\mathbf{x}_{it}\beta_0 + \alpha_i + \varepsilon_{it} \geq 0\} \\ &= 1\{h(\mathbf{z}_{1it}, \mathbf{y}_{it}) + \alpha_i + \varepsilon_{it} \geq 0\} \end{aligned} \tag{11}$$

where α_i is the individual specific effect and ε_{it} is the idiosyncratic shock; $\mathbf{x}_{it} = (\mathbf{z}_{1it}, \mathbf{y}_{it})$, $\mathbf{y}_{it}$ is the endogenous variable (the obligation ratio), and $\mathbf{z}_{1it}$ is a vector of all the other (exogenous) explanatory variables.[35] $\mathbf{y}_{it}$ is in turn determined by the exogenous variables $\mathbf{z}_{1it}$ and an "excluded instrument", $\mathbf{z}_{2it}$, given by house prices (or by the interaction between house prices and interest rates), as follows:

$$\mathbf{y}_{it} = \mathbf{z}_{it}\pi + \delta_i + \mathbf{u}_{it} \tag{12}$$

and

$$\mathbf{z}_{it} = (\mathbf{z}_{1it}, \mathbf{z}_{2it}), \tag{13}$$

[32] The geographic units are "Standard Statistical Regions", namely: North, North-West, Yorkshire and the Humberside, East Midlands, West Midlands, East Anglia, London, South-East, South-West, Wales, and Scotland. The source of the data is the Survey of Mortgage Lenders made available through the Office of the Deputy Prime Minister at www.odpm.gov.uk.

[33] This is justifiable on the basis that most mortgages in the UK have variable intrest rates.

[34] We should also note that using prices at LAD level carried the cost of loosing observations for the years 1993-1994, when prices were not available. This is not the case when using prices at regional level for the time the mortgage was taken out, although some observations are still missing due to not observing either the year the mortgage was taken out or the region of residence.

[35] The function h is left generic to allow for interactions between our exogenous and endogenous variables (in particular, age and the obligation ratio).

δ_i and $\mathbf{u}_{it}$ are, respectively, the individual specific effect and the idionsyncratic error term

As pointed out in Blundell and Powell (2001), the control function approach uses estimates of the reduced form error terms u_{it} as "control variables" for the endogeneity of the regressor $\mathbf{y}_{it}$ in the original equation (11). Testing the significance of these "control variables" is therefore a test of endogeneity of the regressor $\mathbf{y}_{it}$.

The control function assumption is that

$$\varepsilon_{it} \perp \mathbf{y}_{it} | \mathbf{u}_{it}, \delta_i, \mathbf{z}_{it} \quad (14)$$

In order to integrate $\mathbf{u}_{it}$ out, we therefore need to know the form of the distribution of ε_{it} conditional on $\mathbf{u}_{it}$. If the joint distribution of ε_{it} and $\mathbf{u}_{it}$ were normal, as in Smith and Blundell (1986), one could write ε_{it} conditional on $\mathbf{u}_{it}$ as linear: $\varepsilon_{it} = \mathbf{u}_{it}'\gamma + \eta_{it}$. In our context, where estimation is performed by conditional logit, we cannot assume joint normality of the two error terms and linearity of their conditional distribution. Instead, we say that ε_{it} is some function of $\mathbf{u}_{it}$ plus an error term (η_{it}), and we approximate this with a second-order Taylor series expansion.

It follows that the conditional expectation of the binary variable P_{it} given the regressors $\mathbf{x}_{it}$, the fixed effect α_i and the reduced form error terms $\mathbf{u}_{it}$, now takes the form

$$\begin{aligned} E(P_{it} | \mathbf{x}_{it}, \alpha_i, \mathbf{u}_{it}) &\simeq \Pr(\mathbf{x}_{it}\beta_0 + \alpha_i + \gamma_1 \mathbf{u}_{it} + \gamma_2 \mathbf{u}_{it}^2 + \eta_{it} \geq 0) \\ &= \Lambda(\mathbf{x}_{it}\beta_0 + \alpha_i + \gamma_1 \mathbf{u}_{it} + \gamma_2 \mathbf{u}_{it}^2) \end{aligned} \quad (15)$$

and the test of endogeneity is a test of joint significance of the coefficients γ_1 and γ_2. (15) is estimated by a two-stage procedure that allows us to replace $\mathbf{u}_{it}$ and $\mathbf{u}_{it}^2$ with their estimated counterparts $\hat{\mathbf{u}}_{it}$ and $\hat{\mathbf{u}}_{it}^2$ obtained from the first stage estimation of (12).

In practice, the reduced form equation (12) is estimated by a within-groups regression of the obligation ratio on the set of exogenous variables (log of other income, quadratic in age, dummies for the youngest child aged 0-2 or 3-4, number of children) and the "excluded instrument", i.e. the log of the current house prices at LAD level or the log of the interaction between the average house price in the local region at the time the mortgage was taken out and current mortgage interest rates. The results are reported in the top panel of Table 7; column 1 and column 2 report, respectively, the outcomes from using the two different sets of instruments. The t-ratio for our instruments are, respectively, 15.93 for the log of house price at LAD level and 16.17 for the log of the interaction of house prices at regional level and mortgage interest rates. A quadratic form of the estimated residuals from the first stage estimation is included in the conditional logit regression as indicated in equation (15). A $\chi^2(2)$ test of their joint significance takes the values of 1.6063 and 0.0084, respectively for the case where regional or LAD prices are used. Since they do not appear to be significant, we conclude that we cannot reject the null hypothesis of no endogeneity in our model.

5.4 Sensitivity analysis

As mentioned in section 4.2, sensitivity analysis is performed with regard to the definition of participation. Results are reported in table 8 and bring the same conclusions as the definition of participation adopted for the main analysis.

Figures 1.c and 1.d also document the pattern of female labour market behaviour when hours of work are used rather than participation. Although a declining pattern in hours worked is observed in the age range 25-35 for both outright owners and owners with a mortgage (or for owners with low mortgage and owners with high mortgage), it is still true that a more pronounced dip is observed for the group of outright owners (alternatively, for those with low mortgage).

Further sensitivity checks are performed by controlling for wealth. One concern regards real assets, and in particular whether it is necessary to control for the value of the house when analysing labour supply in relation to mortgages. In other words, we need to control for the possibility that some households have experienced an increase in their house value that has relaxed their liquidity constraint. Including a self-reported measure of the value of the house (in logs), however, does not appear to change the results of our analysis.[36] As reported in table 9, the conditional logit estimates are almost identical to those of the basic model of table 5 (column 1) and the house value is not statistically significant.

Another concern relates to financial assets, in that it is necessary to rule out the possibility that those who appear to be more subject to liquidity constraints (in the form of a higher obligation ratio), do not hold financial assets that could be used as collateral instead of human capital. If that were the case, claiming that having a mortgage makes the household work more, would not be correct as the liquidity constraint would not in fact be binding.

The BHPS collects data on household financial wealth every five years, namely in 1995 and 2000. Savings, investments and debt are reported separately by individuals, who

[36] The same conclusion applies when including the ratio between the value of the house and total household income (excluding female's labour income). Results are not reported for brevity.

also report whether they hold their assets jointly with someone else, so that a measure of net financial wealth at the tax-unit level can be constructed. Missing information or information for those who only provide bands for their assets are imputed according to the age of the head of the benefit unit, whether either of the adults in the benefit unit have completed any higher education and whether the head of the benefit unit is self-employed. The single components of net wealth are imputed separately.[37]

As pointed out in Banks, Smith and Wakefield (2002), wealth information across the 1995 and 2000 waves is not fully comparable, due to the different definition of debt, which in 1995 does not include student loans and overdrafts, whereas it does in 2000. We then rely on the two single cross-sections of the data for our analysis. With only this data at hand it is not possible to perform a conditional logit estimation of our model with controls for wealth, which would allow comparability with the baseline model. We therefore investigate the issue at a descriptive level. Table 10 reports the net financial wealth in 1995 and in 2000 for increasing levels of the obligation ratio within each chosen age group. If increasing levels of the obligation ratio were to mean tighter liquidity constraints, we would want those households with higher levels of obligation ratio to hold lower net financial wealth. This is in fact what generally emerges in table 10, being violated only for the year 2000 for the top level of obligation ratio (note, however, that the difference between the third and the fourth column is small and that standard deviations are very large).

A final sensitivity check is performed with respect to the timing of taking out the mortgage. So far, all the observations of the selected sample have been used, regardless of when the mortgage was taken out. The interaction term between the obligation ratio and age of course allows for the mortgage-related constraint to vary over time. However, it is being investigated whether the qualitative results hold for households that have taken out a mortgage recently. In particular, also in relation to the use of house prices between 1995 and 2000 in order to test for endogeneity (see previous section), we perform our estimation on the sub-sample that took out the mortgage between 1995 and 2000 and for whom the house price is not missing, having a final sample of 1318 observations. Conditional logit estimation results are reported in table 11. Because of the small number of observations where a change in outcome is observed, the sample used in the estimation is made of 192 observations, which justifies obtaining very few significant coefficients. The qualitative

[37] The wealth data used in this paper has been derived and imputed by Banks, Smith and Wakefield (2002). For details, please refer to their paper.

results, however, are unchanged and both the obligation ratio (for 25 year old) and the interaction between the obligation ratio and having the youngest child between 0 and 2 remain significant and stronger in magnitude. Consistently with the nature of the sub-sample of those who have taken mortgages out recently, it would take longer to offset the positive effect of mortgage on the participation of a female with no children (16 years) relative to the baseline case (9 years).

6 Conclusion

This paper contains an analysis of whether female labour supply is affected by mortgage commitments. It employs panel data techniques and uses the British Household Panel Study (waves 3-10). The sample used includes any woman aged 25-45, in a couple, and whose husband works full-time; it excludes self-employed individuals and renters. It is found that mortgage commitments, as captured by the ratio between monthly mortgage payment and household income excluding female's earned income, have a positive effect on female participation. However, the negative effect on female participation of having a young child is very strong and the combined effect of children and mortgage commitments on participation can stay negative.

As opposed to previous studies that have used cross-sectional data, the key advantage of the panel structure of this dataset is that it allows estimation of a static model that controls for unobserved heterogeneity. This is done by means of conditional logit and random effects logit estimation. The conditional logit estimation method takes care of the individual specific component of the error term by allowing it to be correlated in any unspecified manner with the explanatory variables. Hence, preference towards work is allowed to be correlated with mortgage decisions.

Endogeneity of the mortgage variable is a potential issue; it could emerge due, for example, to correlation between mortgage decisions and transitory shocks or to reverse causality (from participation to the mortgage). A test of endogeneity is performed in a control function framework using house prices as control variables. We use, respectively, contemporaneous house prices by house type at Local Authority District level, and the interaction between house prices at regional level at the time the mortgage was taken out and current mortgage interest rates. The null hypothesis of no endogeneity cannot be rejected.

Sensitivity checks are performed with respect to real and to financial assets. The value of the house, when controlled for, does not appear to be significant and does not change the results of the analysis. A first look at financial assets, which are measured in 1995 and in 2000, seems to rule out the possibility that many people with higher mortgage commitments could hold financial assets to use as collateral.

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Appendix

Missing house prices at LAD level occur for the years 1993-1994 and mostly for Scottish LADs in subsequent years. In particular, the distribution of missing house prices for the years 1995-2000 is as follows:

Local Authority District	***# of observations in our sample for LADs where house prices are missing***
E Yorkshire; Holderness	3
Thamesdown	67
Blaenau Gwent; Islywn	56
Edinburgh City	106
West Lothian	10
Clackmannan; Stirling	1
Falkirk	21
Annadale; Nithsdale; Stewarty; Wigtown	5
Dunfermline	6
Kirkcaldy; NE Fife	7
Aberdeen City	20
Banff & Buchan; Moray	6
Gordon; Kincardine & Deeside	7
Bearsden ; Clydebank; Strathkelvin	63
Cumbernauld & Kilsyth; Monklands	11
Clydesdale; Cumnock Doon ; Kyle Carrick	31
Cunninghame	46
Eastwood; Kilmarnock & Loudon	19
Glasgow City	7
Renfrew	2
Angus; Perth & Kinross	18
Dundee City	43

Table 1: Female participation by age and tenure

Table 1.a

age	owners w/out mortgage	owners w/mortgage	renters	All
25-30	0.727	0.844	0.608	0.798
	(0.451)	(0.362)	(0.489)	(0.402)
	44	1,677	398	2,119
30-35	0.411	0.801	0.637	0.765
	(0.497)	(0.399)	(0.482)	(0.424)
	51	1,697	281	2,029
35-40	0.724	0.807	0.784	0.801
	(0.450)	(0.394)	(0.412)	(0.399)
	87	1,454	158	1,699
40-45	0.784	0.848	0.787	0.838
	(0.414)	(0.359)	(0.411)	(0.369)
	97	1,148	141	1,386
All	0.688	0.824	0.671	
	(0.464)	(0.381)	(0.470)	
	279	5,976	978	

Table 1.b

age	mortgage payment≤ 213	mortgage payment> 213
25-30	0.800	0.857
	(0.400)	(0.350)
	460	1,261
30-35	0.698	0.827
	(0.460)	(0.379)
	496	1,252
35-40	0.792	0.809
	(0.406)	(0.393)
	552	989
40-45	0.854	0.834
	(0.353)	(0.373)
	583	662
All	0.788	0.833
	(0.408)	(0.373)
	2,091	4,164

Note: Cells contain, top to bottom, the mean, the standard deviation (in brackets), and group size.

213 corresponds to the 33rd percentile of the mortgage repayment distribution

Table 2: Female participation by age and level of obligation ratio

age	$or \leq 0.104$	$0.104 < or \leq 0.158$	$0.158 < or \leq 0.219$	$or > 0.219$
25-30	0.721	0.787	0.838	0.926
	(0.450)	(0.410)	(0.368)	(0.260)
	222	390	520	589
30-35	0.658	0.769	0.832	0.865
	(0.475)	(0.422)	(0.375)	(0.342)
	354	428	493	473
35-40	0.733	0.809	0.809	0.896
	(0.443)	(0.393)	(0.393)	(0.305)
	487	404	341	309
40-45	0.820	0.825	0.829	0.953
	(0.384)	(0.381)	(0.378)	(0.212)
	501	342	210	192
All	0.742	0.796	0.829	0.905
	(0.437)	(0.403)	(0.377)	(0.293)
	1,564	1,564	1,564	1,563

Note: The obligation ratio is defined as the ratio between monthly mortgage payment and other family income (household income minus female's earned income). Cells contain, top to bottom, the mean, the standard deviation (in brackets), and the group size.

Table 3: Female participation by age, level of obligation ratio and age of the youngest child

Youngest child 0-2

age	$or \leq 0.104$	$0.104 < or \leq 0.158$	$0.158 < or \leq 0.219$	$or > 0.219$
25-30	0.651	0.587	0.612	0.737
	(0.481)	(0.495)	(0.489)	(0.442)
	63	92	121	114
30-35	0.381	0.660	0.692	0.667
	(0.490)	(0.476)	(0.463)	(0.474)
	63	94	130	111
35-40	0.385	0.615	0.680	0.775
	(0.493)	(0.496)	(0.471)	(0.423)
	39	26	50	40
40-45	0.571	0.750	0.571	1.000
	(0.535)	(0.463)	(0.534)	-
	7	8	7	1
All	0.488	0.627	0.656	0.714
	(0.501)	(0.485)	(0.476)	(0.453)
	172	220	308	266

Youngest child 3-4

age	$or \leq 0.104$	$0.104 < or \leq 0.158$	$0.158 < or \leq 0.219$	$or > 0.219$
25-30	0.513	0.688	0.696	0.886
	(0.507)	(0.467)	(0.464)	(0.321)
	37	64	69	44
30-35	0.515	0.632	0.795	0.829
	(0.504)	(0.485)	(0.406)	(0.379)
	66	87	88	76
35-40	0.489	0.717	0.729	0.860
	(0.505)	(0.455)	(0.449)	(0.351)
	47	46	48	50
40-45	0.714	0.600	0.500	0.857
	(0.488)	(0.507)	(0.527)	(0.378)
	7	15	10	7
All	0.515	0.665	0.735	0.853
	(0.501)	(0.473)	(0.442)	(0.355)
	157	212	215	177

Note: Cells contain, top to bottom, the mean, the standard deviation (in brackets), and group size

Table 4: Descriptive statistics of variables used in the estimation (N=6255)

variable	**Mean**	**Std. Dev.**	**Min**	**Max**
female participation	0.818	0.386	0	1
other hh income	1996.309	1123.378	235.177	21483.810
log(other hh income)	7.494	0.438	5.460	9.975
age (rescaled by 25)	9.741	5.694	0	20
obligation ratio	0.168	0.096	0	1
youngest child 0-2	0.155	0.362	0	1
youngest child 3-4	0.122	0.327	0	1
no. of children	1.174	1.060	0	7
no education	0.119	0.324	0	1
education O level	0.453	0.498	0	1
education A level	0.203	0.402	0	1
higher degree	0.221	0.415	0	1

Table 5: Conditional ML Logit, dep.var.=female participation

variable	**Conditional ML**	**ML Random Effects**		**ML Pooled**	
log(other hh income)	-1.547***	-0.943***	-1.237***	-0.557***	-0.576***
	(0.391)	(0.205)	(0.222)	(0.084)	(0.092)
age	0.333***	0.229***	0.218***	0.094***	0.085***
	(0.113)	(0.072)	(0.073)	(0.032)	(0.033)
age squared	-0.007	-0.008***	-0.007**	-0.004***	-0.003**
	(0.004)	(0.003)	(0.003)	(0.001)	(0.001)
obligation ratio	5.843**	8.023***	7.705***	6.856***	7.172***
	(2.505)	(2.232)	(2.358)	(1.199)	(1.237)
age*obligation ratio	-0.679***	-0.335*	-0.388**	-0.117	-0.130
	(0.221)	(0.176)	(0.189)	(0.093)	(0.095)
youngest child 0-2	-1.525***	-1.853***	-2.011***	-0.758***	-0.905***
	(0.413)	(0.344)	(0.362)	(0.192)	(0.197)
youngest child 3-4	-1.437***	-1.584***	-1.686***	-0.885***	-0.949***
	(0.225)	(0.197)	(0.193)	(0.103)	(0.105)
child 0-2*obl. ratio	-3.802*	-3.437**	-3.387*	-3.419***	-2.996***
	(2.090)	(1.758)	(1.864)	(1.050)	(1.073)
no. of children	-0.677***	-1.025***	-0.957***	-0.511***	-0.495***
	(0.173)	(0.105)	(0.112)	(0.038)	(0.039)
education O level			0.990***		0.224*
			(0.327)		(0.117)
education A level			1.060***		0.232*
			(0.359)		(0.134)
higher degree			1.817***		0.460***
			(0.383)		(0.139)
intercept		10.977**	11.408***	5.534**	3.638***
		(1.722)	(2.263)	(0.680)	(1.054)
region		-	√	-	√
σ_α		3.249	3.497		
		(0.148)	(0.191)		
No. of observations	1657	6255	6255	6255	6255

Note: Standard Errors in parentheses

*** significant at 1% level; ** significant at 5% level; * significant at 10% level

Table 6: Probit model, dep.var.=female participation

variable	**ML Random Effects**		**Chamberlain Random Effects**
log(other hh income)	-0.531***	-0.685***	-0.617***
	(0.112)	(0.121)	(0.123)
age	0.123***	0.118***	0.142***
	(0.040)	(0.041)	(0.043)
age squared	-0.004***	-0.004**	-0.004**
	(0.002)	(0.002)	(0.002)
obligation ratio	4.083***	4.128***	2.488**
	(1.152)	(1.170)	(1.246)
age*obligation ratio	-0.171*	-0.201**	-0.260**
	(0.093)	(0.095)	(0.102)
youngest child 0-2	-1.041***	-1.116***	-1.112***
	(0.194)	(0.201)	(0.196)
youngest child 3-4	-0.895***	-0.950***	-0.893***
	(0.109)	(0.109)	(0.106)
child 0-2*obl. ratio	-1.862*	-1.985	-1.593
	(0.982)	(1.027)	(1.012)
no. of children	-0.568***	-0.526***	-0.506***
	(0.059)	(0.062)	(0.057)
education O level		0.536***	
		(0.186)	
education A level		0.607***	
		(0.204)	
higher degree		1.013***	
		(0.217)	
intercept	6.095**	6.394***	5.782***
	(0.892)	(1.269)	(0.930)
region	-	√	-
mean(obligation ratio)			6.620***
			(1.324)
mean(obligation ratio)*mean(age)			-0.008
			(0.108)
σ_α	1.838	1.973	1.854
	(0.082)	(0.129)	(0.094)
No. of observations	6255	6255	6255

Note: Standard Errors in parentheses

*** significant at 1% level; ** significant at 5% level; * significant at 10% level

Table 7: Conditional ML Logit, dep.var.=female participation - Endogeneity: control function technique

First stage: Within-groups regression		
	control variable 1	**control variable 2**
log(other hh income)	-0.1534***	-0.1587***
	(0.0043)	(0.0053)
age	0.0135***	0.0044***
	(0.0011)	(0.0015)
age squared	-0.0002***	-2.06e-04***
	(4.50e-05)	(6.13e-05)
youngest child 0-2	0.0042	0.0049
	(0.0029)	(0.0038)
youngest child 3-4	-0.0006	2.19e-04
	(0.0028)	(0.0035)
child	-0.0021	-0.0041
	(0.0021)	(0.0028)
control variable	0.1412***	0.0854***
	(0.0087)	(0.0054)
intercept	-0.6078***	0.4055***
	(0.1174)	(0.0645)
No. of observations	5775	4125
Second stage: test of residuals		
1st-step est. residuals	7.511	0.660
	(6.821)	(8.816)
(1st-step est. residuals)^2	-18.784	-1.954
	(26.301)	(40.140)
$\chi^2(2)$	1.6063	0.0084
No. of observations	1524	867

Note1:
Control variable 1: log(REG house prices at t=mortgage taken out*current interest rates)
Control variable 2: log(LAD house prices, 1995-2000) (original panel: 1993-2000)
Note2:
Bootstrapped St. Err. (2nd stage) in parentheses (500 bootstrap samples of size n)
*** significant at 1% level; ** significant at 5% level; * significant at 10% level

Table 8: Conditional ML Logit, Sensitivity analysis: alternative definitions of dep.var.=female participation

variable	**Def. 1** (#weeks worked)>0	**Def. 2** employment status: in empl.
log(other hh income)	-1.871***	-1.129***
	(0.459)	(0.347)
age	0.345***	0.347***
	(0.128)	(0.097)
age squared	-0.006	-0.006*
	(0.005)	(0.004)
obligation ratio	5.888**	5.561***
	(3.036)	(2.091)
age*obligation ratio	-0.611**	-0.571***
	(0.267)	(0.188)
youngest child 0-2	-1.344***	-1.756***
	(0.475)	(0.339)
youngest child 3-4	-1.871***	-1.112***
	(0.260)	(0.198)
child 0-2*obl. ratio	-3.630	-3.013*
	(2.528)	(1.627)
no. of children	-1.044***	-0.505***
	(0.200)	(0.154)
No. of observations	1388	2237

Note: Standard Errors in parentheses
*** significant at 1% level; ** significant at 5% level; * significant at 10% level

Table 9: Conditional ML Logit, dep.var.=female participation - Sensitivity analysis : house value

variable	
log(other hh income)	-1.501***
	(0.396)
log(house value)	0.260
	(0.388)
age	0.342***
	(0.113)
age squared	-0.006
	(0.004)
obligation ratio	5.962**
	(2.507)
age*obligation ratio	-0.661***
	(0.222)
youngest child 0-2	-1.520***
	(0.413)
youngest child 3-4	-1.442***
	(0.226)
child 0-2*obl. ratio	-3.879*
	(2.091)
no. of children	-0.662***
	(0.174)
No. of observations	1657

Note: Standard Errors in parentheses

*** significant at 1% level; ** significant at 5% level; * significant at 10% level

Table 10: Net financial wealth by age and level of obligation ratio

Year 1995

age	$or \leq 0.104$	$0.104 < or \leq 0.158$	$0.158 < or \leq 0.219$	$or > 0.219$
25-30	18,840	4,635	1,452	2,563
	(37,890)	(11,695)	(9,208)	(10,148)
	31	49	76	77
30-35	20,445	14,564	5,234	3,852
	(50,673)	(47,771)	(17,205)	(13,653)
	47	48	54	54
35-40	16,999	11,381	13,797	8,224
	(33,245)	(30,278)	(32,122)	(17,226)
	56	49	36	38
40-45	33,543	11,993	10,156	9,991
	(151,211)	(25,522)	(30,770)	(44,620)
	46	46	26	21
All	22,444	10,602	6,009	4,883
	(83,860)	(31,519)	(21,228)	(19,238)
	180	192	192	190

Year 2000

age	$or \leq 0.104$	$0.104 < or \leq 0.158$	$0.158 < or \leq 0.219$	$or > 0.219$
25-30	13,563	1,520	1,376	2,285
	(34,591)	(13,808)	(12,719)	(12,836)
	27	39	58	80
30-35	18,346	9,895	5,226	7,360
	(35,157)	(24,040)	(21,800)	(43,853)
	31	53	66	68
35-40	9,721	11,900	8,886	9,464
	(18,909)	(50,624)	(59,756)	(36,987)
	61	52	48	48
40-45	24,346	18,181	2,976	10,169
	(60,353)	(30,431)	(15,543)	(35,010)
	68	46	34	31
All	17,024	10,731	4,623	6,400
	(42,815)	(33,778)	(32,573)	(32,941)
	187	190	190	227

Note: Net financial wealth is defined as (savings+investments-debt)
and does not include housing.
Savings, investments and wealth have been imputed separately when missing
Cells contain, top to bottom, the mean, the standard deviation (in brackets),
and group size

Table 11: Conditional ML Logit, dep.var.=female participation - Sensitivity analysis: restricted sample - hh that took out mortgage 1995-2000

variable	
log(other hh income)	-0.824
	(1.028)
age	0.667
	(0.429)
age squared	-0.020
	(0.016)
obligation ratio	16.564*
	(9.937)
age*obligation ratio	-1.049
	(0.898)
youngest child 0-2	0.734
	(1.418)
youngest child 3-4	-0.574
	(0.658)
child 0-2*obl. ratio	-10.363*
	(6.274)
no. of children	-1.143
	(0.848)
No. of observations	192

Note: Standard Errors in parentheses

*** significant at 1% level; ** significant at 5% level; * significant at 10% level

Fig.1.a – Female participation by tenure (owners, own w/mortgage, renters)

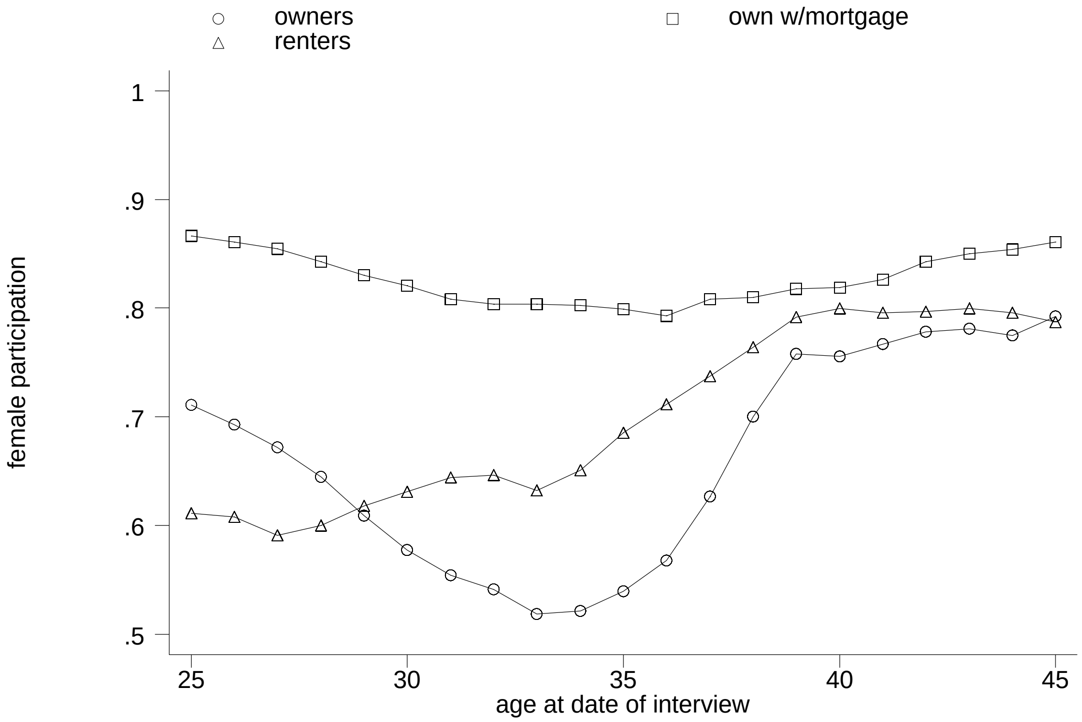

Fig.1.b – Female participation by "tenure" (owners w/ low mortg, w/ high mortgage, renters)

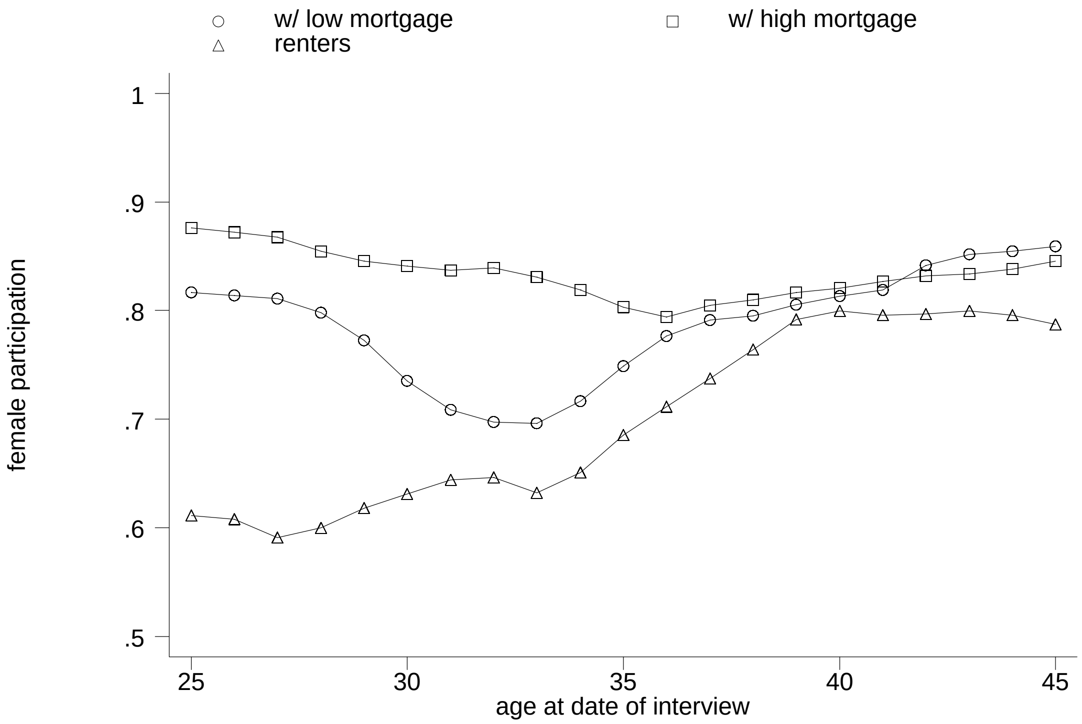

Fig.1.c – Female hours of work by tenure (owners, own w/mortgage, renters)

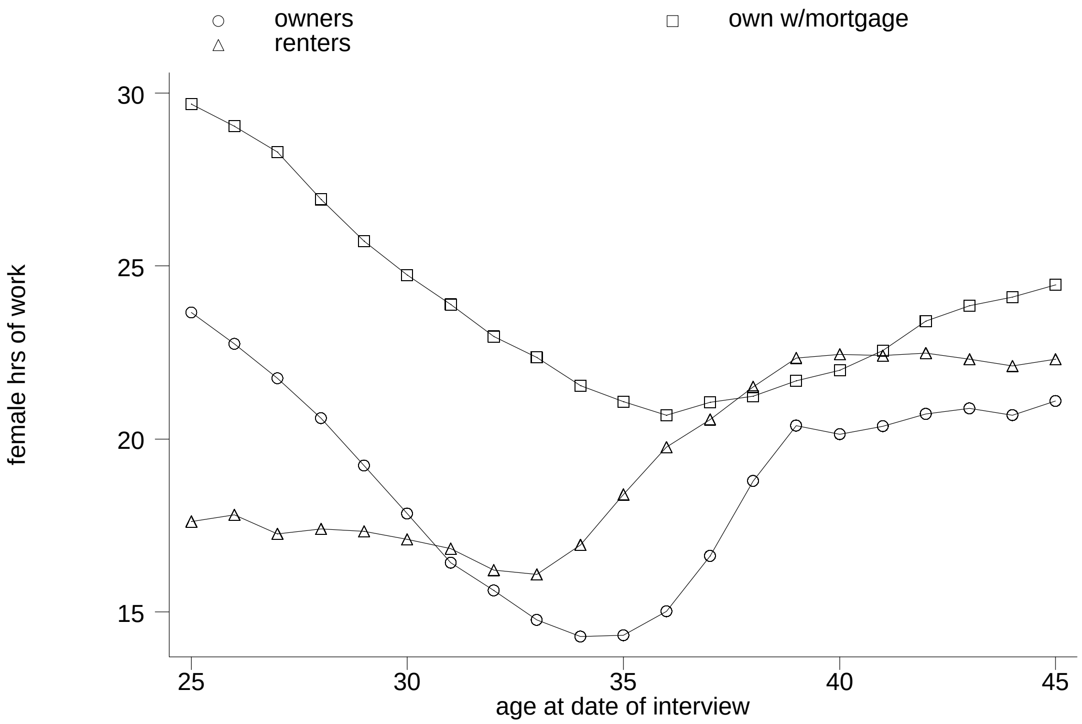

Fig. 1.d – Female hours of work by "tenure" (owners w/ low mortg, w/ high mortgage, renters)

Fig.2 – Female participation by obligation ratio (mortgage payment/ other hh income)

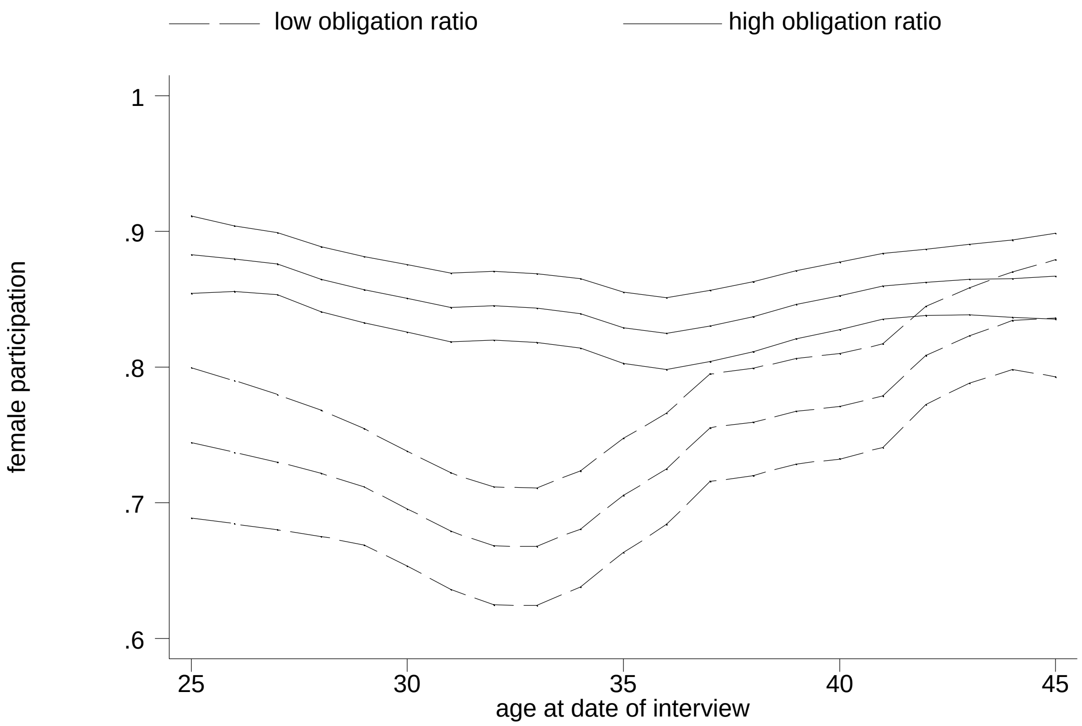

Fig.3 – Female participation by obligation ratio, controlling for age of youngest child