Low Interest Rates and the Distribution of Household Debt*

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April 13, 2021

Abstract

We study how changes in interest rates affect the borrowing of households and the distribution of debt within the population. In a model of household borrowing with credit constraints and endogenous house prices, we show that less constrained households with more pre-existing housing wealth increase their borrowing most when interest rates fall. We then use unique loan level data on the universe of household credit in Belgium to document a shift in the distribution of debt over age, with older households borrowing more as interest rates fell in the last decade. First-time borrowers, who are more likely to be constrained, do not contribute to the rise in household debt. To identify the elasticity of household debt to the interest rate, we use regulatory data on foreign exposures of banks and on the location of bank branches. We find that a 1 percentage point fall in the interest rate is associated with a 15% growth in household debt.

Keywords: Interest Rates, Household Debt, Mortgages, Credit Constraints
JEL Classification: D14, E43, E58, G51

*The views expressed do not necessarily represent the views of the National Bank of Belgium. For comments and discussions, we thank Olivier Blanchard, Hans Degryse, Olivier De Jonghe, Maite de Sola Perea, Mathias Dewatripont, Catherine Fuss, Daniel Greenwald, Chris Palmer, Glenn Schepens, Stijn van Nieuwerburgh, Luigi Zingales and seminar participants at ESCP Business School, Ghent University, K.U. Leuven, Université Paris Dauphine, the University of Luxembourg, the National Bank of Belgium, the Belgian Macro Workshop, the World Congress of the Econometric Society and the 2021 conference of the American Real Estate Association. We thank Jean-Marc Troch for help in constructing the dataset.

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1. Introduction

Mortgage interest rates have declined substantially over the last decade. In the euro area, interest rates fell from a high of 6 percentage points (p.p.) in 2008 to 1.3 p.p. in 2020. In the United-States, mortgage interest rates fell from 6 p.p. to 2.5 p.p. over the same period. As interest rates fell, the indebtedness of households increased. In 2020, the debt of households reached an all time high of $14 trillion in the United-States and €6.8 trillion in the euro area. The household debt to GDP ratio is also close to its 2007 peak in both regions. For other countries that were less affected by the global financial crisis such as France, Belgium, Canada, Sweden or Switzerland, the growth in household debt to GDP has been mostly uninterrupted over the last two decades.

The high level of household debt amid low nominal interest rates raises two concerns. A first concern is that high household debt can create risks to economic and financial stability. While debt can help households achieve their potential (Favilukis et al., 2017), an excessive indebtedness can increase the pro-cyclicality of the business cycle (Mian and Sufi, 2014). As households increase their leverage, their net worth becomes more sensitive to changes in asset prices, thereby threatening the stability of the financial system (Mian et al., 2017). Understanding the role of the interest rate in the increase in household debt is important to assess these risks. A second concern relates to the distributional implications of high household debt in the presence of credit constraints. If credit providers or regulators impose limits on the risk taking of households, the increase in household debt may be heterogeneous with some households being less able to borrow (Farhi and Werning, 2016). These concerns have been at the center of debates on the implementation of macroprudential policies (Svensson, 2019; Acharya et al., 2020).

To understand the aggregate and the distributional implications of changes in interest rates, the sample and the identification strategy should ideally include the full population of borrowers. While a number of authors have studied the response of households to changes in interest rates (Fuster and Willen, 2017; Cloyne et al., 2019; Di Maggio et al., 2017), their studies have often focused on specific debt contracts such as adjustable-rate mortgages. These approaches provide exogenous variations in the interest rate, but they also constrain the interpretation of the results.

In this paper, we use a new database on the universe of household borrowing in Belgium to explore the relationship between household debt and interest rates. The questions we address are twofold: (1) What is the sensitivity of household borrowing to changes in the interest rate? (2) How does this sensitivity vary across households in the presence of credit constraints? To answer these questions, we first provide a benchmark model of household borrowing with credit constraints. We show that a decline in the interest rate increases borrowing most for households that have accumulated some wealth and have future revenues to borrow against. This is consistent with stylized facts from the database which show that the increase in household debt over the last decade is driven by borrowers aged between 45 and 54. To identify the role of the interest rate in household borrowing, we use the location of bank branches together with bank-level exposures to foreign countries to construct a 'Foreign GDP shock' instrument that shifts local credit supply but is independent of local economic conditions. Our estimates suggest that a 1 percentage point fall in the interest rate is associated with a 15% growth in household debt. To distinguish credit constrained households, we rely on the history and scope of the data to single out first-time borrowers, i.e. households that borrow for the first time in a given year. We interpret first-time borrowers as credit constrained households. Our estimates suggest that the sensitivity of first-time borrowers to interest rates is two to three times larger than for average borrowers. On aggregate, first-time borrowers however represent around 5% of borrowers in any given year. This suggests that the largest share of the aggregate response to changes in interest rates is driven by unconstrained, non-first-time borrowers.

Our model extends the work of Stein (1995) to include endogenous house prices and borrowing by households. There are three periods. A continuum of households is endowed with some initial housing wealth as well as some labour income that is paid in the last period. For expositional purposes, we assume that the housing endowment is increasing with age and that the labour income endowment is decreasing with age. In the intermediate period, households consume housing and food - the residual good. Households can borrow in order to transfer their labour resources from the final to the intermediate period. The amount borrowed must however satisfy a credit constraint: for every unit consumed, households must make a downpayment from their existing wealth. We show that the downpayment constraints leads middle aged households, with some existing housing wealth and future labour income, to borrow the most when interest rates fall. Younger households have more future labour income but are unable to borrow against this income because of a lack of resources for the downpayment.

We then compare these predictions to the stylized facts using the household credit registry of the National Bank of Belgium (NBB). The data covers the universe of household borrowing in Belgium from 2006 to 2018. We focus our analysis on mortgage debt which represents 95% of household borrowing and is the main driver of the increase in household debt. Belgium is an interesting laboratory to study the role of the interest rate as it is a small open economy in a large currency union. At the aggregate level, the household indebtedness in Belgium increased strongly as interest rates fell over the last decade. The debt level rose from 40%

to 60% of GDP from 2006 to 2019. House prices also increased relative to income over this period.

Motivated by the model, we provide a series of stylized facts illustrating three features of the model: the distribution of credit by age, the evolution of the lending standards (or downpayment parameters) of banks and the potential identifiers of credit constrained households.

We find that a shift occurred in the distribution of household debt across age groups over the last decade as older households increased their share of total credit. The share allocated to households between 25 and 35 years of age declined by around 10p.p. while the share of households above 45 increased by a similar amount.

In terms of lending standards, we do not find a significant deterioration in the most common indicators of risk at origination. The distribution of loan to value (LTV) ratios of newly originated loans or the debt service to income (DSTI) ratios have remained stable over the last decade despite the strong growth in credit. The stable LTV and DSTI ratios could reflect an allocation of credit directed to unconstrained households, who could already have some housing wealth and may have benefited from the growth in house prices.

A third element to consider in the data is how to distinguish credit constrained borrowers. This is important because the model suggests that the transmission of interest rates to credit differs for constrained and unconstrained borrowers. While unconstrained households benefit from the lower cost to increase their debt, the borrowing of other households is constrained by the value of their existing assets. By increasing asset prices, lower rates relax the borrowing constraint of these households. The model features an age cutoff to separate constrained and unconstrained borrowers. Our preferred proxy, however, focuses on first-time borrowers. The broad scope of our data allows to identify these borrowers more precisely than in previous studies such as Lee and Tracy (2018). Our assumption is that households who buy a house for the first time mobilize all their existing wealth to borrow for their purchases, and are thus at their borrowing constraint at the time of the purchase. In practice, first-time borrowers are also younger so that both measures are consistent.

To understand the allocation of the new credit, we decompose the credit flows into two categories: loans to first time borrowers and loans to other, non-first time borrowers. We define first-time borrowers as households who have no credit history at the time of the loan origination. The decomposition suggests that loans to first time borrowers remained remarkably stable over the years. This suggests that most of the new credit originated from non-first time borrowers.

In section 4, we quantify the sensitivity of household borrowing to changes in the interest rate. In general, the interest rate on individual mortgages depends on a wide range of variables that are mostly unobserved by the econometrician. These include for instance the future economic prospects of the household, the credit history or guarantees. To avoid a bias in our estimates, we first construct a measure of the local interest rate using data on the physical location of bank branches and on interest rates for each bank at the national level. We use this data to compute an average local interest rate that is less dependent on local economic conditions (we use in addition only the location at the beginning of our sample).

We then instrument this local interest rate using foreign shocks to credit supply. The instrument is based on regulatory data on the international exposure of Belgian banks. As in the granular instrumental variables proposed by Gabaix and Koijen (2019), the idea is that shocks in foreign countries can affect local banks through their foreign lending. We use the exposure data to compute a foreign GDP growth shock for each bank, which we then combine with the branch locations to construct a local credit supply shock. We use this variable as an instrument for the local interest rate.

Our results suggest that a one percentage point decline in the interest rate is associated with a 15% increase in the debt of households. When we focus the sample on first-time borrowers only, we find that the elasticity increases to around 50%. Since first-time borrowers only represent around 5% of borrowers in any given year, the growth in credit to other borrowers outsizes the growth to first time borrowers, in line with the aggregate stylized facts. We discuss a number of alternative specifications focusing for instance on specific age groups.

Related Literature. Cloyne et al. (2019), Fuster and Willen (2017) and Di Maggio et al. (2017) also study the sensitivity of household borrowing or consumption to changes in the interest rate. The main difference with our work is that their identification strategy focuses on a specific mortgage contract, Adjustable-Rate Mortgages (ARM). In these contracts, borrowers pay a fixed interest rate for a given number of years, and the interest rate is then reset at a level that depends on current market conditions. Given that borrowers do not know ex-ante the level of future interest rates, the reset provides an exogenous variation in the interest rate. One limitation of this approach is that it restricts the analysis to holders of ARM contracts. This affects the interpretation as and a decline in interest rates is then similar to an unexpected income boost. Their results illustrate this point as they show that most households use these lower rates to reduce their indebtedness (Di Maggio et al., 2017). In general, however, one would expect lower rates to be associated with higher debt levels. In this paper, the use of regulatory data together with borrower level data for the whole population allows to analyze a more general transmission channel of interest rates, and we find that lower interest rates tend to increase the level of household indebtedness.

Bernanke and Blinder (1992) and Kashyap and Stein (2000) have shown that bank lending is an important transmission channel of monetary policy. Changes in interest rates can affect both household and corporate borrowing. Most of the evidence so far has however focused on bank lending to firms (see e.g. Khwaja and Mian 2008, Jiménez et al. 2014 or De Jonghe et al. 2020) and the evidence on bank lending to households is more limited. Gyöngyösi et al. (2019) use data from a household credit registry in Hungary to document how monetary policy affects credit supply. Our work complements theirs by focusing on the demand for credit by households and by documenting the response of households to interest rate shocks.

Our work is also related to new macroeconomic models that take into account the heterogeneity of households and firms in the economy (Kaplan et al., 2018, 2020; Auclert, 2019; Mian et al., 2020). Our findings on the heterogeneous responses of households in the data could inform the calibration of heterogeneous agent models and shed further light on financial constraints faced by households (Karaivanov and Townsend, 2014).

Household debt was at the center of the 2007-2009 financial crisis in the United-States and some researchers have documented the lower credit standards towards subprime borrowers (Keys et al., 2010; Mian et al., 2013; Mian and Sufi, 2014). Adelino et al. (2016) have however argued that most of the increase in household debt came from the middle class. Our findings for Belgium suggests that borrowers with pre-existing mortgages play an important role in the aggregate credit growth. Our results are in fact consistent with those of Acharya et al. (2020). They study the transmission of macroprudential policies in Ireland and find that tighter credit constraints led banks to redirect credit towards less constrained households, with no sizeable impact on aggregate credit growth. Our analysis suggests that most of the recent credit growth in Belgium was also driven by less constrained households in a context where lending standards of banks were broadly stable.

The paper is structured as follows. We first present the model in section 2, including an analysis of the first-best outcome and the equilibrium with credit constraints. We describe the data and review key stylized facts in section 3. We then explain the empirical strategy and discuss the estimation results and robustness analysis in section 4.

2. Model

To frame the analysis, we first explore a model of household borrowing under credit constraints, where households differ in their initial endowments of housing and labour income wealth.

Setup

As in Stein (1995), there are three periods indexed 0, 1 and 2. A continuum of households $i \in [0,1]$ receives an initial endowment of cash and housing and chooses a level of consumption of housing H_i and food F_i. The amount of housing in the economy is fixed to 1 and the housing stock is divisible. While Stein (1995) considers an exogenous distribution of debt and focuses on the implications for house prices, we endogenize the borrowing process as follows. Each household is endowed with a house of size H_i^0, received in period 0, and a labour income (wage) W_i paid in period 2. Households must however consume in period 1 and thus borrow in order to transfer their labour resources from period 2 to period 1.

To guide the interpretation of the results, we assume that H_i^0 is increasing in i, $\partial H_i^0/\partial i \leq 0$, and that W_i is decreasing in i, $\partial W_i/\partial i \geq 0$. In this case, the index can be interpreted as the age of households. Young households with low i have little wealth but high future income. Old households on the other hand have accumulated more wealth but have lower future income. Households with a low index i have a high future labour income W_i but low housing wealth H_i^0. Households with a high index i have relatively high housing wealth H_i^0 but less labour income W_i. While the assumption on the distribution of endowments allows to clarify the exposition, all our results go through without this assumption. We discuss further in the empirical analysis how to analyze borrowers beyond the age characteristic.

In period 1, each household i chooses the amount of housing H_i and food F_i to maximize the Cobb-Douglas utility

$$\max_{H_i,F_i} U_i = \alpha \ln H_i + (1-\alpha) \ln F_i, \tag{1}$$

where α represents the taste of the household for housing. In order to fund the housing and food consumption in period 1, the household can sell its housing endowment at a unit price of P and can borrow against its future (period 2) income at an interest rate r. The amount borrowed is thus $F_i + H_iP - H_i^0P$ and the budget constraint is:

$$H_iP + F_i + r\left(F_i + H_iP - H_i^0P\right) \leq H_i^0P + W_i. \tag{2}$$

Households face constraints on the amount that can be borrowed. These borrowing constraints could result from a moral hazard problem as in Holmstrom and Tirole (1997) or value-at-risk constraints as in Brunnermeier and Pedersen (2009). For each unit of down-payment, households may consume up to an amount $1/\gamma$. The parameter $\gamma \in [0,1]$ therefore determines the share of consumption that must be financed by existing wealth in period 1 -

in our case the housing wealth. The borrowing constraint is

$$\gamma\left(H_iP+F_i\right)\leq H_i^0P. \tag{3}$$

Finally, the supply of housing is normalized to one and the housing market clearing constraint is

$$1=\int_0^1 H_i di. \tag{4}$$

Figure 1 summarizes the timeline. In period 0, households receive their housing endowment. In period 1, they choose their food and housing consumption, sell their existing house and borrow against future income. In period 2, they receive their income W_i and pay back their debt.

No downpayment constraint

Consider first the model without the downpayment constraint. In this case, the resources available to households to purchase housing and food are composed of the proceeds from the sale of the housing endowment, H_i^0P, and the present value of future wages, $W_i/\left(1+r\right)$. Households allocate a fraction α of their resources to housing and the remainder to food. Let $W=\int_0^1 W_i di$. The next proposition summarizes the outcome.

Proposition 1 (First-best outcome)**.** *Without credit constraints, household i allocates a fraction* α *of its resources* $H_i^0P+\frac{W_i}{1+r}$ *to housing consumption and* $(1-\alpha)$ *to food consumption. House prices are equal to*

$$P=\frac{\alpha W}{\left(1-\alpha\right)\left(1+r\right)}. \tag{5}$$

Proof. See section A. □

The price of the housing in proposition 1 is inversely proportional to the gross interest rate $1+r$. As such, the housing endowment could be thought of as a fixed income asset such as a bond, whose value increases when the interest rate falls.

The interest rate affects both the value of the housing endowment in period 1 and the present value of the future income available to the household. A rise in interest rates increases the cost of transferring resources from period 2 to period 1 and therefore reduces the resources available for consumption in period 1. This in turn reduces house prices. While low interest rates benefit young households by increasing the present value of their future income, they also benefit older households through higher house prices. In fact, in our case all households benefit equally (in terms of available resources) from a fall in interest rates. We formalize this in the next proposition.

Proposition 2 (Distribution in first-best)**.** *Let $R = H_i^0 + W_i/W$ be the share of resources endowed to household i. In this case the amount of housing consumed is the same for all households with a same share of resources $H_i^0 + W_i/W$. Housing consumption is independent of interest rates and of the relative share of housing and labour wealth in the resources.*

Proposition 2 relates to the debate on the winners and losers from low interest rates. Coibion et al. (2017) suggest for instance that expansionary monetary policy decreases inequality in labor earnings, total income, consumption and total expenditures. Auclert (2019) shows that redistribution is an important transmission channel of monetary policy, and that expansionary policies tend to benefit households with a high marginal propensity to consume. On the other side, some have argued that low interest rates and unconventional policies such as quantitative easing tend to increase inequality by pushing up asset prices. These two forces are to some extent also present in the model: on the one hand, low interest rates can benefit older and wealthier households by boosting the value of their housing portfolio. On the other hand, low interest rates can support younger borrowers by making credit cheaper. In the simple case with no borrowing constraints, we show that both effects cancel each other out so that the resources of all households increase by a same proportion, irrespective of age.

Downpayment constraint

Let us now introduce the borrowing constraint (3), so that households must pay down a fraction γ of their expenses in period 1 using their housing wealth. In this case households fall in one of two regimes. If their housing wealth is low relative to their income wealth,

$$\frac{1-\gamma}{\gamma} H_i^0 P \leq \frac{W_i}{1+r},$$

the household will not be able to transfer all its labour income from period 2 to period 1 because of a lack of initial resources. Since H_i^0 and W_i are respectively increasing and decreasing in i, there exists a threshold $\bar{i} \in [0, 1]$ where households $i < \bar{i}$ are constrained while others are not.[1] When the household is constrained, the resources available are determined by the borrowing constraint. The allocation of the resources between food and housing are of shares α and $1 - \alpha$ respectively. The next proposition formalizes the outcome with downpayment constraints.

Proposition 3 (Second best outcome)**.** *With downpayment constraints, the housing and food consumption of household i is the same as in proposition 1 if $i > \bar{i}$ where the threshold*

[1] The parameter conditions are the following. Let $\underline{H}$, $\underline{W}$, $\overline{H}$ and $\overline{W}$ be the housing and wage endowments respectively for $i = 0$ and $i = 1$. Then $\bar{i} \in [0, 1]$ if $\frac{1-\gamma}{\gamma}\underline{H}P < \frac{\underline{W}}{1+r}$ and $\frac{1-\gamma}{\gamma}\overline{H}P > \frac{\overline{W}}{1+r}$, where P solves (8).

$\bar{i}$ solves

$$\frac{1-\gamma}{\gamma} H^0\left(\bar{i}\right) P = \frac{W\left(\bar{i}\right)}{1+r}. \tag{6}$$

If $i \leq \bar{i}$, the household is credit constrained and housing and food consumption are given by

$$\begin{cases} PH_i & = \alpha\left(\frac{H_i^0 P}{\gamma}\right) \\ F_i & = (1-\alpha)\left(\frac{H_i^0 P}{\gamma}\right) \end{cases}. \tag{7}$$

The price P solves

$$P = \int_0^{\bar{i}} (1-\alpha)\left(\frac{H_i^0 P}{\gamma}\right) di + \int_{\bar{i}}^1 \alpha\left(H_i^0 P + \frac{W_i}{1+r}\right) di. \tag{8}$$

Proof. Appendix A. □

The age threshold in proposition 3 could alternatively be expressed as a condition on the endowment of housing H_i relative to labour income W_{i0}. As explained earlier, the age assumption regarding the distribution of endowments is made for expositional purposes and we will discuss further in the empirical analysis how to identify credit constrained borrowers.

The intuition for proposition 3 is the following. As in the first best case without credit constraints, a fall in interest rates increases the net present value of wage income. This increases demand for housing and thus also increases house prices. A key difference with the first best however is that constrained households are unable to transfer all their labour resources from period 2 to period 1. The amount of resources that can be transferred depends on the value of the initial housing endowment. The increase in demand from less constrained households increases house prices. Given the downpayment constraint, every unit increase in the endowment allows the household to transfer an additional amount of resources equal to $(1-\gamma)/\gamma$. If for instance lenders require that 20% of the consumption is financed by own funds ($\gamma = 0.2$), every unit increase in the value of the housing endowment allows the household to borrow an additional 4 units of resources. The higher house prices combined with the leverage multiplier will thus alleviate the borrowing constraints, however the magnitude will clearly depend on the amount of housing endowed to the household. If the household has no housing to begin with, the increase in house prices will be of limited use and the labour resources will remain trapped in period 2. In fact, the main beneficiaries of higher house prices will be the households in the middle of the distribution, with a fair amount of housing resources available but also with substantial labour income in period 2 that must be transferred to period 1. We formalize this in the next proposition, where the debt $D(i)$ is computed from proposition 3 as

$$D\left(i\right) = F_i + H_i P - H_i^0 P.$$

Proposition 4 (Comparative statics)**.** *The increase in debt oustanding in case of a reduction in interest rates is higher for middle-aged households, i.e. the debt increase is concave with a maximum at* $i = \bar{i}$*.*

Proof. Let $r_1 > r_2$ and consider the respective debt levels $D_1\left(i\right)$ and $D_2\left(i\right)$. The debt increase with low rates is given by

$$D_2\left(i\right) - D_1\left(i\right) = \begin{cases} \frac{(1-\gamma)}{\gamma} H_i^0 \left(P_2 - P_1\right) & \text{if } i \leq \bar{i} \\ W_i \left(\frac{1}{1+r_2} - \frac{1}{1+r_1}\right) & \text{if } i > \bar{i} \end{cases}. \tag{9}$$

The debt of constrained households is

$$D = \frac{(1-\gamma)}{\gamma} H_i^0 P$$

from which we derive the change in debt of constrained households ($i \leq \bar{i}$) in (9). This is an increasing function of i since H_i^0 is also increasing in i. Similarly, unconstrained households borrow $D = W_i / \left(1 + r\right)$ and the distribution of W_i is decreasing in i so that $D_2 - D_1$ is decreasing in i for $i > \bar{i}$. □

Figure 2 illustrates the equilibrium and the impact of a fall in the interest rates. We consider a linear distribution of housing endowments and wages, assuming that $H_i^0 = 2i$ and $W_i = 1 - i$. The blue line is the net present value of the period 2 labour income, which is also the amount borrowed in the unconstrained first-best case. When we introduce downpayment constraints, the amount borrowed (and the labour resources transferred to period 1) becomes hump shaped. This is the yellow line on the figure. Households to the right of the age distribution are unconstrained and are able to transfer all their labour income to period 1. Households to the left of the threshold (the vertical dotted line on the figure) are however constrained and unable to transfer all their resources to period 1. The amount transferred depends on the initial housing endowment, which increases with age. At the limit where $i = 0$, households have no housing wealth and are thus unable to borrow in period 1.

The right hand side of Figure 2 shows the impact of a fall in the interest rate, where the grey line is the outcome with a high interest rate and the blue and yellow lines are the new low rate outcome. A decline in the interest rate first increases the net present value of period-2 income, so the blue line becomes steeper. The slope of the constrained borrowing amounts also increases because of the leverage multiplier. The value of the housing endowment increases which allows households with some housing wealth to increase their borrowing. Households to the left of the distribution, who had little housing wealth, remain unable to borrow. The flow of new credit to households is the difference between the new yellow line and the grey line. It is again hump shaped: younger households remain constrained by their lack of resources required to borrow, and the new borrowing is close to the borrowing with high rates. Older households on the other hand do not need to borrow much and therefore do not significantly change their borrowing behaviour. The bulk of the increase in credit therefore originates from the middle-aged households who have accumulated some housing wealth but still expect substantial income resources in period 2.

3. Stylized Facts

With the main predictions of the model in mind, we now turn to the data to explore how the distribution of household debt in Belgium changed over the last decade. Belgium is is a small open economy in a large currency union. As in the analysis of Jiménez et al. (2014), we may thus argue that monetary policy is more independent of local economic conditions than in countries with their own currency. Our sample period also includes the sovereign debt crisis when the ECB relaxed its monetary policy to respond to shocks hitting some member states, while Belgium was less affected by the sovereign debt crisis.

We first describe the data and the macroeconomic context. We then explore the changes in the distribution of debt. We then focus on the evolution of lending standards (the down-payment parameter γ in the model). We also discuss how to identify the credit constrained borrowers.

Data

The main dataset that we use is the household credit registry of the NBB. The NBB maintains a credit registry for households as part of its mandate to prevent the overindebtedness of households. In addition to a production database that is used by banks before allocating new loans. The NBB also maintains an anonymized dataset to inform its policies. We use this dataset for our analysis. The registry includes data on all borrowing by residents in Belgium since 2006, including both mortgages and consumer loans. For our analysis, we focus on mortgage loans which account for 95% of total household borrowing. Mortgage debt also accounts for the bulk of the increase in household debt as the amount of consumer loans stayed broadly constant over our sample period.[2]

The registry data includes borrower characteristics such as the age, the gender and the municipality of residence (zip code) of the borrower. When a loan is allocated to multiple borrowers, we use the characteristics of a randomly selected lead borrower. The lead borrower is the same for all identical groups of borrowers so that e.g. couples with multiple loans are linked to the same borrower.

The loan characteristics in the registry include the total amount due, the maturity in months of the loan and the start date of reimbursements. It does not include however the current loan balance and we assume a linear amortization to compute the outstanding balance of the loans. We compute the outstanding amount at t years since issuance as the product of the remaining maturity as percent of origination maturity and the origination amount D_0. If the maturity of mortgage is of T years, the debt outstanding at t years since issuance is computed as:

$$D_t = D_0 \times \frac{T - t}{T}. \tag{10}$$

We verify in appendix B.1 that the aggregate stock of loans outstanding is consistent with alternative data series from the financial accounts. The correlation between the stock of loans - both new and existing - in our data and in the financial accounts is 98% (Figure 13 in appendix). At the bank level, the correlation between the registry and the financial accounts are of 99.5% (Figure 14). In appendix B.2, we verify the robustness of our figures to the assumption of linear amortization. We show that the differences with an annuity-based calculation of the outstanding balances are small because the average years since issuance of outstanding loans is small. In most years, more than 70% of mortgages have been issued less than 3 years in the past. The importance of loan renegotiation by households explains the relatively low lifespan of mortgages. This in turn attenuates the role of the formula used to compute the outstanding balance.

The data includes around 1.5 million borrowers at the beginning of the sample and 1.8 million towards the end (Table 1). This represents around 15% of the total population for 2006. The weighted average age of borrowers increases from 39 to 41 years and borrowers generally have around 2 loans outstanding. The number of first time borrowers falls from 98,564 to 63,205 from 2006 to 2013, while the amount borrowed per household increases to €164k from €131k. The average age of first time borrowers falls slightly over time from 34 to 33 years. The average amount borrowed increases to €127k from €72k (+76%) for all borrowers between 2006 and 2018, while first time borrowers experience a 56% increase in

[2] In 2006, consumer loans outstanding represented 7% of the total, or €8 billion. In December 2018 the amount outstanding had increased to €10.6 billion and the share in overall household debt had declined to 4.5% (Source: NBB.stat, loans and deposits).

loan size (from €131k to €205k).

While the registry data is granular and provides exhaustive information on credit, it lacks other information on household income, house prices or bank balance sheets. We thus complement the main dataset with a number of other databases. For the income, we use data on taxable income from the Finance ministry. The data provides the mean and median income by municipality and age group over our sample period. There are eight age groups: less than 25 years old, 25 to 34, 35 to 44, ..., 75 to 84 and above 84 years old.

We use data on real estate transactions from the statistical agency. For each municipality and year, the data includes the number of transactions and key moments of the price distributions. It also distinguishes among property types (house, apartments and villas). For each municipality, we compute a house price index following the Laspeyres methodology.

We also use a series of regulatory datasets and disaggregated statistics. The NBB collects data on the interest rates of new and outstanding loans of banks. We use the bank-level series to explore the role of interest rates as we explain in section 4. Finally, we also use data on credit flows used for the financial accounts, the bank balance sheets (Schema A) and the regulatory surveys on loan portfolios (Prêts Hypothécaires Leningen, PHL survey) to explore the evolution of bank lending standards and verify the accuracy of the outstanding amounts in the credit registry data.

Context

Our sample covers the period from 2006 to 2018. Interest rates fell substantially over this period, from a high of 6% in late 2008 to 1.5% in 2018. Mortgage rates in Belgium closely track the rates in the euro area which fell by similar magnitudes.

Over the same period, household indebtedness increased strongly. The ratio of household debt to GDP increased from 40% in late 2004 to more than 60% in 2018. This is illustrated in Figure 3a. While Belgian households had a low level of indebtedness relative to the euro area average in 2004, the level of debt increased above that of the euro area in 2015. The pattern of high household debt amid low interest rates is not specific to Belgium. Countries such as Switzerland, France, Sweden or Canada all experienced increases in household debt to GDP ratios of more than 30% in relative terms over the same period. At the same time as household debt was going up, real estate prices also increased in Belgium. In particular, prices rose faster than the average disposable income of households and this rise was strongly correlated to the increase in household debt (Figure 3b).

As in our model, lower interest rates were associated with higher household debt and higher house prices. Housing represents the largest asset of most households in Belgium. According to the Household Finance and Consumption Survey (HFCS), housing accounts for more than 75 % of the assets of households in the bottom 80 % of the wealth distribution. Households in the top 20 % of the wealth distribution have around 60 % of their assets invested in real estate, of which half is invested in real estate other than the main residence. The net wealth of households, defined as the total assets after deducting the debt, has remained stable from 2006 to 2018 at 200 % of GDP according to the NBB financial accounts. The increase in household debt has thus increased the leverage of households and their exposure to potential declines in house prices.

Lending standards and distribution of household debt

Households became more indebted as interest rates fell over the last decade. How is the increase in debt distributed within the population? Figure 4 shows the loan to income (LTI) ratios computed at the municipality level broken down by age groups, in 2006 and 2016. We observe a change in the pattern of household indebtedness over age. In 2006, households seemed to take up a mortgage at the age of 25 to 34 then gradually pay it back over time. In 2016, households seem to take on debt at 25 to 34, then take on additional debt aged 35 to 44, and only then to pay it back over time.

Figure 5 provides an additional illustration of the increase in borrowing from older age groups. It shows the share of credit by age groups in 2006 and 2018. We find that the share allocated to households between 25 and 35 years old declined by around 10 percentage points while credit allocated to the age groups 45 and above increased their share by a similar amount.

The change in the distribution of debt across age groups in Figure 4 is in line with the predictions of the model of a hump shaped distribution of debt in Figure 2, where we showed that lower interest rates would increase debt most for middle aged households, who have some accumulated wealth and future income to borrow against.

In the comparative statics of Figure 2, the downpayment requirement γ remained constant. Could the increase in debt be driven by a change in credit standards by banks? We explore in Figure 6 two indicators of credit standards: the Loan To Value (LTV) ratio and the Debt Service To Income (DSTI) ratio of newly originated mortgages.

The LTV ratio measures the average size of the loan relative to the value of the house used as collateral. Figure 6a compares the distribution of the LTV ratios of new loans in 2009 with that of 2017. We find an increase in the share of loans with LTV between 80 and 110 percent. The share of loans with LTV higher than 110 percent however declined so that the share of loans with LTV higher than 80 percent stayed broadly stable.

Another measure of credit standards is the Debt Service To Income (DSTI) ratio which measures the share of disposable income allocated to the reimbursement of mortgages and the payment of interests. Lower interest rates could have conflicting effects on the DSTI ratios. On the one hand, it could lower interest payments and therefore the cost. On the other hand the higher borrowing amounts could increase the principal payments. Figure 6b shows the distribution of new loans in 2006 versus 2017 by DSTI categories. As for LTV ratios, the distribution remained rather stable with an increase in the density around 35%.

The maturity of the mortgages remained stable and around 17 years from 2006 to 2017. We find that the share of loans with maturities above 25 years declined, but this was compensated by a decline in shorter maturities of 10 to 15 years (see Figure 7). In fact, the maturity of mortgages seems to be driven primarily by the age of the borrower. Borrowers aged less than 25 years borrow at maturities around 23 to 25 years, and the maturities then decline monotonically with age. The maturity of mortgages of borrowers older than 55 years is around 10 years (Figure 8).

The regulatory data suggests that the majority of mortgages in Belgium have a fixed rate. The share of fixed rate mortgages has declined somewhat between 2007 and 2017, falling from 82% to around 78%. The rate of default on mortgages is low and varies between 1 % and 1.2 % between 2006 and 2018.

Credit constraints and first-time borrowers

In the model, we use the age to distinguish constrained from unconstrained borrowers, assuming that older households have a larger housing endowment but a lower wage income. This provides an age cutoff below which households are constrained. In practice, income and endowment trajectories over age can differ across households and it is likely that within an age group, some households are constrained and others are not. An alternative way to identify constrained households is to focus on first time borrowers, i.e. borrowers in a given year that were previously absent from the database.

The broad scope of our data allows to identify first time borrowers with a higher precision than previously used measures. For instance, one approach used in the United-States relies on the Universal Residential Loan Application forms, which include a question on ownership over the prior three years. This is often used to measure first time homebuyers, even though the history is of only three years. Lee and Tracy (2018) propose an alternative measure using data from the Federal Reserve Bank of New York Consumer Credit Panel, which is a 5 percent random sample of U.S. households with credit files derived from Equifax. Since the begining of our sample in 2006 also includes information on all loans outstanding, we are able to obtain a broader and more exhaustive measure of first time borrowers.[3]

[3]Because the 2006 data only includes the loans outstanding, our measure of first time borrowers could capture borrowers who had reimbursed their loan before 2006 and took on a new loan after 2006. To account

Figure 9 shows the distribution of debt to first time borrowers and other borrowers by age group. Figure 9a shows that the age of first time borrowers is indeed concentrated in the younger age group 25 to 34, thus motivating the use of age to compute the regimes in our model. However, older age groups (in particular 35 to 44 years) also have first time buyers that are presumably more credit constrained.

Figure 9b shows the weighted average age of all borrowers in the population and that of first-time borrowers only. The average age of first-time borrowers fell slightly over the period, from 34 to 33. This suggests that the access of first-time borrowers to credit was not reduced with the increased aggregate level of credit. If credit constraints would reduce access to housing with high house prices, one could expect households to delay their purchase to a later age, with a greater accumulation of savings. The decline in the average age of borrowers suggests that this is not the case and households could for instance have chosen smaller properties. The decline in the age of first-time borrowers is also in line with our model which predicts that low interest rates increase the borrowing of all households (including constrained households). Our model also predicts that less constrained borrowers, who may already have some existing housing wealth, will increase their borrowing most in response to lower interest rates. This is consistent with the observations in Figure 9b: the increase in credit to younger, first-time borrowers is crowded out by the increase in indebtedness of existing borrowers so that the average age of all borrowers increases over the same period.

Table 11 in the Appendix further illustrates the relationship between age and first-time borrower indicators of credit constraints. The table shows the homeownership rate by age groups. The homeownership rate in Belgium is around 75% for households aged 35 to 65. For younger households aged 25 to 34, the home ownership rate is 51%. This suggests that around two thirds of households buy their first property at the age of 25 to 34. Around a quarter of households in their later stages of life also owns properties that are not their main residence, but this fraction is low for the younger age groups whose housing wealth is concentrated in their main residence.

To understand the increase in household debt, we decompose the credit flows into two categories. For each year t, we distinguish loans D_{jt} issued to first time borrowers ($j = 1$), defined as borrowers who were previously absent from the database. We then compute the flow of credit to first time borrowers as

$$F_{1t} = D_{1t} - D_{1t-1}.$$

for this issue we run specifications of the regressions in section 4 without the first years in our sample where the bias is likely to be higher, and provide the breakdown by years of the credit flows in Table 2.

The other borrowers are non first time borrowers ($j = 2$), who had a loan outstanding before year t. We similarly compute the debt flows as:

$$F_{2t} = D_{2t} - D_{2t-1}.$$

The results for the decomposition of credit stocks are shown in Table 2. From 2006 to 2018 the total stock of credit grew from €112 billion to €236 billion. We find that the amount of loans held by first time borrowers remained remarkably stable over this period, at around €12 billion. As a consequence, most of the credit growth originated from non first time borrowers, as shown in panel B of Table 2.

Recent work has emphasized the role of "investor borrowers" in the housing boom in the United-States. DeFusco et al. (2020) for instance find that much of the rise and fall in volumes in the real estate market arose from changes in short-term investment. To explore whether the borrowing by non-first-time borrowers could be driven by a smaller group of investor borrowers, we decompose the stock of credit for different borrower groups depending on the debt percentile. We sort all borrowers in increasing order of debt outstanding. The group <p10 includes the first 10% of borrowers, the second group (p10-p50) includes the next 10% to 50 % of borrowers, followed by the groups p50-p90, p90-p95 and the last 5% in the group >p95. Table 3 shows the total mortgage debt outstanding for the different groups. The table suggests that credit in the 5% of households with the largest debt outstanding did not increase more rapidly than the others, with a share that remained constant at around 20% of total credit between 2006 and 2018. These statistics suggest that "investor borrowers", or the concentration of large borrowing by a limited category of individuals, probably did not play a significant role in the overall increase in credit in the case of Belgium.

4. Econometric Analysis

The previous section examined key characteristics of the credit growth in Belgium since 2006. While interest rates fell over that period, many other events could have influenced the borrowing of households. In this section, we aim to quantify the role of the interest rate in household borrowing. The identification strategy uses regulatory data to construct credit supply shocks which we use as instrumental variables. We first explain the identification strategy. We then introduce the different specifications that we estimate and the estimation results. We then present a number of alternative specifications to verify the robustness of our analysis, followed by a discussion of the results.

Identification

Our objective is to measure the elasticity of household borrowing to changes in interest rates. In the model, the response of borrowing by households takes two forms. If the household is constrained, the amount borrowed is determined by its downpayment capacity. The change in borrowing of equation (9) is

$$D_2(i) - D_1(i) = \frac{(1-\gamma)}{\gamma} H_i^0 (P_2 - P_1)$$

and consists of two terms: the leverage multiplier $(1-\gamma)/\gamma$ and the change in value of the available assets, $H_i^0 (P_2 - P_1)$. A change in the interest rate then affects the borrowing by changing the value of the housing endowment. This increases the borrowing capacity through the leverage multiplier.

The unconstrained households also respond to changes in the interest rate but the channel is different. Since they only use a fraction of their endowment as collateral, the amount borrowed is independent of the change in the value of the endowment. The amount borrowed is instead affected by the change in the interest rate through the increase in the NPV of their future income:

$$D_2(i) - D_1(i) = W_i \left(\frac{1}{1+r_2} - \frac{1}{1+r_1} \right).$$

Assuming that the value of the endowment is inversely proportional to the interest rate (e.g. $P = f(W, A) / (1+r)$), we can estimate these relationships through separate regressions for constrained and unconstrained borrowers of the following type:

$$\log D_{it} = \alpha_0 + \alpha_1 \log \frac{(1-\gamma)}{\gamma} + \alpha_2 \log H_i^0 + \alpha_3 \log W_i + \alpha_4 \log r_{it} + X_{it} + \epsilon_{it}, \qquad (11)$$

where X_{it} includes borrower and year fixed effects and ϵ_{it} are the unobserved characteristics.

There are two challenges to estimate (11). The first one is to distinguish constrained from unconstrained households. The second is to ensure that the variation in the interest rate is independent of the unobservable characteristics.

To separate the constrained households, we use first-time borrowers as a proxy for constrained households. First-time borrowers are borrowers in year t who were previously absent from the database. The assumption, which we discussed in the previous section, is that households must accumulate some wealth before buying a house. When they have enough capital, households then borrow the maximum amount allowed by their credit constraint. Once the purchase is made, households accumulate further wealth and reimburse their mortgage, and thus become unconstrained. An illustration for this is given by the difference in LTV ratios of first time buyers and other buyers. While 30% of other buyers have LTVs higher than 90%, the share increases to 45% for first time buyers.[4] By estimating equation (11) separately for first-time and non-first time borrowers, we can thus assess the different sensitivities of constrained and unconstrained households to changes in the interest rate.

A second challenge is that the interest rate r_{it} generally depends on unobserved borrower characteristics such as future income prospects, private wealth, additional guarantees or private information available to the bank. If households with better economic prospects borrow more against lower rates, this could bias our estimates downwards. To address this concern, we use a measure of the local interest rate faced by each borrower in its municipality instead of using the actual rate paid by the borrower. The local interest rate combines the average interest rate of each bank at the national level and the geographic location of the bank branches.

For each municipality m and bank b, we compute the local presence of the bank as the fraction of the total number of branches of bank b in the municipality, N_{bm}, divided by the total number of branches in m at the start of our sample ($t = 2006$):

$$\omega_{bm} = \frac{N_{bm}}{\sum_b N_{bm}}. \tag{12}$$

The historical location of bank branches can predict the current location of bank branches, which in turn influence the supply of credit to borrowers. An extensive literature has shown that credit supply varies with the physical distance between the borrower and the nearest branch (Degryse and Ongena, 2005). Argyle et al. (2020) have shown in the case of the United-States that credit markets have retained a strong local component: shopping for credit is costly and households tend to favour their local bank. If there are differences in pre-existing coverage of bank branches across municipalities, a shock at the bank level could create a contraction in credit in municipalities where this bank has a stronger presence. Figure 10 illustrates the differences in local market shares for two banks. While some banks have a national coverage, other banks are more focused on specific parts of the country. Importantly, the shares also vary across neighbouring municipalities.

We then use data on the average interest rate on mortgages for each bank at the country level. The data is from the NBB's survey on interest rates (MFI Interest Rate statistics, MIR) and has been used by Boeckx et al. (2020) to assess the transmission of monetary

[4] NBB Financial Stability Report 2020, page 118.

policy. For a given bank interest rate r_{bt} we compute the local interest rate as

$$r_{mt} = \sum_b \omega_{bm} r_{bt}. \tag{13}$$

Our measure of the local interest rate addresses potential endogeneity at the borrower level. The local interest rate could still be dependent on local economic prospects, however. A bank that focuses on wealthy municipalities with strong economic prospects may be able to offer more loans at lower rates than a bank that focuses on more vulnerable municipalities. To address this, we instrument the interest rates of banks using shocks to their foreign country loan portfolios. Most banks in Belgium lend to borrowers located in foreign countries. We use consolidated regulatory data to measure the exposures of banks by country to construct an instrument for bank credit shocks, in the spirit of the granular IVs of Gabaix and Koijen (2019). Figure 11 illustrates the foreign exposures of Belgian banks. The largest countries by exposure are the Netherlands, the United-Kingdom and the United States which together account for close to 50% of total exposures. Consider a set of foreign countries indexed by $f = 1, \ldots, F$. Let g_{ft} be the GDP growth of foreign country f in year t. Let e_{bf} denote the exposure of bank b to country f in 2007, normalized so that $\sum_f e_{bf} = 1$. For each bank, we compute the foreign growth shock as

$$G_{bt} = \sum_{f=1}^{F} e_{bf} g_{ft}. \tag{14}$$

The average foreign growth shock in our data varies over time from a low of -3.48% in 2009 to a high of 3.42% in 2015. Within each year there are substantial differences across banks as illustrated in Table 4.

To construct a local measure of the instrument, we use the branch locations as in equation (13). For each municipality m and year t, we compute the weighted average foreign growth shock as

$$Z_{mt} = \sum_b \omega_{bm} \times G_{bt}. \tag{15}$$

The key identification assumption is that foreign economic shocks only affect the local economy through their impact on banks and their interest rate and that the historical location of bank branches exogenously changes the choice set of households wishing to take up a mortgage. Figure 12 illustrates the first stage relationship for banks and municipalities. The green dots indicate for each bank and year in our sample the foreign GDP shock and the difference between the bank rate r_{bt} and the average rate across all banks in year t. The blue dots show the first stage for municipalities, where the interest rate is computed using equation (13), substracting the year average. In both cases we observe a strong negative relationship between the foreign GDP shock and interest rates, which suggests that bad foreign shocks for banks are associated with higher interest rates in the domestic market.

Table 5 further checks the power and the validity of the instrument. While our sample includes 60 bank-year observations, the use of the branch locations allow to use the variation across municipalities and years for a total of 5,390 observations. The relationship between the average interest rate and the growth shock remains similar whether we use bank variation or municipality-level variation, with respective coefficients of -0.15 and -0.105. If we include bank characteristics such as the leverage ratio or the share of deposits in total liabilities, the relationship remains stable and statistically significant.

Specifications

For the second stage, we consider two levels of analysis: at the municipality level (specification 1) or at the borrower level (specification 2).

Municipality level. Consider a municipality m in year t. We regress the logarithm of debt per capita $\log(D_{mt})$ against the change in the instrumented interest rate faced by households in the municipality, $\hat{r}_{mt}$:

$$\log(D_{mt}) = \alpha\hat{r}_{mt} + \beta_1 X_{mt} + \beta_2 1_t + \beta_3 1_{r(m)} + \varepsilon_{mt} \tag{16}$$

where X_{mt} are the observable municipality-year characteristics, 1_t is a vector of year fixed effects, and ε_{mt} includes the unobservable characteristics. The debt per capita D_{mt} is computed as the total mortgage debt of borrowers in municipality m divided by the number of residents in the municipality. We also run the specification (16) for first-time borrowers only, with the dependent variable as the debt per capita of first-time borrowers.

The controls include the average income in the municipality, the property price index and a dummy for municipalities with a low volume in the real estate market. We also include the share of young in the population to account for differences in demographic patterns and the market concentration to account for potential market power of local banks. The specifications also include year fixed effects and indicators for the region of the municipalities (Flanders, Wallonia or Brussels). The first stage at the municipality level was described above and consists of the regression

$$r_{mt} = \gamma Z_{mt} + \delta_1 X_{mt} + \delta_2 1_t + \xi_{mt}. \tag{17}$$

Borrower level. In the second specification, we use the full granularity of the data to exploit the variation over time for a given borrower. We consider the following specification

$$\log\left(D_{it}\right) = \alpha r_{m(i)t} + \beta_1 X_{it} + \beta_2 1_i + \beta_3 1_{at} + \varepsilon_{it} \tag{18}$$

where D_{it} is the total debt of borrower i in year t and $r_{m(i)t}$ is the local interest rate faced by borrower i in its municipality $m\left(i\right)$. The specification includes borrower fixed effects 1_i as well as age group and time interaction effects 1_{at}.

First time borrowers. In the third specification, we focus on first time borrowers to understand the interest rate elasticity of borrowing of constrained households. Since borrowers can be categorized as "first time" only once in our sample, we cannot include borrower fixed effects. We instead estimate

$$\log\left(D_{it}\right) = \alpha r_{m(i)t} + \beta_1 X_{it} + \varepsilon_{it} \tag{19}$$

where $r_{m(i)t(i)}$ is the local interest rate of the municipality $m\left(i\right)$ where i took on its first loan and $t\left(i\right)$ is the year in which the loan was taken. The controls X_i include age-year interaction effects as well as local income and property prices.

Results

Table 6 shows the estimation results at the municipality level. There are 589 municipalities in Belgium and our sample covers 9 years from 2007 to 2016, giving us 5273 observations after winsorizing the top and bottom 1% of debt levels. We focus on the period 2007-2016 for which we have the income data. To compute the debt per capita, we exclude credit issued by banks that do not provide interest rate information, representing around 15% of the outstanding, and we exclude borrowers below 25 and above 65 years old. The first column shows the first stage and is in line with the results of subsection 4. The OLS specification in column (2) yields a negative and weakly significant relationship. The use of the instrument in columns (3) increases the magnitude and the precision of the coefficient. In terms of magnitudes, the results suggest that a 1p.p. decline in the interest rate is associated to a 10% increase in household indebtedness for all borrowers. When we focus specifically on first time borrowers in column (4), the sensitivity to changes in the interest rate increases further to around 34%.

Table 7 shows the results at the borrower level using the full population with borrower fixed effects as well as age group - year interaction effects. The sample is from 2007 to 2016 with around 1.5 million borrowers per year and a total of 13 million borrower - years. As for the municipality level regressions, the coefficients are negative so higher rates are associated with lower borrowing. The use of the instrument in columns (3) and (4) increases the magnitude of the coefficients relative to the OLS regression in (2). In terms of magnitudes, the borrower level coefficients are somewhat higher than for the municipality level specification, implying that a 1 p.p. fall in interest rates is associated with an 18.85% increase in household indebtedness in column (4).

Table 8 shows the results of the specification focusing on first-time borrowers only. In this case, the OLS specification is not statistically different from zero but the IV estimates remain negative and statistically significant. The magnitude of the relationship increases relative to the specification with all borrowers in Table 7. This is consistent with the municipality level regressions (Table 6, column 4) which also suggested that first-time borrowers are more sensitive to changes in interest rates.

In terms of magnitudes, the different specifications suggest that the sensitivity of household borrowing to interest rates is around 0.15 so a 1 percentage point reduction in the interest rate is associated with a 15% growth in household debt. The magnitudes for first-time borrowers are larger, and a 1p.p. decline in interest rate is associated with a increase in borrowing of 30% to 50% depending on the specification. At the aggregate level, first-time borrowers however only represent around 5% of the population of borrowers in a given year, so the higher sensitivity of first time borrowers is not inconsistent with the stylized facts of section 3 where we show that credit growth is driven by non-first-time borrowers. Borrowers that already have a mortgage increase their borrowing less than first-time borrowers in response to a fall in interest rates, but since they are so numerous relative to first time borrowers their borrowing drives the aggregate increase in household debt.

Robustness

In the baseline specifications, we assume that first-time borrowers are credit constrained. In Table 9, we use age as an alternative proxy of credit constraints (also motivated by the model). We estimate the baseline specification on households aged 18 to 34. In the model, this would thus be equivalent to having a cutoff for constrained borrowers at the age of 34. The results in Table 9 are qualitatively similar to those using first-time borrowers as constrained borrowers, with a debt sensitivity of around 36% in column (3) with all controls.

Our identification strategy assumes that the foreign GDP growth shocks are uncorrelated with the local state of the economy. The GDP shocks are then weighted using the exposure of banks to the different countries. One potential concern with this approach is that the lending interlinkages of banks could be related to the trade interlinkages of Belgian firms, which transmit foreign shocks to the local economy. A foreign GDP shock would then affect both the demand and the supply of credit. To address this concern, we estimate the baseline specifications with an additional control for trade-weighted foreign GDP growth. This variable is constructed using the share of exports to total exports as country weights. The results are broadly unchanged relative to the baseline estimations, as shown in in Tables 12, 13 and 14 in appendix.

Discussion

The differences in the borrowing response across households is consistent with Di Maggio et al. (2017). They find that the consumption of borrowers with little housing wealth is almost twice as responsive to rate reductions as those of other borrowers. Their analysis however focuses on borrowers with Adjustable Rate Mortgages (ARM) where borrowers experience an exogenous reduction in the interest rate paid. Most borrowers then react to this income shock by reducing their leverage. Our identification strategy, using regulatory data on banks to construct credit supply shocks, allows to consider a more general response of household borrowing to changes in interest rates. An increase in debt in response to lower interest rates is also in line with most theoretical predictions (Campbell and Cocco, 2003).

Our results are consistent with the work of Acharya et al. (2020) who study the introduction of macroprudential policies in Ireland. They show that the requirement of a maximum LTV ratios for the issuance of mortgages led to a reallocation of credit towards unconstrained borrowers. The measure however did not prevent aggregate credit growth. In our model, a cap on LTV ratios would be similar to a change in the downpayment constraint γ. If banks require a higher downpayment, this reduces the borrowing of constrained borrowers while unconstrained borrowers remain unaffected. In our sample, we find that the lending standards of banks remained broadly stable (notwithstanding some year to year variation) and credit growth seems to have originated mostly from non-first-time borrowers. Since these borrowers already had a mortgage and thus some housing wealth, they are less likely to be constrained.

Our finding that the transmission of interest rates to borrowing varies within the population can further motivate an ongoing effort to include heterogeneity in macroeconomic models. Auclert (2019) or Kaplan et al. (2018) show for instance that the response of consumers with a high propensity to consume is a key transmission channel of monetary policy. Our analysis confirms that they are more responsive to changes in interest rates but they may be crowded out in aggregate. Quantifying further the share of constrained households to complement our measure based on first-time borrowers would be an interesting avenue for future research. Beyond macroeconomic models of heterogeneity, the distributional focus of our work is also relevant for models of systemic risk indicators. The work of Schularick and Taylor (2012) for instance uses aggregate credit measures to construct early warning indicators of financial crises. The composition of credit could also matter as a credit growth driven by vulnerable borrowers would have different implications relative to a growth driven by unconstrained borrowers.

5. Conclusion

We explore the sensitivity of borrowing by households to changes in interest rates and the impact of interest rate changes on the distribution of credit within the population. We build a model of household borrowing with endogenous house prices and credit constraints. In the model, households differ in their endowments of housing wealth and labour income. Young households having little housing wealth and more future labour income whereas old households have more housing resources and fewer labour income. We show that middle aged households who have some pre-existing housing wealth increase their borrowing most in response to a fall in interest rates. These households have more resources to use as downpayment whereas younger households with less resources face borrowing constraints.

We use unique loan level data from Belgium to show that most of the increase in household debt over the last decade was driven by middle aged households who have some debt outstanding. While the loan to income ratios increased, we find that other indicators of credit standards such as debt service to income (DSTI) or loan to value (LTV) ratios remained broadly stable.

We then estimate the elasticity of household borrowing to interest rates distinguishing the full population of borrowers and first-time borrowers. For identification, we construct an instrumental variable using foreign country exposures of banks and the location of bank branches. We find that a 1 p.p. decline in the interest rate is associated with a 15% increase in household debt and that first time borrowers respond more to changes in interest rates.

Our results emphasize the importance of heterogeneity in the response of households to lower interest rates. While the findings of this paper are mostly positive in nature, the disaggregation of headline credit series using exhaustive data such as the credit registry offers opportunities to inform policy and normative analysis. Understanding the trade-off between financial stability and access to credit as well as constructing alternative measures of credit constraints of households are promising avenues for future research.

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Table 1. Overview of mortgage credit registry

This table provides an overview of mortgages in the credit registry. We consider two samples: *All borrowers* includes all households with a mortgage outstanding. *First-time borrowers* only includes households that borrow for the first time in a given year. *Households*: number of households with a mortgage outstanding. *Age*: Average age of lead borrower in household weighted by the outstanding amount borrowed by each household. *Loans*: Average number of loans per household, weighted by the outstanding amount borrowed by each household.

Sample	Characteristic	Year		
		2006	2013	2018
All borrowers	Households	1,553,744	1,730,771	1,858,462
	Age	38.9	40.3	41.3
	Loans	1.8	2.1	2.2
	Amount	71 964	101 992	126 727
First-time borrowers	Households	98,564	63,205	73,371
	Age	34.2	32.8	32.9
	Loans	1.3	1.4	1.4
	Amount	130 842	163 606	204 607

Table 2. Decomposition of mortgage debt by borrower type

This table shows the breakdown of total mortgage debt for first-time and non-first-time borrowers. Panel *A* decomposes the stock of debt and panel *B* provides the flows over specific periods, computed as the difference in stocks.

Panel A. Credit stocks in billion euros

Year	Total credit	First time borrowers	Non-first time borr.
2006	111.8	12.9	98.9
2010	151.2	12.2	139
2014	185.7	11.7	174
2018	236.0	15.0	221

Panel B. Credit flows in billion euros

Period	Total credit	First time borrowers	Non-first time borr.
2006-2010	39.4	-0.7	40.1
2010-2014	34.5	-0.5	35
2014-2018	50.3	3.3	47
Total	124.2	2.1	122.1

Table 3. Distribution of mortgage debt by household indebtedness

This table shows the distribution of the mortgage debt outstanding for different groups of borrower indebtedness. We sort borrower by their debt outstanding, then consider in panel *A* the groups of borrowers below the 10th debt percentile, from the 10th to the 50th percentile, from 50th to 90th, 90th to 95th and above the 95th percentile. Panel A shows the total mortgage debt oustanding for each group in billion euros as well as the share of each group in %. Panel B shows the debt per borrower for the main percentiles.

Panel A. Amount outstanding in billion euros and share in %

Year	Total Credit	Indebtedness percentile 0 to 10	10 to 50	50 to 90	90 to 95	95 to 100
Amount						
2006	112	1	17	56	14	25
2012	171	1	26	88	20	36
2018	236	1	39	121	27	48
Share						
2006	100	1	15	50	13	22
2012	100	1	15	51	12	21
2018	100	1	16	51	11	20

Panel B. Amount outstanding per borrower in euros

Year	Total borrowers	Indebtedness percentile 10	50	90	95
2006	1,553,744	8,180	50,111	152,277	200,000
2012	1,716,918	11,984	73,140	210,000	265,000
2018	1,858,462	12,603	100,000	257,587	326,920

Table 4. Foreign growth shock

The table shows summary statistics of the foreign GDP growth shock computed using foreign exposures of banks. Panel *A* documents the foreign GDP shock computed at the bank level from equation (14). Panel *B* shows the foreign growth shocks computed at the municipality level as in equation (15). The sample includes 9 banks per year and 539 municipalities with bank branches.

Year	Observations	Mean	Standard Deviation	Min	Max
Panel A: Bank level					
2007	9	3.2	0.5	2.5	4.1
2008-2009	18	-1.7	2.2	-4.2	1.2
2010-2012	27	1.2	1.0	-0.9	2.5
2013-2014	18	1.3	0.9	-0.1	3.1
2015-2018	36	2.7	1.0	1.9	6.7
All years	111	1.4	2.0	-4.2	6.7
Panel B: Municipality level					
2007	539	3.5	0.2	3.2	4.1
2008-2009	1,078	-1.5	2.1	-3.8	0.9
2010-2012	1,617	1.5	0.8	-0.1	2.5
2013-2014	1,078	1.7	0.7	0.7	3.1
2015-2018	2,156	2.9	0.8	2.0	6.7
All years	6,468	1.7	1.9	-3.8	6.7

Table 5. Interest rates and foreign growth shock (first stage regression)

This table shows the results of the first stage regression of the interest rate on the foreign growth shock instrument, from equation (17). Columns (1) and (2) show the specifications at the bank level and columns (3) and (4) the specification at the municipality level. In column (2), Bank characteristics include the common equity to assets ratio, the loans to assets ratio, the deposits to assets ratio and the ratio of loans to deposits. In column (4), municipality characteristics include the average income, the property price index and an indicator for low volume in the real estate market. Sample : 2007-2017, excluding 2009. Robust standard errors.

	(1)	(2)	(3)	(4)
Foreign growth	-0.154*	-0.116*	-0.105***	-0.105***
	(0.0676)	(0.0454)	(0.00295)	(0.00297)
Bank characteristics	No	Yes	No	No
Municipality characteristics	No	No	No	Yes
Year FE	Yes	Yes	Yes	Yes
R^2	0.943	0.951	0.993	0.993
Observations	60	60	5390	5390

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 6. Interest rate sensitivity of debt at municipality level

This table shows the sensitivity of mortgage borrowing to the interest rate estimated at the municipality level as in equation (16). Column (1) shows the first-stage regression of the interest rate r_{mt} in municipality m and year t on the average foreign GDP growth of banks in m and t. In (2) to (3), the dependent variable is the log of debt per capita in m and t. In (4), the dependent variable is debt per first time borrower. (2) shows the OLS results without instrument. (3) is the IV specification for all borrowers and (4) focuses on first-time borrowers only. All variables are taken in logs. Mean income is the average income in m and t. Property price is the average price of real estate in m and t, and low volume is a dummy for municipalities with a low volume of real estate transactions. Share of young is the share of population aged between 25-34 years. Market concentration is the Herfindahl index computed as the sum of squares of bank market shares. Robust standard errors.

	(1) First stage	(2) OLS All borrowers	(3) IV All borrowers	(4) IV First-time borr.
Foreign growth	-0.0800**			
	(0.0313)			
Interest rate		-5.048**	-10.41**	-34.05**
		(2.126)	(4.482)	(14.87)
Mean income	0.0000460	1.251***	1.251***	0.624***
	(0.0000687)	(0.0221)	(0.0222)	(0.0107)
Property Price	-0.0000462	0.0473***	0.0468***	-0.0777***
	(0.0000472)	(0.00785)	(0.00795)	(0.00885)
Low volume dummy	-0.00104**	-0.0431***	-0.0481***	-0.130
	(0.000450)	(0.0117)	(0.0124)	(0.109)
Share of young	-0.00102*	0.931***	0.926***	1.243***
	(0.000471)	(0.0702)	(0.0696)	(0.0988)
Market concentration	-0.00441***	-0.800***	-0.826***	-0.611**
	(0.00103)	(0.0594)	(0.0511)	(0.261)
Year FE	Yes	Yes	Yes	Yes
Region	Yes	Yes	Yes	Yes
R^2	0.994	0.839		
Observations	5273	5273	5273	5273

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 7. Interest rate sensitivity of debt at borrower level (all borrowers)

This table shows the sensitivity of mortgage borrowing to the interest rate estimated at the borrower level as in equation (18). Column (1) shows the OLS specification without instrument. Columns (2) to (4) show the second stage of the IV estimation under different specifications. *Mean income* is the average income in $m(i)$ and $t(i)$. *Property price* is the average price of real estate in $m(i)$ and $t(i)$. *Low volume* is a dummy indicator for municipalities with a low volume of real estate transactions. *First-time* is an indicator for first-time borrowers. The specifications include borrower fixed effects and age-time interaction effects. Robust standard errors clustered at the borrower-level. Sample: all borrowers aged between 25 and 65 years.

	(1) OLS All borrowers	(2) IV All borrowers	(3) IV All borrowers	(4) IV All borrowers
Interest rate	2.972***	-17.92***	-18.82***	-18.85***
	(0.410)	(5.076)	(5.013)	(5.013)
Mean income			0.270***	0.270***
			(0.00603)	(0.00602)
Property Price			-0.0420***	-0.0417***
			(0.00400)	(0.00400)
Low volume dummy			0.0455***	0.0455***
			(0.0119)	(0.0119)
First-time				0.0155***
				(0.000492)
Age x Year	Yes	Yes	Yes	Yes
Borrower	Yes	Yes	Yes	Yes
Observations	13,041,574	13,041,574	13,041,574	13,041,574

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 8. Interest rate sensitivity of debt at borrower level (first-time borrowers)

This table shows the sensitivity of mortgage borrowing to the interest rate for first time borrowers as in equation (19). The estimation is done at the borrower level for first-time borrowers only. Column (1) shows the OLS specification without instrument. Columns (2) and (3) show the second stage of the IV specification. *Mean income* is the average income in $m(i)$ and $t(i)$. *Property price* is the average price of real estate in $m(i)$ and $t(i)$, and *low volume* is a dummy indicator for municipalities with a low volume of real estate transactions. The specifications include year fixed effects. Robust standard errors clustered at the year level. Sample: first time borrowers aged between 25 and 65 years.

	(1)	(2)	(3)
	OLS	IV	IV
	First-time borr.	First-time borr.	First-time borr.
Interest rate	7.442	-50.12***	-56.33***
	(12.51)	(14.93)	(16.06)
Mean income			-0.0972***
			(0.0284)
Property Price			-0.0914***
			(0.0182)
Low volume dummy			-0.614**
			(0.279)
Year	Yes	Yes	Yes
Observations	581,884	581,884	581,884

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 9. Interest rate sensitivity of debt of younger borrowers

This table shows the sensitivity of mortgage borrowing to the interest rate for borrowers aged 18 to 34. As younger borrowers could be more credit constrained, this specification is an alternative to using first-borrowers as constrained households in Table 8. The estimation is done at the borrower level. Column (1) shows the OLS specification without instrument. Columns (2) and (3) show the second stage of the IV specification. *Mean income* is the average income in $m(i)$ and $t(i)$. *Property price* is the average price of real estate in $m(i)$ and $t(i)$, and *low volume* is a dummy indicator for municipalities with a low volume of real estate transactions. The specifications include year fixed effects. Robust standard errors year clustered at the year level. Sample: first time borrowers aged between 18 and 34 years.

	(1) OLS	(2) IV	(3) IV
Interest rate (p.p.)	-50.85***	-92.34***	-36.36***
	(11.42)	(15.33)	(10.80)
Mean income			0.479***
			(0.0507)
Property Price			-0.150***
			(0.00932)
Low volume dummy			-0.165***
			(0.0286)
Age x Year FE	Yes	Yes	Yes
Observations	2,997,863	2,997,863	2,996,980

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

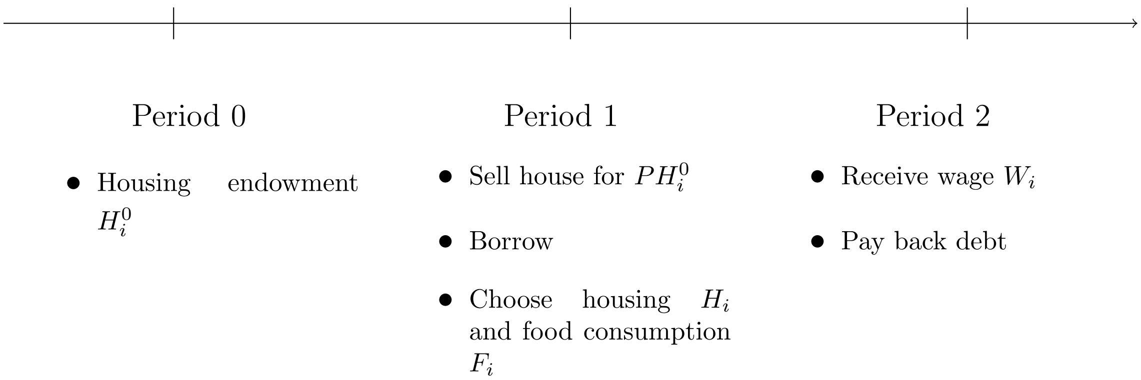
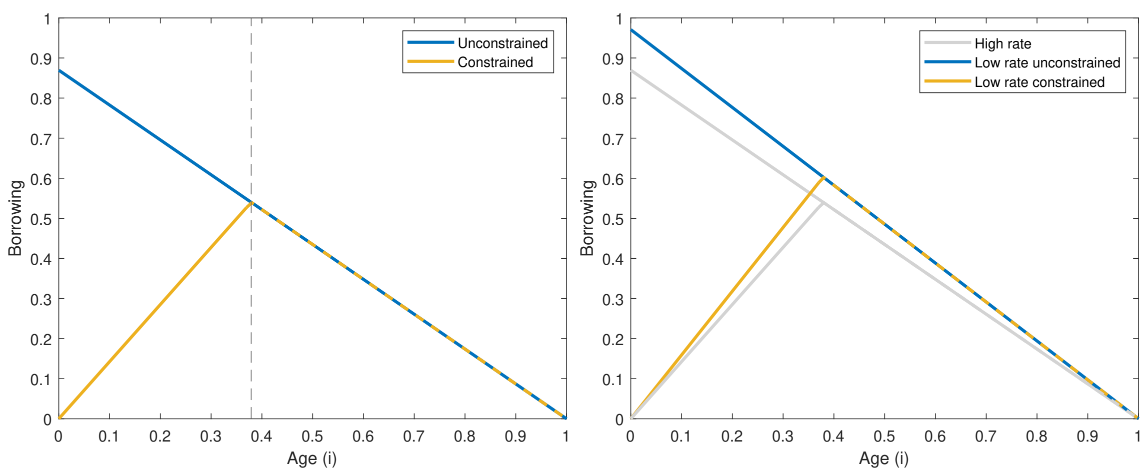


Figure 1. Model timing



(a) Baseline rate r_1

(b) Rate $r_2 < r_1$

Figure 2. Interest rate counterfactuals

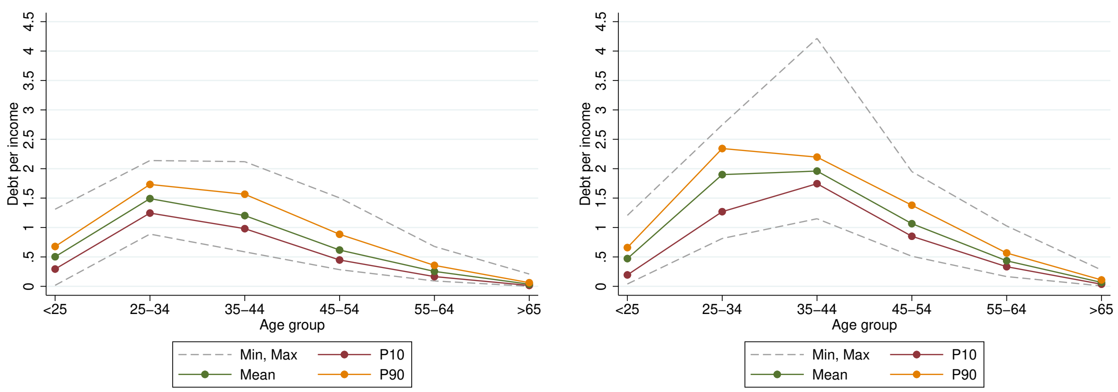
Figure 2a is a numerical simulation of the model with linear endowments $H_i^0 = 2i$ and $W_i = 1 - i$. The blue line shows household borrowing in the unconstrained, first-best case. The orange line shows the amount borrowed with credit constraints. Figure 2b illustrates comparative statics of borrowing with a lower interest rate $r_2 < r_1$. The parameters used are $\gamma = 0.25$, $\alpha = 0.3$, $r_1 = 0.15$ and $r_2 = 0.03$.

(a) Household debt to GDP

(b) Price to income

Figure 3. Household debt to GDP ratio and house price to disposable income ratio in Belgium and the Euro area

Figure 3a shows the ratio of household debt to GDP in Belgium and the euro area (Source: ECB Quarterly Sector Accounts and Main Aggregates statistics). Figure 3b shows the ratio of house prices to disposable income in Belgium and the euro area (Source: OECD Housing Prices).



(a) Year 2006

(b) Year 2016

Figure 4. Ratio of total mortgage debt to annual income across municipalities in Belgium

These figures show the distribution of debt to income across municipalities and age groups in 2006 (Figure 4a) and 2016 (Figure 4b). The figures show the 10th and 90th percentile, the minimum and maximum of debt to income across municipalities for each age group. The mean is the national average. Percentiles are computed across municipalities using population weights.

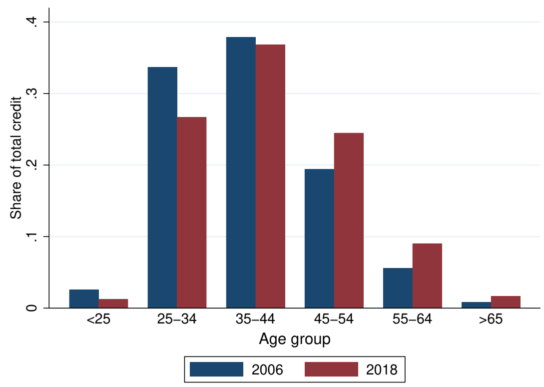
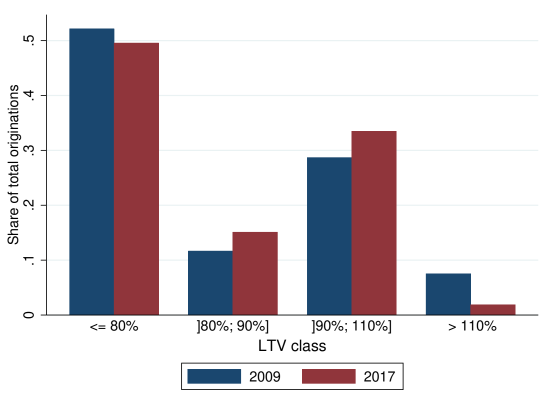
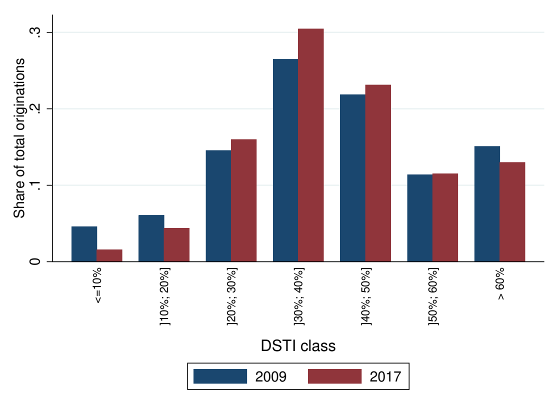


Figure 5. Distribution of credit across age groups in 2006 and 2018

This figure shows the share of total mortgage credit outstanding allocated to the different age groups in 2006 and 2018.



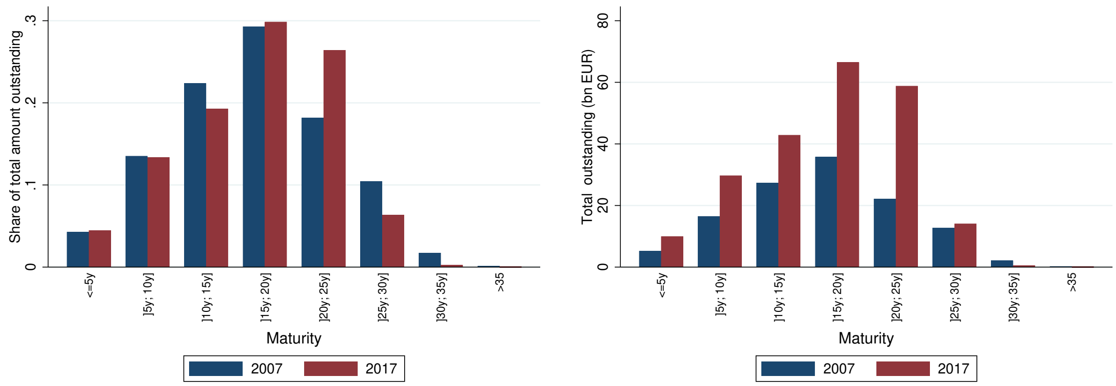
(a) Loan-to-value ratio



(b) Debt service to income ratio

Figure 6. Indicators of loan quality at origination

Figure 6a shows the distribution of the loan-to-value ratio of mortgages at origination in 2009 and 2017. Figure 6b shows the distribution of the debt service to income ratio of mortgages at origination in 2009 and 2017. Source: NBB PHL Residential Real Estate Survey.



(a) Share (b) Amount

Figure 7. Maturity structure of outstanding mortgages

This figure shows the maturity structure of outstanding morgage loans in 2007 and 2017. The left hand side figure shows the share of each maturity group in the total and the right hand side figure shows the outstanding amount in euros. Loan maturities are grouped in ranges: below 5 years, from 5 to 10 years, 15 to 20, 20 to 25, 25 to 30 and above 30 years.

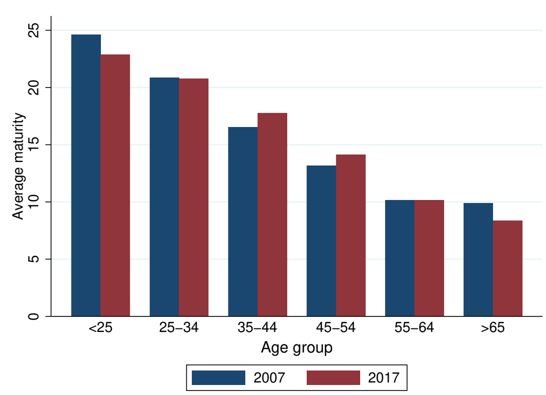
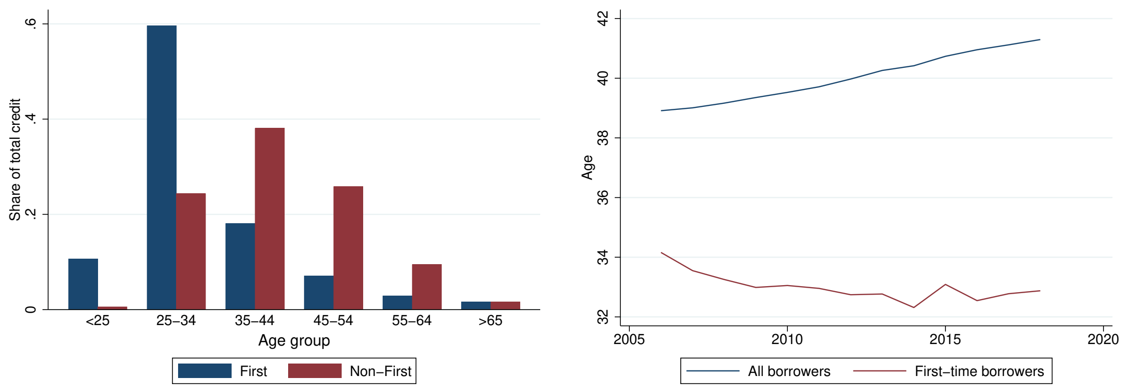


Figure 8. Average maturity of outstanding mortgages by age group in 2007 and 2017.

This figure shows the valued weighted average maturity of mortgage loans outstanding by age group in 2007 and 2017. Source: KCP.

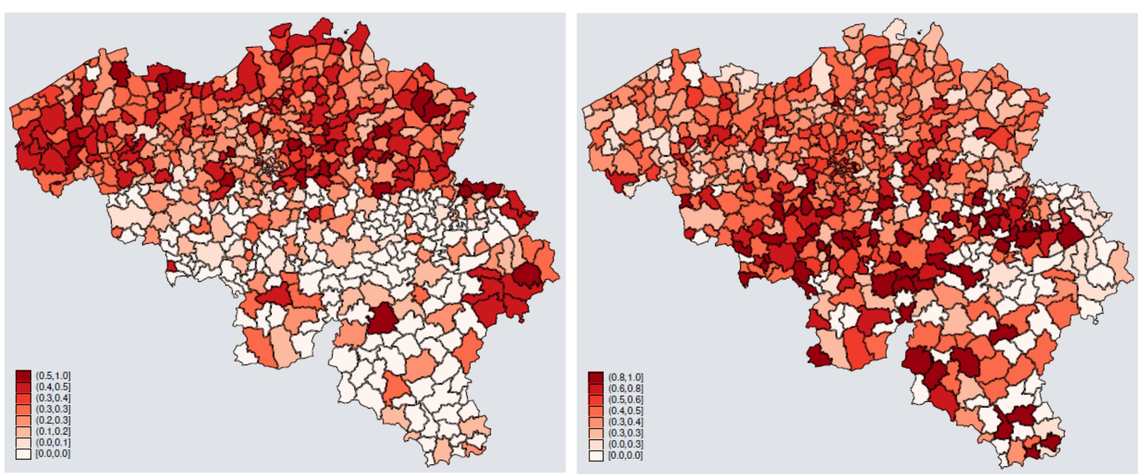


(a) Distribution of credit to first time borrowers and non-first time borrowers in 2018

(b) Age of all borrowers and first-time borrowers

Figure 9. Age distribution of first time and non-first time borrowers

Figure 9a shows the share of outstanding mortgage credit to first time and non-first time borrowers in 2018, broken down by age group. Figure 9b shows the average age of all borrowers and first-time borrowers, computed using value weights.



(a) Bank A

(b) Bank B

Figure 10. Branch market share of two banks

These figures show the market shares of two banks which we use to construct the instrument. The market share is computed as the number of branches of a bank relative to total branches in a municipality. Source: Banque Carrefour des Entreprises.

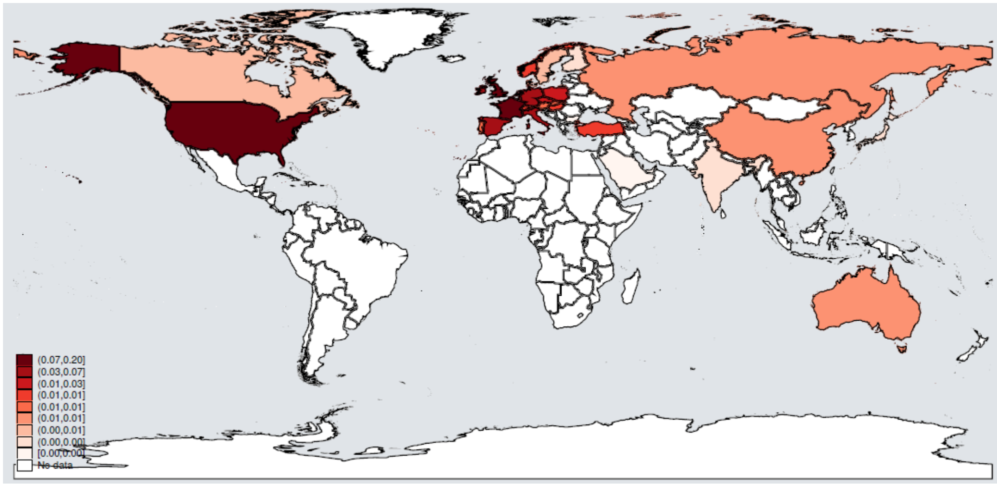


Figure 11. International exposures of Belgian banks
This figure illustrates the international exposures used to compute the instrument. International exposures are computed as the share of foreign exposures out of total foreign exposures. Foreign country exposures are international financial claims of domestic bank head offices on a worldwide consolidated immediate borrower basis, i.e. including the exposures of own foreign offices but excluding inter-office positions. Source: NBB Schema A.

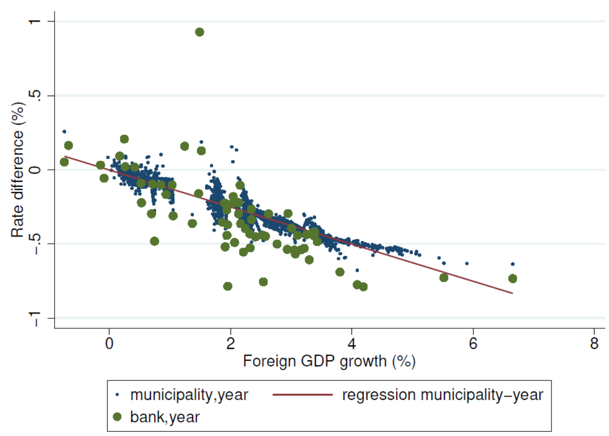


Figure 12. First stage relationship between interest rates and foreign GDP growth
This figure shows the relationship between interest rates and foreign GDP growth which we use as the first stage regression. The green points are observations at the bank and year level and the blue points are observations at the municipality and year level. For the bank-level observations, the foreign growth shock is computed as G_{bt} in equation (14). The interest rate is the bank rate r_{bt} in equation (13) minus the year fixed effects, i.e. we regress $r_{bt} = G_{bt} + \delta_t + \epsilon_{bt}$ and plot $r_{bt} - \hat{\delta}_t$ on the y-axis. For the municipality-level observations, the foreign growth shock is computed as Z_{mt} in equation (15). The interest rate is the bank rate r_{mt} in equation (13) minus the year fixed effects, i.e. we regress $r_{mt} = Z_{mt} + \delta_t + \epsilon_{mt}$ and plot $r_{bt} - \hat{\delta}_t$ on the y-axis. The regression line shows the linear fit between the interest rate and the foreign growth shock at the municipality level. The sample period is from 2007 to 2017, excluding the year 2009.

A. Proofs

No credit constraint (Proposition 1)

Proof. The problem is:

$$\max_{H_i,F_i} U_i = \alpha \ln H_i + (1-\alpha) \ln F_i.$$

such that

$$H_i P + F_i + r\left(F_i + H_i P - H_i^0 P\right) = H_i^0 P + W_i.$$

The constraint may be rewritten as

$$(1+r) H_i P + (1+r) F_i = (1+r) H_i^0 P + W_i.$$

$$F_i = H_i^0 P + \frac{W_i}{1+r} - H_i P.$$

Plug into the objective function:

$$\max_{H_i} U_i = \alpha \ln H_i + (1-\alpha) \ln \left(H_i^0 P + \frac{W_i}{1+r} - H_i P\right)$$

The FOC is:

$$\frac{\alpha}{H_i} - \frac{(1-\alpha) P}{H_i^0 P + \frac{W_i}{1+r} - H_i P} = 0$$

$$\alpha \left(H_i^0 P + \frac{W_i}{1+r} - H_i P\right) = (1-\alpha) P H_i$$

$$P H_i = \alpha \left(H_i^0 P + \frac{W_i}{1+r}\right)$$

The amount of food is given by

$$F_i = H_i^0 P + \frac{W_i}{1+r} - \alpha \left(H_i^0 P + \frac{W_i}{1+r}\right).$$

i.e.

$$F_i = (1-\alpha) \left(H_i^0 P + \frac{W_i}{1+r}\right)$$

House prices are pinned down by market clearing (4):

$$1 = \int_0^1 H_i di$$

Plug in demand for housing:

$$1 = \int_0^1 \alpha \left(H_i^0 + \frac{W_i}{(1+r)P} \right) di$$

The initial housing stock is normalized to one, $\int_0^1 H_i^0 di = 1$ and $\int_0^1 W_i di = W$:

$$1 = \alpha \left(1 + \frac{W}{(1+r)P} \right)$$

Again:

$$(1+r)P = \alpha 1 (1+r)P + \alpha W$$

$$(1+r)(1-\alpha)P = \alpha W$$

$$P = \frac{\alpha W}{(1+r)(1-\alpha)}.$$

□

Constrained outcome (Proposition 3)

Proof. The problem is:

$$\max_{H_i, F_i} U_i = \alpha \ln H_i + (1-\alpha) \ln F_i.$$

Such that

$$H_i P + F_i + r \left(F_i + H_i P - H_i^0 P \right) \leq H_i^0 P + W_i.$$

$$\gamma (H_i P + F_i) \leq H_i^0 P.$$

$$1 = \int_0^1 H_i di.$$

There are two cases: the downpayment constraint (3) binds or is slack.

Case 1: Slack downpayment constraint

If (3) is slack, demand is as in section (2):

$$PH_i = \alpha \left(H_i^0 \frac{\alpha W}{(1+r)(1-\alpha)} + \frac{W_i}{1+r} \right)$$

The constraint becomes binding at the threshold $\bar{i}$ such that

$$\gamma \left(H(\bar{i}) P + F(\bar{i}) \right) = H^0(\bar{i}) P.$$

Consumption is equal to available resources so this may be rewritten as

$$\gamma\left(H^{0}\left(\bar{i}\right)P+\frac{W\left(\bar{i}\right)}{1+r}\right)=H^{0}\left(\bar{i}\right)P$$

or:

$$\gamma\frac{W\left(\bar{i}\right)}{1+r}=\left(1-\gamma\right)H^{0}\left(\bar{i}\right)P. \tag{20}$$

Case 2: binding downpayment constraint.

If the constraint binds, the household can only transfer a fraction of its wealth to the first period and the rest is lost. In this case, the leverage constraint defines the wealth available, and the household optimizes given that wealth. The budget constraint is slack and the leverage constraint is binding:

$$\gamma\left(H_iP+F_i\right)=H_i^0P.$$

Total consumption is determined by the initial housing wealth and the leverage constraint: H_i^0P/γ. Food and housing consumption are given by:

$$\begin{cases} PH_i & =\alpha\left(\frac{H_i^0P}{\gamma}\right)\\ F_i & =\left(1-\alpha\right)\left(\frac{H_i^0P}{\gamma}\right)\end{cases}.$$

House prices. The price of housing is given by the market clearing equation:

$$1=\int_0^1 H_i di.$$

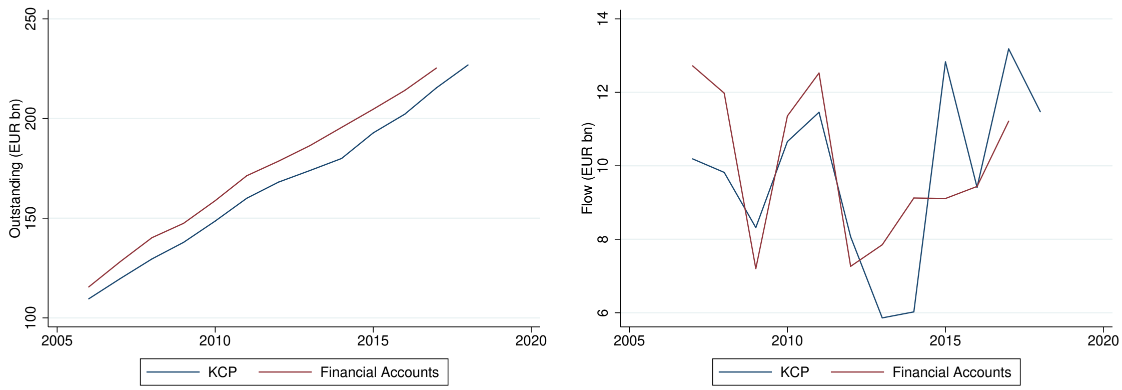
This can be decomposed into:

$$1=\int_0^{\bar{i}} H_i di+\int_{\bar{i}}^1 H_i di.$$

Plug in the demand functions for each type of household (constrained or not):

$$P=\int_0^{\bar{i}}\left(1-\alpha\right)\left(\frac{H_i^0P}{\gamma}\right)di+\int_{\bar{i}}^1\alpha\left(H_i^0P+\frac{W_i}{1+r}\right)di.$$

□



(a) Stocks

(b) Flows

Figure 13. Comparison of aggregate mortgage credit stocks and flows using the credit registry data and the financial accounts

These figures compare the stocks and flows of outstanding mortgages in Belgium using the credit registry and the financial accounts statistics. Figure 13a shows the stocks of mortgages outstanding for each series and figure 13b shows the flows. Figures are in billion euros.

B. Data consistency

B.1. Comparison with other databases

Figures 13 and 14 illustrate the comparison of the credit registry data with data from the financial accounts explained in section 3.

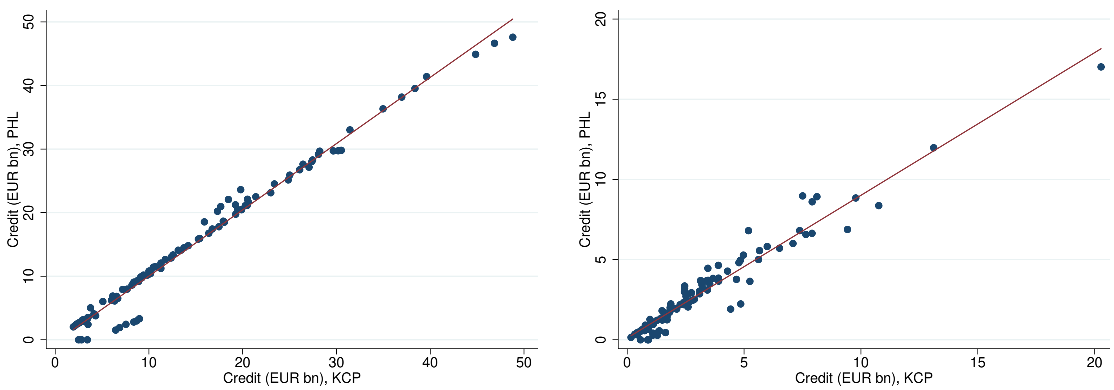
B.2. Annuity-based calculation of outstanding amounts

As explained in section 3, we recover the outstanding balance of a mortgage from the amount at origination using a linear approximation, definining the outstanding debt balance D_t as

$$D_t = D_0 \times \frac{T - t}{T},$$

where D_0 is the debt amount at origination, T is the maturity in years and t is the years since issuance.

In this subsection, we compare the amount outstanding using the linear approximation to the amounts computed using an annuity-based amortization of the mortgages. With annuity-based contracts, the borrower reimburses a fixed amount for the full duration of the mortgage, and this amount includes both the interest payments and the reimbursement of the principal amount. If the interest rate on the mortgage is r and the annual payment to



(a) Total credit

(b) New credit

Figure 14. Comparison of mortgages outstanding by banks

These figures compare the total mortgages outstanding at the bank-level for the 10 largest banks using data from the credit registry (x-axis) and the regulatory survey of mortgage portfolios (NBB PHL Residential Real Estate Survey, y-axis). Figure 14a includes all mortgages outstanding while figure 14b focuses on new loans originated in a given year. Figures are in billion euros and annual from 2007 to 2017.

be made is C, the mortgage at origination is such that

$$D_0 = \frac{C}{r}\left(1 - \frac{1}{(1+r)^T}\right).$$

Using the interest rate in the year of issuance, we can therefore compute the annual payment as

$$C = \frac{D_0 \times r}{1 - \frac{1}{(1+r)^T}}.$$

and the amount outstanding in period t is equal to

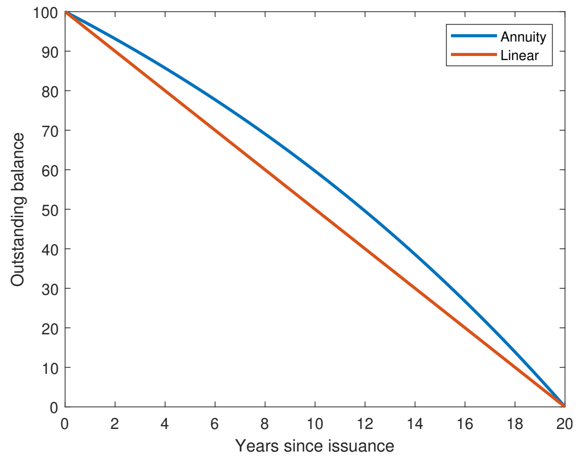
$$D_t = \frac{C}{r}\left(1 - \frac{1}{(1+r)^{T-t}}\right). \tag{21}$$

Figure 15 illustrates the differences in outstanding balances using the linear and annuity approximations for a 20 year mortgage with a 4% interest rate. The largest difference between the two formulas arises in the middle of the life of the mortgage. In the early years of the loan, the difference is smaller.

To verify the robustness of our results to the assumption of a linear amortization, we compute the outstanding balances using an annuity based amortization. For the annuity-based balance, we use the interest rate on 10 year government debt in the year of issuance. Table 10 compares the amount outstanding using the two methodologies. The difference ranges from €4 to 12 billion across years. The outstanding amount using the annuity formula

Figure 15. Amount outstanding with annuity-based or linear amortization

This figure compares the outstanding balance of a mortgage worth 100 at origination, issued with a 20 year maturity at an interest rate of 4%. "Annuity" is the balance computed using an annuity-based amortization of the mortgage while "Linear" is a linear amortization.



is around 3% to 7% larger than the amount with the linear approximation.

One reason for the relatively small differences is that the average years since issuance is low. This is illustrated in Figure 16 which shows the share of total mortgages outstanding for different ranges of years since issuance. While the average maturity of mortgages at origination is around 15 years, more than 70% of mortgages have an average life smaller than 3 years. This reflects the importance of refinancing, as borrowers frequently renegotiate the terms of their debt with banks. The frequent refinancing of mortgages then minimizes the differences between the use of an annuity-based amortization and a linear amortization, since the differences are small at the early years of the mortgage.

C. Additional tables

Table 11 shows the home ownership rates for different age groups. Tables 12, 13 and 14 show alternative specifications of the baseline.

Table 10. Mortgages outstanding with linear and annuity-based amortization

This table compares the total outstanding value of mortgages using a linear amortization as in equation 10 and an annuity-based amortization as in equation 21. Amounts are in euro billion.

Year	Linear	Annuity	Difference
2006	112	116	4
2007	122	127	5
2008	131	138	7
2009	140	148	8
2010	151	161	10
2011	164	174	10
2012	171	182	11
2013	176	188	12
2014	186	198	12
2015	196	206	10
2016	208	217	9
2017	223	232	9
2018	236	244	8

Figure 16. Years since issuance of outstanding mortgages

This figure provides a breakdown of outstanding mortgages by years since issuance from 2006 to 2018.

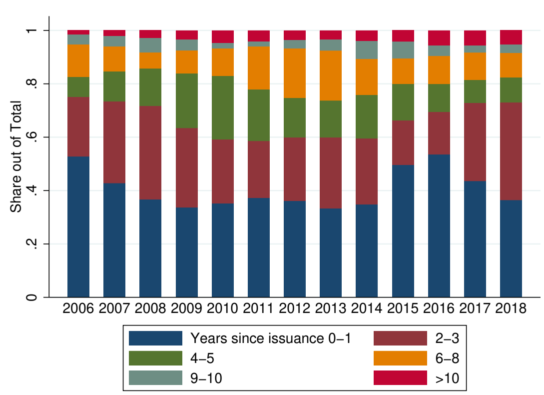


Table 11. Homeownership and age

The table shows the share of households who own their main residence, other real estate or both. source: HFCS, Third wave (2017).

	Share of households that own:		
Age	Main residence	Other real estate	Both
< 25	0%	0%	0 %
25 - 34	51%	8%	7 %
35 - 44	73%	12%	9 %
45 - 54	75%	22%	18 %
55 - 64	74%	27%	24 %
> 65	69%	21%	17 %

Table 12. Robustness: Trade interlinkages (municipality level)

This table shows the sensitivity of mortgage borrowing to the interest rate estimated at the municipality level as in the specifications of Table 6, but accounting for trade interlinkages. The trade-weighted foreign growth is the weighted average foreign GDP growth using the share of exports to each country as weights. Other variables are identical to those of Table 6.

	(1) First	(2) OLS	(3) ALL	(4) FT
Foreign growth	-0.109***			
	(0.0323)			
Interest rate		-5.032	-11.07***	-41.67***
		(2.829)	(2.749)	(14.67)
Trade-weighted Foreign growth	-0.391	5.301	5.495	-78.20
	(1.721)	(15.06)	(23.97)	(56.01)
Mean income	-0.000364***	1.255***	1.252***	0.738***
	(0.000107)	(0.0105)	(0.0109)	(0.0526)
Property Price	-0.0000246	0.0551***	0.0547***	-0.0253
	(0.0000537)	(0.0122)	(0.0120)	(0.0203)
Low volume dummy	-0.00132*	-0.103**	-0.109***	-0.301**
	(0.000696)	(0.0360)	(0.0377)	(0.137)
Year FE	Yes	Yes	Yes	Yes
R^2	0.149	0.700		
Observations	5274	5274	5274	5274

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 13. Robustness: Trade interlinkages (all borrowers)

This table shows the sensitivity of mortgage borrowing to the interest rate estimated at the borrower level as in the specifications of Table 7, but accounting for trade interlinkages. The trade-weighted foreign growth is the weighted average foreign GDP growth using the share of exports to each country as weights. Other variables are identical to those of Table 7.

	(1) OLS	(2) IV	(3) IV	(4) IV
Interest rate	-2.973***	-9.905***	-11.04***	-11.00***
	(0.410)	(2.725)	(2.699)	(2.699)
Trade-weighted foreign growth		-13.84***	-13.56***	-13.52***
		(4.061)	(4.031)	(4.031)
Mean income			0.271***	0.271***
			(0.00599)	(0.00599)
Property Price			-0.0435***	-0.0431***
			(0.00392)	(0.00392)
Low volume dummy			0.0438***	0.0437***
			(0.0120)	(0.0120)
First-time				0.0155***
				(0.000492)
Age x Year	Yes	Yes	Yes	Yes
Borrower	Yes	Yes	Yes	Yes
Observations	13,042,403	13,042,403	13,042,403	13,042,403

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Table 14. Robustness: Trade interlinkages (first-time borrowers)

This table shows the sensitivity of mortgage borrowing to the interest rate estimated at the borrower level and for first-time borrowers only as in the specifications of Table 8, but accounting for trade interlinkages. The trade-weighted foreign growth is the weighted average foreign GDP growth using the share of exports to each country as weights. Other variables are identical to those of Table 8.

	(1) OLS	(2) IV	(3) IV
Interest rate	7.442	-48.38***	-53.17***
	(12.51)	(12.68)	(12.90)
Trade-weighted foreign growth		-10.01	-18.21
		(130.1)	(131.0)
Mean income			-0.0971***
			(0.0282)
Property Price			-0.0913***
			(0.0182)
Low volume dummy			-0.614**
			(0.280)
Year FE	Yes	Yes	Yes
Observations	581,884	581,884	581,884

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$