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HOW DOES BANK CAPITAL AFFECT THE SUPPLY OF MORTGAGES? EVIDENCE FROM A RANDOMIZED EXPERIMENT

by Valentina Michelangeli* and Enrico Sette**

Abstract

We study the effect of bank capital on the supply of mortgages. We fully control for endogenous matching between borrowers, loan contracts, and banks by submitting randomized mortgage applications to the major online mortgage broker in Italy. We find that: higher bank capital is associated with a higher likelihood of application acceptance and lower offered interest rates; banks with lower capital reject applications by riskier borrowers and offer lower rates to safer ones. Finally, nonparametric estimates of the probability of acceptance and of the offered rate show that the effect of bank capital is stronger when capital is low.

JEL Classification: G21, D14.
Keywords: mortgages, banks, household finance, randomized experiment.

Contents

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1 Introduction[1]

The recent financial crisis revived the attention on how banks' health affects financial stability and macroeconomic growth. In particular, the academic and policy debates are currently focused on the effects of bank capital on lending and risk taking. Indeed, both macroprudential and the microprudential regulatory reforms propose to raise bank capital ratios and strengthen bank capital buffers, with the aim of preventing "excessive" lending growth and increasing the system's resilience to adverse shocks (Brunnermeier et al., 2009; Blanchard et al., 2010; Hanson, Kashyap and Stein, 2010).

Yet, there is limited consensus on the effect of higher bank capital on lending (Thakor 2014; Admati et al., 2013; Baker and Wurgler, 2015). On the one hand, higher bank capital increases both the risk bearing capacity of banks and the incentives to screen and monitor borrowers, in this way boosting lending (Holmstrom and Tirole, 1997; Allen et al., 2011; Mehran and Thakor, 2011). On the other hand, as debt creates the right incentives for bankers to collect payments from borrowers, lower debt and higher capital may reduce banks' lending and liquidity creation (Diamond and Rajan, 2000). As such, the impact of higher bank capital on lending is an issue to be resolved empirically. Yet, the empirical evidence is mixed too (Peek and Rosengren, 1997; Kashyap and Stein, 2000; Gambacorta and Mistrulli 2004; Peydró, 2010; Berrospide and Edge, 2010; Aiyar et al., 2014). Recent work looking at the 2007-2008 financial crisis found only an indirect effect of bank capital on lending (Iyer et al., 2013).

In this paper we study the effect of bank capital on the banks' propensity to grant mortgages and on their pricing. We also explore how bank capital affects the selection of borrowers and the characteristics of offered mortgages, deriving implications for risk taking. Finally, to detect possible non-linearities, we provide nonparametric estimates.

[1]The analysis and conclusions expressed herein are those of the authors and should not be interpreted as those of the Bank of Italy. We are especially grateful to MutuiOnline for letting us use their data. Enrico Sette completed this project while visiting the Bank for International Settlements under the Central Bank Research Fellowship programme. We would particularly like to thank Effrosyni Adamopoulou, Roberto Anedda, Adonis Antoniades, Matteo Bugamelli, Lorenzo Burlon, Emilio Calvano, Giuseppe Cascarino, Alessio De Vincenzo, Nicola Gennaioli, Sara Formai, Scott Frame, Leonardo Gambacorta, Edward Glaeser, Giorgio Gobbi, Simone Lenzu, Silvia Magri, Francesco Manaresi, Fabio Natalucci, Francesco Palazzo, Wayne Passmore, Matteo Piazza, José Luis Peydró, Alfonso Rosolia, Carmelo Salleo, Hyun Shin, Martino Tasso, Larry Wall, Paul S. Willen, Jeffrey Wooldridge and all participants at the Bank of Italy, Federal Reserve System and ECB Policy Research Meeting on Financial Markets and Institutions, and at seminars at BIS and Bank of Italy for their useful comments.

We focus on mortgages, whose relevance for both macroeconomics and financial stability has been unquestionable following the 2007-2008 financial crisis. In the first half of the 2000s, a strong increase in mortgage originations fueled a housing boom in several countries (US, UK, Spain, Ireland). That boom in turn led to a high accumulation of risks, which subsequently materialized causing the failure of several banks and a large drop in house prices. Understanding how bank capital affects mortgage originations and the way banks select the risk profiles of borrowers is thus critical to evaluate developments in the mortgage market and the potential accumulation of both idiosyncratic and systemic risks.

Identifying the impact of bank capital on lending in general, and on the supply of mortgages in particular, is a difficult task. First, it requires disentangling supply from demand. Second, the matching between banks and borrowers is endogenous. For example, banks with lower capital ratios may lend to riskier borrowers (Jiménez et al., 2014). Third, borrower characteristics may drive the demand for certain mortgage types. For instance, borrowers with low income may sort into, say, longer or variable-rate mortgages. In turn, banks with different capital levels may have a different willingness to grant those kinds of loans. Finally, changes in the business cycle that affect lending supply also impact on the number and the characteristics of borrowers seeking for loans.

To overcome these identification challenges, we use a new and unique dataset of mortgage applications and contract offers obtained through a randomized experiment. In particular, we post randomized mortgage applications to the major online mortgage broker in Italy (MutuiOnline) in two dates (October 16, 2014, and January 12, 2015). Upon submitting any application, the online broker requires prospective borrowers to list both their demographic characteristics (income, age, job type) and the main features of the contract requested (amount, duration, rate type). By varying those characteristics, we create profiles of several "typical" borrowers that submit distinct applications for first home mortgages. Crucially, through the online broker all participating banks (which include the 10 largest banks in the country accounting for over 70% of the market for mortgage originations) receive the same mortgage applications, defined by the same borrower and loan characteristics. Hence, our estimates are not biased by the endogenous selection of borrowers into contracts or banks and, furthermore, there are not missing data due to discouraged potential borrowers not submitting applications. We then merge those data with the banks' characteristics from the supervisory reports and, in our empirical analysis, we

include several bank-level controls to reduce concerns about omitted variable bias; we exploit the time dimension of our data and we include bank fixed effects to control for unobserved determinants of bank capital in the cross-section; finally, in some specifications, we include bank*time fixed effects, to fully account for all bank specific, time-varying characteristics.

This database is suitable to study how bank capital affects both the probability that a bank makes a loan offer and the interest rate charged. We can also evaluate how banks with different capital ratios select borrowers and contract types, providing evidence on the type of risk (default risk, interest rate risk) banks are willing to take according to their capitalization.[2] Our results show that bank capital (measured both as a leverage ratio and as a ratio of risk-weighted assets) has a positive effect on the supply of mortgages: a one percentage point higher capital ratio raises the likelihood of acceptance by about 20 percentage points and lowers the offered interest rate by about 30 basis points. These findings support the view that bank capital boosts lending capacity and liquidity creation. We also show that banks with less capital accept applications from borrowers with higher and more stable income and prefer loans of smaller amount and longer duration with lower per-period installments and lower default risk. Conditional on making an offer, less capitalized banks are more likely to offer the lowest APR to borrowers with a permanent job and to longer loan contracts, again indicating that those banks target safer borrowers and, at the same time, aim at reducing their risk that borrowers may go into arrears.

A further novel contribution of our paper is the nonparametric estimation of the impact of bank capital on credit supply. The randomization of borrower and mortgage characteristics allows us to obtain an unbiased estimate of the shape of the mortgage supply schedule for different values of bank capital, thus identifying non-linearities and differential effects across borrower characteristics. We show that the effect of bank capital on the probability of acceptance varies non-linearly with households' characteristics. In particular, the likelihood of acceptance is increasing in capital when capital is relatively low. As capital increases, the likelihood of acceptance becomes substantially flat.

To the best of our knowledge, ours is the first paper to estimate the effect of bank capital on the supply of mortgages, controlling for the endogenous matching of banks, borrowers and loan

[2]Bank capital may affects macroeconomic fragility through its impact on the banks' willingness to take risk (Dewatripont and Tirole 1994, Hellman et al. 2000).

contracts. Other works use data on mortgage offers from online brokers. Michelangeli (2014) analyses the effect of borrower characteristics, in particular the stability of the job contract, on the supply of mortgages and consumer credit. Basten and Koch (2014) and Basten et al. (2015) use data on realized mortgage offers from a Swiss online broker. The former study the impact of the introduction of a countercyclical capital buffer on interest rates; the latter analyze the choice of the mortgage fixation period. Different from those works, we rely on a randomized experiment, which allows us to address endogeneity concerns, as opposed to actual accepted offers, and we study both the probability of loan acceptance and the offered interest rates.

Our findings on the effects of borrower and contract characteristics on banks' supply of mortgages complement several recent works studying the impact of these characteristics on default rates (Koijen et al., 2009; Mian and Sufi, 2010; Keys et al., 2012; Demyanyk et al. 2011, Loutskina and Strahan, 2011), on household consumption (Brunnermeier and Julliard, 2008; Mian and Sufi, 2011), and on house prices (Dell'Ariccia et al., 2012; Adelino et al., 2012; Favara and Imbs, 2015). Even if we do not aim at analyzing the general equilibrium effects of changes in credit supply, our results suggest that better capitalized banks can also play a role in driving real economic activity through the bank lending channel. From a methodological perspective our work is related to Bertrand and Mullainathan (2003) who study discrimination in the labor market through a randomized experiment. Our work uses a similar randomized experiment with a different focus. To the best of our knowledge ours is the first application of this identification approach to mortgage lending and to a developed country.

Our findings bear important policy implications. The non-linear effect of bank capital on lending supports the view that increasing capital ratios may help to smooth fluctuations in credit supply. Our results also indicate that banks with lower capital ratios take *less* risk in the residential mortgage market, by targeting safer borrowers. While we cannot rule out that less capitalized banks take more risk on other assets (business loans, securities), we can still draw implications on the transmission of financial shocks from the residential mortgage market to the real sector.

The remainder of the paper is organized as follows: section 2 discusses the institutional details of the mortgage market in Italy, section 3 describes the dataset, section 4 the empirical strategy, section 5 presents the main results, section 6 an analysis of the selection of borrowers,

section 7 results from nonparametric estimates, section 8 concludes.

2 Institutional setting: the mortgage market in Italy

The Italian mortgage market has experienced a fast growth between 1995 and 2007, driven by an increase in house prices, low real interest rates and deregulation and financial innovation (Rossi, 2008). Following the financial crisis, the growth of mortgage loans to households decelerated strongly, due to a drop in the demand for mortgages and a higher selectivity of financial intermediaries in lending.

Nearly all mortgages are originated by banks. Even though other financial companies could offer mortgage loans, they specialize in different segments of the credit market, such as consumer credit. The market is relatively concentrated: in 2014, the share of new mortgage originations coming from the five largest banks equals about 40% of the total (Felici et al., 2012).

In 2014 the total amount of new mortgage originations was about 23 billion euros and average loan-to-value (LTV) was about 60% (The Regional Banking Lending Survey 2014). Loans with a LTV above 80% are fairly uncommon (only 6% of new loans) because they are penalized by regulation, as banks need to hold extra capital if they offer those kind of loans. Average mortgage length was 20 years and about 20% of new loans had duration above 30 years. Data from supervisory reports indicate that about 75% of the total new originations in 2014 are adjustable rate mortgages, for which the reference rate is the 3 month Euribor. The relative share of adjustable and fixed rate mortgages depend strictly on the level of interest rates (Foa et al., 2015). Mortgages with "hybrid" rates, such as those with a cap, are seldom used. Refinancing of mortgages became more common since 2008 when a law slashed renegotiation fees. The same law ruled that fees to transfer mortgages across banks had to be significantly reduced, boosting the portability of mortgages. In 2014 about 7% of the existing loans have been refinanced, in augment with respect to previous years. Home equity extraction instruments and reverse mortgages are almost non-existent, also because regulation dictates which financial contracts can be offered by intermediaries in the mortgage market. The largest local mortgage market in Italy is the municipality of Milan, the second largest city in the country, and the major financial and business center. According to data from CRIF

Real Estate Services, in April 2015, about 25% of all new daily Italian mortgage originations occur in Lombardy, the region where Milan is located, and, among those, about 50% occur in the city of Milan. Thus, the market of Milan is well suited to study the aggregate dynamics in the Italian mortgage market.

3 The dataset

3.1 The online mortgage broker

We construct a new database of randomized mortgage applications and banks' offers obtained from the online broker MutuiOnline (*www.mutuionline.it*). This is the leading online mortgage broker in Italy, working with the largest commercial banks in the country. Overall, 62 banks, belonging to 20 banking groups offer mortgages through MutuiOnline, and those banks granted around 70 percent of total new mortgage loans in 2013.

For any loan application that specifies the borrower characteristics (age, net income and job type) and the contract characteristics (house value, mortgage amount, rate type and duration), the online broker either rejects the application or posts an offer which details the APR, the mortgage rate and installment. When MutuiOnline shows an offer, it means that the application has been pre-approved (this is our measure of acceptance of the mortgage application).[3] Next, the prospective borrower needs to provide further information on herself (the full name, the current address of residence, the tax identification number, etc.) and the address of the house it intends to buy. Finally, to finalize the contract, the prospective borrower will be contacted by the bank with the preferred offer.

Banks working with Mutuionline have incentives not to post teaser rates and, overall, the offers made through the online broker are realistic. First, making false offers through the online broker damages banks' reputation; second, the online broker has a commitment that the offers made through the website are true ones and it makes efforts to ensure that banks do not modify offered rates; third, as shown in the descriptive statistics section below, the average characteristics of mortgages offered through Mutuionline are similar to the official data from

[3]In the paper we use the term "the application has been accepted" when it has been pre-approved and the online broker posted an APR from that bank.

supervisor reports and Eurosystem banking statistics.

Mutuionline cannot partially accept a mortgage application by modifying the contract characteristics. This is not a limitation, since partial acceptance is very uncommon in Italy. Indeed, as confirmed by the Survey on Income and Wealth (SHIW) data on the Italian households, in 2012 about 57% of the mortgage applications for home purchase have been completely accepted, about 40% have been completely rejected and only about 3% have been partially accepted. This also occurs in other countries: Agarwal and Ben-David (2014) show that the major US commercial bank they study either fully accepts or rejects residential mortgage applications.

3.2 Data construction

To obtain a database of randomized mortgage applications we create profiles of "typical" borrowers that submit online mortgage applications for the purchase of the main residence. We consider different values for borrower age, income and job type. In particular, we set four values for the age (30, 40, 50, 60), nine values for the net monthly income (1,000; 1,500; 2,000; 2,500; 3,000; 3,500; 4,000; 4,500; 5,000 euros), while the job type falls into five categories (permanent contract, fixed time contract, self-employed, professional, retired). Next, we define the characteristics of the mortgage contract. The mortgage rate can be of two types (fixed and variable), we set four values for duration (10, 20, 30, 40 years) and eight values for the mortgage amount (60,000; 120,000; 180,000; 240,000; 300,000; 360,000; 420,000; 480,000 euros), which are equal to 60% of the house value. This is chosen in line with data from the Regional Bank Lending Survey, conducted by the Bank of Italy, according to which the median LTV was 59.3% in 2013. We limit attention only to a LTV of 60%, to avoid increasing too much the number of loan applications that have to be submitted at Mutuionline. For the same reason, we restrict our analysis to mortgage applications for Milan, which is the major mortgage market in Italy.[4] Overall, the total number of possible combinations of borrower and contract characteristics equals 8640.

We submit all these applications to the website of the online broker in two dates, in October 2014 (October 16) and in January 2015 (January 12). This is equivalent to applying for exactly the same mortgages, as defined by the same borrower and contract characteristics, to all the

[4]We do include only 3 possible values for duration (10, 20, 30 years) when the borrower's age is 40 or 50, while we include only 2 possible values for duration when the borrower's age is 60 (10 or 20 years).

banking groups working with the online broker. The final dataset contains borrower-contract-bank combinations, detailing which banks are willing to grant a loan, as well as the APRs, mortgage rate and loan installment that each bank applies to the loan.

To obtain estimates that are representative of the Italian population, we construct weights for each household type (a triple of age, net income, job type) using the 2012 SHIW data. In detail, as in our database we have four age categories, we allocate a SHIW household to the age-bin 30, 40, 50 and 60 if its household's head is aged respectively between 26 and 35, between 36 and 45, between 45 and 55 or between age 55 and 65. We adopt a similar procedure for disposable income and the job type. The distribution of household characteristics is then used to obtain the weights to assign to each "typical borrower" in our database.[5]

Next, we merge the database of loan applications and APR offers with the characteristics of the banks. The bank data are obtained from the supervisory reports (June 2014 bank data are matched with the observations obtained from Mutuionline in October 2014, December 2014 bank data with those for January 2015) and refer to the bank holding company each bank pertains to. We exclude branches of foreign banks for which we do not have complete balance sheet information and banks which do not have branches in the province of Milan. Overall, our sample comprises 14 bank holding companies, including the 10 largest banks in the country.[6] These banks hold about 70% of total assets of the whole Italian banking system.

3.3 Descriptive statistics

Table 1 describes the measures of the supply of mortgages. In our sample, about 43% of the loan applications are accepted. Importantly, among the loans accepted, the terms of the loans are in line with the empirical evidence based on official statistics from the Bank of Italy (Bank of Italy Statistical Bulletin 2014 and 2015). The mean APR (the interest rate gross of fees, commissions and other expenses) equals 3.22% in our database versus an average of 3.13% between October 2014 and January 2015 in the official statistics. The mean rate for variable rate mortgages equaled 2.21% in our database versus 2.57% in the official statistics; while the

[5]The weighting scheme we use does not invalidate our empirical strategy because the weights refer to the total population, and not to the population of households that obtained a mortgage. Nevertheless, we also perform all the analysis on the unweighted distribution, and results are qualitatively similar.

[6]Our sample includes: BNL, MPS, Unicredit, Credito Emiliano, Deutsche Bank, UBI, Intesa San Paolo, Banca Sella, Banco Popolare, Banca Popolare dell'Emilia Romagna, Banca Popolare di Milano, Carige, Cariparma, Mediobanca (CheBanca).

mean rate for fixed rate mortgages is 3.83 and 3.77% respectively in our database and in the official statistics. These figures confirm that our dataset is representative of the realized market data, and that the offers made through the online broker are realistic.

The descriptive statistics of borrowers and mortgages are reported in Table 2. The mean borrower is 45 years old, with monthly income of 2,488 euro and a 25 year mortgage loan of 270,000 euro. About 70% of households are employed with a permanent job, about 12% are employed with a fixed time job, about 6% are self-employed, about 5% are professional and the remaining 7% are retired. These figures reflect the way we constructed the randomized sample (see Section 3.2).

Descriptive statistics of bank variables are reported in Table 3. Our preferred measure of bank capital, in line with the literature (Iyer et al. 2013, Jiménez et al. 2014), is the capital ratio (a simple leverage ratio defined as tier 1 capital to total assets), but we also look at the regulatory capital ratio (tier 1 capital to risk-weighted assets). Besides capital, we also consider other bank-level characteristics that may affect lending: bank liquidity, measured by the liquidity ratio (cash, deposits to the central bank and government bonds); bank profitability, measured by the return on assets (profits to total assets); the evolution of credit quality, measured by the net loan charge−offs ratio (loan charge−offs to loans as in Santos, 2011); a measure of the weight of wholesale funding, the more volatile component of banks' funding, measured by the interbank ratio (interbank deposits to total assets). The average capital ratio is 6.4% with significant heterogeneity across banks. Similarly, the regulatory capital ratio is on average 11%, ranging between 6.3% and 13.6% (the regulatory minimum is 4%). The other bank-level controls are heterogeneous across banks, too. These data indicate that the banks in our sample are similar to other large European commercial banks (EBA, 2014). Finally, Panels B and C of Table 3 show the distribution of the two measures of bank capital in each period. While the mean is quite stable, there is some variation at the median, 10th, 75th, and 90th percentiles of the distribution. This is important because in the baseline we exploit the time variation in the measures of capital to control for bank unobservables.

4 The model

We estimate reduced form equations to identify the impact of bank capital on two key measures of the supply of mortgages: the first is the probability that a mortgage application is accepted; the second is the APR offered by the bank conditional on acceptance. Formally, we estimate the following model for the probability of acceptance:

$$\begin{aligned} Pr(acceptance)_{i,j,t} &= \beta_0 + \beta_1 Bank_{i,t} + \beta_2 Contract_{i,t} \\ &+ \beta_3 Borrower_{j,t} + time_t + \nu_i + \epsilon_{i,j,t} \end{aligned} \tag{1}$$

where $acceptance_{i,j,t}$ is a dummy variable equal to 1 if the loan application from borrower j to bank i in period t is accepted (the online broker shows an offer with an APR), zero otherwise. The vector of bank characteristics ($Bank$) in each period includes: the capital ratio, or as a robustness check the regulatory capital ratio, the return on assets, the liquidity ratio, the net loan charge-off over total loans, the interbank funding to total assets ratio, the log of bank's assets. Contract and borrower characteristics include: the log of the mortgage amount, the mortgage duration, a dummy for the rate type equal to 1 for fixed rate mortgages and equal to zero for adjustable rate ones, the log of the borrower income, the borrower age (in level and squared), a set of dummy variables capturing the borrower job type. We also include a time dummy ($time$) and, in some specifications, bank fixed effect (ν_i). Standard errors are clustered at the bank-time level. The model for the APR offered by bank i to borrower j in period t, conditional on acceptance, is analogous. In this case, the vector of parameter coefficients identifies the effect of bank, borrower and loan characteristics on the APR offered, conditional on the application being accepted. Yet, even though we observe an APR only for those applications that are accepted, we can fully control for all borrower and loan characteristics, addressing the concern of potential omitted variable bias.

Identification of the effect of bank capital ratio is achieved because our dataset is constructed so as to obtain an exogenous matching between borrowers, contract types and banks. This ensures that, contrary to the analysis based on actual transaction data, our results are not affected by the endogenous sorting of borrowers into banks or contracts. Indeed, all borrowers, irrespective of their characteristics, apply for different mortgage contracts to all banks working

with Mutuionline.[7]

A further identification assumption is required to evaluate the effect of bank capital on mortgage supply: bank capital has to be uncorrelated with bank unobservables. To reduce the chances that this assumption is violated we include several bank-level controls capturing the size of the bank, its funding structure, and credit quality. The latter is crucial given that banks may hold higher capital because their asset side is riskier. Moreover, we estimate all models including bank fixed effects, which control for all time-invariant bank-level unobservables. In this way, our estimates take into account the bank's business model, ability of the management, long-term strategies, etc., all of which may influence the lending policy of the bank and be correlated with capital ratios. Finally, to estimate the impact of bank capital on the selection of borrowers and risk taking, we run regressions including interactions between bank capital ratio and borrower and contract characteristics, which proxy for default risk and interest risk. Crucially, in these regressions we also include bank*time fixed effects, which allows us to obtain an estimate of how the effect of bank capital on the propensity to accept mortgage applications and the level of the APR changes across borrower and contract characteristics, while conditioning for all bank time varying observable and unobservable characteristics.

5 Results

Table 4 reports the estimates of model (1). Columns 1 and 2 show that banks with higher capital ratios are more likely to accept a mortgage application. The effect is economically significant: a one percentage point increase in the capital ratio raises the likelihood of acceptance by about 20 percentage points, ceteris paribus. This is a large effect as the average probability of acceptance is 43%. Importantly the result holds when other bank controls and bank fixed effects are included (Column 2): the coefficient of the capital ratio remains significant and with a positive sign. Moreover, the size of the estimated coefficients of capital is similar across specifications, suggesting that the correlation between the capital ratio and other bank observable and unobservable characteristics has a limited impact on that result.

In Columns 3 and 4 we include a measure of regulatory capital and results are qualitatively

[7] A similar issue arises in the empirical literature on optimal contracts (Ackerberg and Botticini 2002), and incentive provision, in which it has been dealt with using field experiments (Bandiera et al. 2007, among others).

unchanged: banks with a higher regulatory capital ratio are more likely to approve a mortgage application. In particular, a one percentage point increase in the regulatory capital ratio increases the likelihood of acceptance by about 10 percentage points, ceteris paribus. Again, this is a large effect compared to the average probability of acceptance. In Column 4 we also include the other banking variables and the bank fixed effects and the coefficient of the regulatory capital ratio remains positive and highly significant.

Among the other banking variables, the loan charge-off ratio has a positive and significant coefficient, while ROA has a negative and significant one. Banks with a higher loan charge-off ratio may be more willing to grant mortgages, as these are safer than business loans. More profitable banks may instead move their portfolio more towards riskier assets whose returns are higher than loans to households. Differently from other studies that found that liquidity and cost of funding are the main variables driving the banks' decision to accept an application, our paper points to bank capital as the leading variable affecting it. In our sample period, liquidity is abundant and conditions on wholesale markets are not tense, so neither the liquidity position, nor the relative importance of wholesale and retail funding appear as key drivers of credit supply.

The model also includes a set of borrower and contract characteristics, whose coefficients allows us to understand what type of risk banks are willing to take on. First, a loan application is about 46 percentage points less likely to be accepted if the borrower has a fixed term job. Relatively to other work status, this kind of job is associated with a higher uncertainty about the borrower future income flow, as the job may not be renewed or renewed under different conditions, thus limiting the ability to repay the debt. Second, the borrower income, which is strongly associated with the ability to service the debt, has a positive effect on the probability of acceptance: a 500 euros higher income increases the likelihood of acceptance by about 9 percentage points. Age has a non-linear effect: the probability of acceptance is the highest for borrowers aged 40 and 30, while it is the lowest for those aged 60, ceteris paribus. This means that once the correlation between age and income is controlled for, younger individuals are safer borrowers, likely because of the lower health risk and longer life-span associated with increasing income profile. Applications for larger and longer mortgages are less likely to be accepted. The effect is economically significant in the first case: the probability of acceptance of a 60,000 euro larger mortgage is about 16 percentage points lower. In the second case, the

effect is small: a ten-year longer mortgage is associated with a reduction in the probability of acceptance by about 2 percentage points. Larger mortgages are more expensive to be repaid, while longer mortgages take longer before the total repayment is completed: in both cases the risks for the banks are higher. Finally, the type of the interest rates (fixed versus adjustable) does not have a significant effect on the probability of acceptance: banks do not seem to be especially averse to take on interest rate risk.

Overall, these findings indicate that on average banks are less likely to grant a mortgage to borrowers more exposed to negative shocks to their income, which make them more likely to default. Banks try to reduce default risk also by selecting mortgages that are smaller and faster to repay.

In Table 5 we report OLS estimates of the APR offered by those banks that have accepted a mortgage application. The bank capital (either the simple leverage ratio or the regulatory capital ratio) has a negative and statistically significant coefficient if bank controls and bank fixed effects are included (Columns 2 and 4). The effect is economically significant: a one percentage point higher capital ratio leads to a 29 basis points lower offered APR. In the case of the regulatory capital ratio, the effect is halved in size.[8] Regarding the other bank controls, banks with higher liquidity and higher reliance on interbank funding charge lower rates. This reflects the abundant liquidity in the market and the cheap funding conditions on interbank markets. Banks with a higher loan charge-off ratio also offer lower APRs. This is in line with the result on the probability of acceptance and can be interpreted analogously.

Banks set lower rates if the borrower has a temporary job, although the effect is small, about 8 basis points in the specification that includes all controls and bank fixed effects. This may seem counter-intuitive, but it should be recalled that this result holds conditional on the mortgage being offered and on all other borrower and contract characteristics. Hence, banks may be willing to charge lower rates to these borrowers to reduce the risk they will not repay. This is consistent with a model of screening in which high-risk borrowers whose application is accepted also get an interest rate that does not fully reflect their riskiness (they would be subsidized by other types of borrowers). Interestingly, conditional on offering a mortgage, a lower income has no impact on the APR offered. Age has again a non-linear effect: APRs are

[8]The significance of the coefficients of the two measures of bank capital only when other controls and the bank fixed effects are included indicates that bank characteristics affect the selection of borrowers in the equation of interest rates. This is not surprising, since the probability of acceptance is affected by those variables.

the lowest for borrowers aged 60, followed by those aged 30. Again, this points to a strategy such that, once an offer is made, banks price the mortgage to reduce the risk of default. Banks offer lower rates on larger mortgages, although the effect is economically small: a 60,000 euro increase in the mortgage amount leads to a reduction in the APR by 8 basis points. Again, this can be explained by similar logic as before: a lower rate reduces the amount of the installment and thus the risk that the loan is not repaid.[9] Finally, banks set higher rates if the mortgage has a longer duration and has a fixed rate: a ten-year longer mortgage comes with a 10 basis point higher rate; fixed rate mortgages come with 166 basis points higher rates than adjustable rate mortgages. While the rate type has not a statistically significant effect on the acceptance decision, it affects the APR. Indeed, for fixed-rate mortgages the interest rate risk is borne by banks and they translate (at least part of) the cost of this risk to borrowers by charging a higher APR.

We subject the baseline results to several robustness checks. In the baseline regressions, we weighted observations according to the distribution of household demographic characteristics as reported in the 2012 SHIW. Accounting for population weights allows us to obtain estimates of borrower and contract characteristics which would be comparable to those obtained working on actual transaction data. In Tables A1 and A2 in the Appendix we report the estimates of unweighted regressions, in which all borrower and contract types have exactly the same weight. All the baseline results are confirmed, and parameter estimates in both the regression for the probability of acceptance and for the APR are numerically analogous to those of the baseline (weighted) regressions.

Some of the artificial profiles that we created may be unlikely to post an application for certain kind of loan contracts (e.g. a borrower with a net monthly income of 1,000 euros looking for a 400,000 euros mortgage of 30 years of duration). Hence, we set a limit to the debt to income ratio of the borrower:[10] the amount requested cannot be larger than 5 times the yearly net income of the borrower. Results shown in Table A3 are in line with the baseline estimates. We also try with a limit of 10 times the net income and results are unchanged.

[9]Moreover, the fixed fees and commissions have a lower incidence on larger loans and this contributes to reducing the APR which is charged.

[10]We do not impose a limit on the installment/income ratio because the installment depends on the APR offered by the bank.

6 Selection of borrowers

A key question raised by these results is whether banks with different capital ratios target different types of borrowers or contracts. The selection process can occur in two ways: through the acceptance/rejection of mortgage applications and through the pricing policy. Since mortgages can be considered as homogeneous goods, banks compete against each other by offering low rates to the class of borrowers they wish to target the most. The platform provided by the online broker slashes search costs for borrowers, who can effectively compare different offers and easily identify the one with the lowest rate.

As a first step to study the selection process, we compare the characteristics of the applications accepted by banks with capital ratios above or below the median (Table 6). Banks with capital ratios below the median select safer borrowers and contracts. In particular, they prefer borrowers with higher income, more secure jobs, and younger that are less exposed to health risk and with expected positive income growth. They also target mortgages smaller in amount and longer in duration, with lower per-period installments and lower default risk, and adjustable-rate ones, for which the bank does not bear interest rate risk. The latter result may also reflect the higher cost of buying coverage for interest rate risk faced by less capitalized banks.

These findings are confirmed when we add interactions between the capital ratio and borrower income, the dummy for fixed term job, the mortgage duration, and the dummy for fixed rate mortgage. We run these regressions including bank*time fixed effects. This demanding specification implies that our findings of the effect of bank capital on the selection of borrowers hold conditional on all bank*time unobservables. Estimates are shown in Table 7. The effect of higher bank capital is weaker if the borrower has higher income (Column 1), or the mortgage has longer duration (Column 3); while it is stronger if the borrower has a fixed term contract (Column 2, although this result becomes weaker when all interactions are controlled for all together, Column 5) or for fixed rate mortgages (Column 4). These results suggest that bank capital is an important driver of the banks' willingness to take risks. Indeed, banks with higher capital ratios are more willing to accept applications from borrowers who are ex-ante more likely to default and to take on interest rate risk. We also test the same regressions with distinct fixed effects for bank and time. Results, shown in the Appendix (Table A4), are

consistent and indicate that the inclusion of bank*time fixed effects does not affect much the coefficients of the interactions.

Next, we explore the pricing policy. First, we run regressions of the APR on the same controls and interaction terms as done for the probability of accepting a mortgage applications. Results are shown in Table 8: the coefficients of the interactions between capital and the dummy for fixed term job or the duration are significant and positive, indicating that banks with higher capital ratios offer higher interest rates to borrowers with higher income risk and to longer mortgages. This result suggests that more capitalized banks price more the higher default risk associated with these borrower and contract characteristics than less capitalized banks. Again, this is consistent with the fact that the latter, once they decide to make an offer, set lower interest rates to reduce the risk that borrowers default (see also Table A5 in the Appendix for a robustness to excluding bank*time fixed effects).

We then make a further step. As mortgages are homogeneous goods, the borrower will likely choose the bank that offers the cheapest rate. Hence, we evaluate whether higher bank capital raises the likelihood of offering the cheapest rate by borrower characteristics. To this aim, for each borrower-contract profile (i.e. for each combination of age, income, job type, mortgage amount, duration, rate type, as defined in section 3) we identify the lowest APR offered and create a dummy variable ("cheapest") equal to one if the offered rate is the lowest, zero otherwise. There are overall eight banks out of fourteen that offer the cheapest rate for at least one borrower-contract profile. Half of those have a capital ratio below the median (computed across all 14 banks), and half above it. We then regress the dummy "cheapest"on bank, borrower, contract characteristics, and the interaction between capital ratio and borrower income, the dummy for fixed term job, mortgage duration, and the dummy for fixed rate mortgage. Results in Table 9 show estimates from a linear probability model including bank fixed effects.[11] Banks with lower capital are less likely to offer the lowest interest rate to borrowers with fixed term jobs[12] and to borrowers asking for shorter duration mortgages, all else equal.[13] This suggests that banks with lower capital price mortgages more aggressively when these are safer, while they offer higher rates on riskier ones, when they decide to still

[11] A Probit model with bank fixed effects did not converge, see Table A6 in the Appendix for a probit model without bank fixed effects

[12] Banks with capital ratio below the median do not accept applications from borrowers with a fixed term contract in our sample

[13] As argued above, longer duration mortgages, controlling for their size, are less risky because they come with smaller installments which are more easily to be repaid.

make an offer. Their strategy would be to obtain a high enough margin if the borrower accepts the offer (despite not being the most competitive one), so as to compensate for the higher risk. The bank chooses not to make any offer if the interest rate required to compensate for the risk of borrower default is too high.

Finally, we run a regression of the dummy "cheapest"on bank-level controls and a dummy equal to one if the borrower has a temporary job or a net income below or equal to 1,500 euros per month ("risky borrower"). Results are shown in Table 10. The capital ratio does not affect the probability of offering the cheapest rate if the borrower is safe. By contrast, it is a key determinant of the probability that banks offer the cheapest rate when the borrower is risky. In particular, banks with a one standard deviation higher capital are about 30 percentage points more likely to offer the lowest APR to that borrower-mortgage profile. The negative sign of the dummy risky borrower indicates that it is less likely that more than one bank is "the cheapest" for that borrower-mortgage profile. This confirms that banks on average compete less aggressively on risky borrowers. Further confirmation of this result can be obtained by comparing the average capital ratio of the banks offering the cheapest rate to risky and safe borrowers. The former is 7.4%, the latter is 6.3%, almost one standard deviation lower.

Overall, our results show that banks with lower capital ratio are less willing to take risk in the mortgage market. Their acceptance and pricing strategy is oriented to select borrowers that have a lower risk of getting into arrears and, possibly, default. This finding is consistent with the view that capital is a determinant of the risk bearing capacity of banks.

7 Nonparametric estimation

A final important question that we tackle is whether the bank capital ratio has a non-linear effect on the mortgage supply. To this aim, for the different values of borrower and contract characteristics, we estimate a local polynomial regression (LPR), a nonparametric estimation technique, to evaluate how the probability of accepting a mortgage application and the APR offered change with the bank capital ratio. This approach is useful not only because it allows us to detect non-linearities in the effect of bank capital on the supply of mortgages, but also

since it provides a graphical estimate of these effects.[14] The Appendix shows the details of the estimation of the model.

The top-left panel of Figure 1 displays the estimated nonparametric relation between the probability of acceptance and the capital ratio by job type. We find a non-linear relationship between the two variables that confirms that banks with lower capital ratio are less likely to make an offer. We also detect large differences across job types. In particular, for loan applications submitted by households with fixed term contracts the estimated probability of acceptance is around 0 for values of the capital ratio below 6.5%, then it progressively increases until a value of 8%, when it becomes mildly decreasing. If the borrower has a job different than the fixed term contract, we can identify only one threshold that captures the change in the relationship between dependent and independent variables. For values of the capital ratio below 8.2%, the curve is about linear and upward sloping, implying a constant increase in the likelihood of acceptance for higher values of bank capital; for values above 8.2%, the curve is almost flat or mildly decreasing, thus a small positive change in the capital ratio has a negligible effect on the probability of acceptance.

The top-right panel of Figure 1 shows the estimated relation between the APR and the capital ratio by job type, conditional on approval of the loan application. Interestingly, the relation is linear for borrowers with a fixed term contract: higher values of bank capital are associated with a proportional reduction in the offered APR. In addition, banks with a capital ratio above 7.5% offer to fixed term job borrowers an APR that is lower compared to the one offered to other borrowers, confirming that once the banks have selected the "good-quality" households with a fixed term contract, most of the risk is already accounted for and does not need to be incorporated in the price. A non-linear relationship between APR and bank capital remains for permanent contract, self-employed or professional borrowers. The curve is concave and increasing up to a capital ratio of 7.5%, implying that higher capital is associated with higher APR, but the APR increase is less than proportionally. Values of the capital ratio higher than 7.5% are associated with decreasing APRs.

We also study the impact of the capital ratio on the probability of acceptance and on the APR for different values of income and age (middle and bottom panel of Figure 1).[15] Again,

[14] This is a "quasi-supply" schedule, as it relates bank capital ratio with the probability of acceptance and with the offered APR.

[15] Nonparametric estimates for different values of loan duration, loan amount and the rate-type are available

results confirm that the effect of the capital ratio is more pronounced when this is low and for riskier borrowers or contract types, in line with the findings of the parametric estimates.

8 Conclusion

In this paper we study the effect of bank capital on mortgage lending. We construct a new and unique database by submitting randomized mortgage applications to the major online mortgage broker in Italy. This database allows us to fully control for the endogenous matching between banks and borrowers and for the endogenous sorting of borrowers into contracts. On the one hand, we find that banks with higher capital ratios are more likely to accept mortgage applications and to offer lower APRs. On the other hand, banks with lower capital ratios are less willing to take risk in the mortgage market and their acceptance and pricing strategy is oriented to select safer borrowers and contracts. This result is consistent with the view that capital is a key determinant of the banks' risk bearing capacity. It does not confirm the hypothesis that less capitalized banks target riskier borrowers to gamble for resurrection.

We also provide a quantitative estimate of the effect of bank capital ratio on the supply of mortgages, using a nonparametric approach. We find that the capital ratio has a non-linear effect on the probability of acceptance, stronger at low values of the ratio, almost zero for higher values. This non-linearity is more pronounced when the borrower or the contract are riskier.

upon request

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Tables and figures

Table 1: Descriptive statistics: measures of mortgage supply

Notes: The table shows the descriptive statistics of the main measures of mortgage supply. The dummy acceptance is equal to 1 if the mortgage application has been accepted (pre-approved), zero otherwise. APR is the interest rate gross of all fees and commissions proposed by the bank. Mortgage rates - adjustable and fixed- are the interest rates on approved applications requiring variable and fixed rates, respectively. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used.

	Mean	St.Dev.	Median	Min	Max	Obs.
P(acceptance)	0.434	0.496	0	0	1	391680
APR	3.221	0.905	3.06	1.7	5.33	154329
Mortgage rate, adjustable	2.205	0.205	2.23	1.57	2.84	77537
Mortgage rate, fixed	3.829	0.449	3.95	2.67	4.91	76792
Installment (euros)	1651	1105	1448	180	4848	154329

Table 2: Descriptive statistics: borrower and contract characteristics

Notes: Panel A shows the descriptive statistics of borrowers and contracts. Panel B presents the borrowers' classification by job type. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used.

Panel A

	Mean	St.Dev.	Median	Min	Max	Obs.
Age (years)	44.977	10.132	50	30	60	391680
Income (euros)	2488	1132	2000	1000	5000	391680
Mortgage amount (euros)	270000	137477	270000	60000	480000	391680
Duration (years)	25	11.18	20	10	40	391680

Panel B

Job type	Freq.	Percent	Job type	Freq.	Percent
Permanent contract	272557	69.59	Self-employed	25383	6.48
Fixed term contract	45518	11.62	Professional	18646	4.76
Retired	29575	7.55			

Table 3: Descriptive statistics: Banks

Notes: The table shows the descriptive statistics of the bank variables. Data are from June 2014 and December 2014 supervisory reports.

Panel A: Whole sample							
	mean	median	p10	p25	p75	p90	σ
Capital ratio	6.42	6.25	5.07	5.51	7.16	8.53	1.37
Regulatory capital ratio	11.05	11.18	8.53	10.67	12.26	13.28	1.76
Roa	0.00	0.24	-0.58	-0.20	0.49	0.68	0.78
Liquidity ratio	12.68	13.75	5.24	9.34	17.46	18.04	5.20
Loan charge-offs	1.84	1.53	0.86	1.17	2.17	3.06	1.07
Interbank	8.01	4.76	2.41	3.08	11.17	17.47	7.09
Bank Size	11.28	11.17	10.07	10.78	11.72	13.17	1.04

Panel B: June 2014							
	mean	median	p10	p25	p75	p90	σ
Capital ratio	6.38	6.25	5.07	5.51	6.79	8.40	1.30
Regulatory capital ratio	11.03	11.16	8.02	10.67	12.73	13.47	1.97
Roa	0.25	0.31	-0.38	-0.11	0.59	0.79	0.40
Liquidity ratio	13.47	15.15	5.52	11.35	17.46	18.04	5.11
Loan charge-offs	1.91	1.84	1.15	1.31	2.38	3.06	0.74
Interbank	8.21	5.16	2.62	3.08	11.17	14.63	7.28
Bank Size	11.28	11.17	10.07	10.79	11.72	13.17	1.02

Panel C: December 2014							
	mean	median	p10	p25	p75	p90	σ
Capital ratio	6.47	6.24	4.76	5.50	7.36	8.53	1.44
Regulatory capital ratio	11.07	11.20	8.67	10.90	12.21	12.33	1.52
Roa	-0.25	0.15	-1.68	-0.58	0.48	0.54	0.98
Liquidity ratio	11.84	11.99	5.24	9.01	15.56	19.18	5.17
Loan charge-offs	1.76	1.28	0.75	1.00	1.82	3.82	1.34
Interbank	7.81	4.37	2.41	2.90	10.50	17.47	6.89
Bank Size	11.29	11.23	10.04	10.59	11.72	13.19	1.05

Table 4: Baseline: Probability of acceptance (marginal effects)

Notes: The table shows probit estimates for the probability that a mortgage application is accepted (pre-approved) on the bank capital ratio, other bank controls, borrower and contract characteristics. All variables are defined in Table A7 in the Appendix. All regressions include time fixed effects. Columns 2 and 4 include bank fixed effects. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
Capital ratio	0.1852***	0.2184***		
	(0.0320)	(0.0820)		
Regulatory capital ratio			0.0693*	0.1038**
			(0.0366)	(0.0473)
Roa		-0.0771***		-0.1092***
		(0.0282)		(0.0220)
Liquidity ratio		-0.0054		-0.0053
		(0.0085)		(0.0118)
Loan charge-offs		0.1012**		0.0900*
		(0.0461)		(0.0511)
Interbank		-0.0025		-0.0010
		(0.0059)		(0.0072)
Log bank assets	0.0088	0.5725	-0.0756	-0.1501
	(0.0443)	(0.7659)	(0.0566)	(0.9183)
Fixed term contract	-0.4743***	-0.4624***	-0.4487***	-0.4621***
	(0.0535)	(0.0197)	(0.0598)	(0.0198)
Self-employed	-0.0003	-0.0001	-0.0003	-0.0001
	(0.0017)	(0.0022)	(0.0015)	(0.0022)
Professional	0.0016	0.0030	0.0014	0.0030
	(0.0067)	(0.0081)	(0.0057)	(0.0081)
Retired	-0.0195	-0.0233	-0.0175	-0.0232
	(0.0188)	(0.0219)	(0.0165)	(0.0219)
Log income	0.0675***	0.0855***	0.0592***	0.0856***
	(0.0175)	(0.0226)	(0.0139)	(0.0226)
Age	0.0273***	0.0326***	0.0232***	0.0326***
	(0.0048)	(0.0056)	(0.0044)	(0.0056)
Age square	-0.0004***	-0.0004***	-0.0003***	-0.0004***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Duration	-0.0166***	-0.0194***	-0.0140***	-0.0194***
	(0.0031)	(0.0037)	(0.0030)	(0.0037)
Rate type	0.0060	0.0054	0.0051	0.0052
	(0.0167)	(0.0209)	(0.0145)	(0.0209)
Log amount	-0.1370***	-0.1655***	-0.1203***	-0.1656***
	(0.0340)	(0.0423)	(0.0271)	(0.0423)
Time FE	-0.1851**	-0.2310***	-0.1478	-0.2543***
	(0.0847)	(0.0349)	(0.1072)	(0.0296)
Bank FE	N	Y	N	Y
Observations	380160	380160	380160	380160

Table 5: Baseline: Interest rates on the mortgage (APR)

Notes: The table shows OLS estimates of the offered APR on the bank capital ratio, other bank controls, borrower and contract characteristics. All variables are defined in Table A7 in the Appendix. All regressions include a time fixed effect. Columns 2 and 4 include bank fixed effects. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
Capital ratio	0.0117	-0.291***		
	(0.0255)	(0.0864)		
Regulatory capital ratio			-0.00437	-0.125***
			(0.0330)	(0.0399)
Roa		0.0110		0.0370
		(0.0541)		(0.0660)
Liquidity ratio		-0.0164***		-0.0139
		(0.00486)		(0.00874)
Loan charge-offs		-0.174***		-0.162***
		(0.0279)		(0.0510)
Interbank		-0.0128***		-0.0146**
		(0.00436)		(0.00644)
Log bank assets	0.0426	-1.883***	0.0466	-1.187*
	(0.0408)	(0.535)	(0.0588)	(0.690)
Fixed term contract	-0.195***	-0.0848***	-0.176**	-0.0856***
	(0.0562)	(0.0164)	(0.0661)	(0.0168)
Self-employed	0.000399	0.000219	0.000360	0.000225
	(0.000668)	(0.000456)	(0.000659)	(0.000453)
Professional	-0.00216	-0.00146	-0.00234	-0.00141
	(0.00237)	(0.00125)	(0.00235)	(0.00124)
Retired	-0.0219	0.00447	-0.0218	0.00433
	(0.0184)	(0.00286)	(0.0175)	(0.00284)
Log income	-0.00236	-0.00113	-0.00411	-0.000935
	(0.00773)	(0.00184)	(0.00721)	(0.00182)
Age	0.0202***	0.0197***	0.0202***	0.0197***
	(0.00381)	(0.00363)	(0.00378)	(0.00362)
Age square	-0.000254***	-0.000255***	-0.000254***	-0.000254***
	(4.63e-05)	(4.31e-05)	(4.61e-05)	(4.31e-05)
Duration	0.0100***	0.0100***	0.0100***	0.0100***
	(0.00132)	(0.00125)	(0.00134)	(0.00125)
Rate type	1.660***	1.673***	1.662***	1.673***
	(0.0614)	(0.0601)	(0.0609)	(0.0601)
Log amount	-0.0983***	-0.0784***	-0.0942***	-0.0784***
	(0.0211)	(0.00722)	(0.0213)	(0.00723)
Time FE	-0.243**	-0.357***	-0.243**	-0.328***
	(0.0930)	(0.0195)	(0.0921)	(0.0290)
Bank FE	N	Y	N	Y
Observations	152369	152369	152369	152369

Table 6: Descriptive statistics of applications receiving an offer by bank capital ratios

Notes: The table shows the average of borrower and contract characteristics for those applications that receive an offer (pre-approved) distinguishing between banks with capital ratio above and below median. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. Median capital is computed as the median of the capital ratio in each period.

	Below median	Above median
Age (years)	43.63	43.96
Income (euros)	3,189	3,011
Fixed term contract	0.0	0.04
Amount (euros)	217,649	264,374
House value (euros)	362,748	440,624
Duration (years)	21.99	21.52
Rate type	0.47	0.51

Table 7: Probability of acceptance with interactions (marginal effects)

Notes: The table shows probit estimates for the probability that a mortgage application is accepted (pre-approved) on the bank capital ratio, other bank controls, borrower and contract characteristics. The model also includes interactions between capital ratio and borrower and contract characteristics. All variables are defined in Table A7 in the Appendix. All regressions include bank*time fixed effects. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. One bank is dropped in one period due to no variation in the dependent variable. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)
Capital ratio*Log income	-0.076**				-.0567**
	(.0299)				(.0273)
Capital ratio*Fixed term contract		0.244*			.1488
		(0.1299)			(0.1601)
Capital ratio*Duration			-0.0076**		-.0069**
			(0.0033)		(0.0032)
Capital ratio*Fixed rate				.0352**	.0354**
				(.01648)	(.0161)
Borrower Controls	Y	Y	Y	Y	Y
Contract Controls	Y	Y	Y	Y	Y
Bank*Time FE	Y	Y	Y	Y	Y
Observations	368640	368640	368640	368640	368640

Table 8: APR with interacted variables

Notes: The table shows OLS estimates of the offered APR on the bank capital ratio, other bank controls, borrower and contract characteristics. The model also includes interactions between capital ratio and borrower and contract characteristics. All variables are defined in Table A7 in the Appendix. All regressions include bank*time fixed effects. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)
Capital ratio*Log income	0.00146				0.00212
	(0.00190)				(0.00198)
Capital ratio*Fixed term contract		0.0617***			0.0624***
		(0.0200)			(0.0206)
Capital ratio*Duration			0.00151*		0.00148*
			(0.000790)		(0.000792)
Capital ratio*Fixed rate				0.0257	0.0251
				(0.0484)	(0.0483)
Borrower Controls	Y	Y	Y	Y	Y
Contract Controls	Y	Y	Y	Y	Y
Bank*Time FE	Y	Y	Y	Y	Y
Observations	152369	152369	152369	152369	152369

Table 9: Cheapest: linear probability model with bank fixed effects

Notes: The table shows estimates of a linear probability model for the probability that the offered APR to that borrower-contract type is the lowest among all those observed. Control variables are defined in Table A7 in the Appendix. The model also includes interaction terms between capital ratio, borrower and contract characteristics. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)
Capital ratio	0.110	0.151*	0.177**	0.166*	0.142
	(0.0951)	(0.0819)	(0.0755)	(0.0843)	(0.0905)
Capital ratio*Log income	0.00537				0.00590
	(0.00547)				(0.00551)
Capital ratio*Fixed term contract		0.428***			0.0928***
		(0.0310)			(0.00773)
Capital ratio*Duration			-0.00340**		-0.00348**
			(0.00144)		(0.00149)
Capital ratio*Fixed rate				-0.0271	-0.0255
				(0.0303)	(0.0300)
Bank Controls	Y	Y	Y	Y	Y
Borrower Controls	Y	Y	Y	Y	Y
Contract Controls	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y
Observations	152369	152369	152369	152369	152369
R^2	0.343	0.349	0.289	0.275	0.366

Table 10: Cheapest: risky borrowers

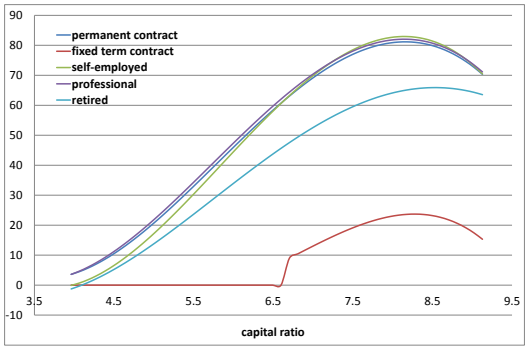
Notes: The table shows probit estimates for the probability that the offered APR is the lowest for that borrower-contract profile. The dummy D(Risky=1) equals 1 if borrower's net monthly income is below 1,500 Euros or the borrower is on a fixed term contract. Control variables are defined in Table A7 in the Appendix. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
Capital ratio	-0.243	-0.0266	-0.195	-0.220
	(0.172)	(0.384)	(0.162)	(0.156)
D(Risky=1)	-1.295**	-1.412***	-1.288**	-1.301***
	(0.606)	(0.245)	(0.513)	(0.492)
Capital ratio*D(Risky=1)	0.236***	0.256***	0.234***	0.238***
	(0.0854)	(0.0274)	(0.0694)	(0.0679)
Bank Controls	N	N	Y	Y
Borrower Controls	N	N	N	Y
Contract Controls	N	N	N	Y
Time FE	Y	Y	Y	Y
Bank FE	N	Y	N	N
Observations	152369	123174	152369	152369

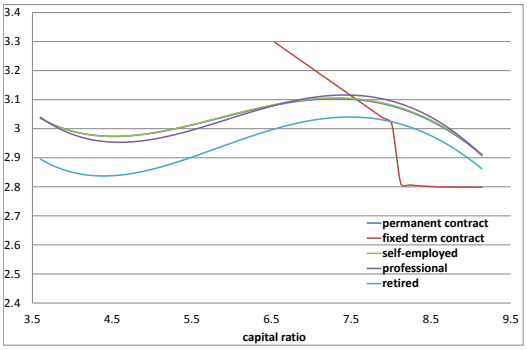
Figure 1: Nonparametric estimation

Notes: The figure shows the nonparametric estimates for the probability that a mortgage application is accepted (pre-approved) and for the offered APR by borrower's job type, income and age (percentages).

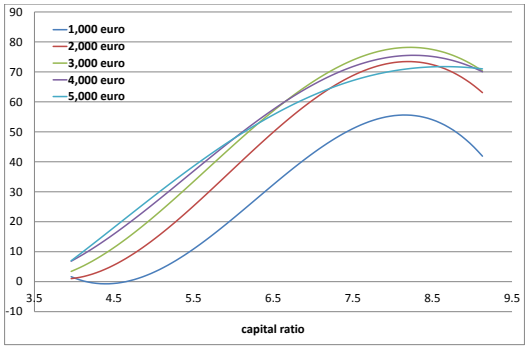
(a) Probability of acceptance by job type



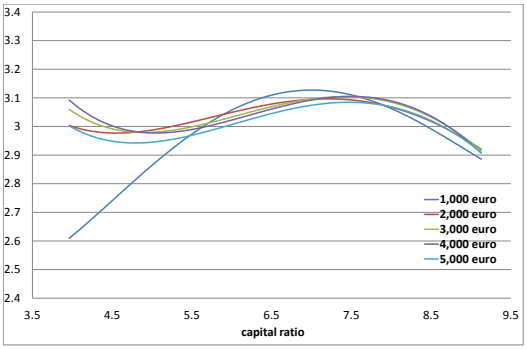
(b) APR by job type



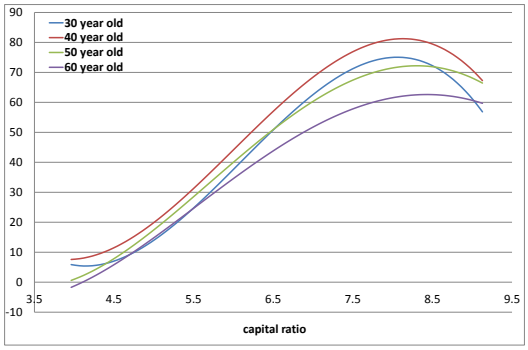
(c) Probability of acceptance by income



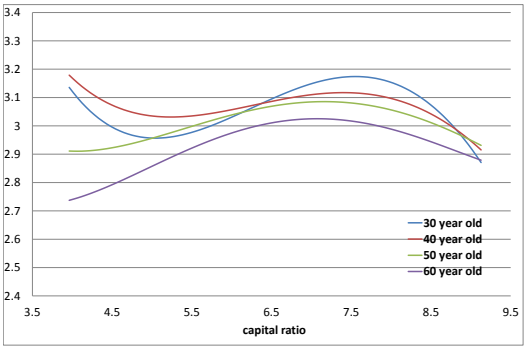
(d) APR by income



(e) Probability of acceptance by age



(f) APR by age



Appendix

Estimation of the local polynomial regression

Formally, we estimate the following functions:

$$Pr(acceptance) = \gamma_1 capitalratio + \epsilon \tag{2}$$

$$APR = \gamma_2 capitalratio + \epsilon \tag{3}$$

The LPR model differs from the Probit or OLS regression primarily because the equation is estimated at each point on an equally-spaced grid of the independent variable. The relation between the dependent (probability of acceptance, APR) and the independent variable (bank capital) is linear in the neighborhood, but may vary across values of the independent variable. The smoothing approach is thus based on local averaging by down-weighting those observations that are more distant from the grid points. Importantly, it also allows for non-linearities in the effect of the bank capital ratio,[16] while remaining linear for the other variables. Graphically, it fits a line to the observations, conditional on the function values estimated at each grid point. See the Appendix for the details of the estimation of the model. As our data are generated by a randomized experiment, the LPR estimates for the probability of acceptance are not affected by omitted variables bias. Those for the APR may instead be affected. To check the potential extent of this bias, we compare these results with the parametric estimates shown in Section 5. In our model, we include 50 knots (or target points) on the grid spanning the values taken by the independent variable. The function used to calculate the weighted local polynomial estimate is the alternative Epanechnikov kernel function, which is considered among the most efficient functions in minimizing the mean integrated squared error. The choice of the kernel function is not as crucial as the choice of the bandwidth. Indeed, the choice of the size of the bandwidth affects whether an observation will be employed in the estimation of the function value at the grid point. A smaller bandwidth implies that more weight is placed on nearby observations, while a larger bandwidth includes more observations yielding a smoother estimate. Thus, the choice of the bandwidth implies a trade-off between high variance, for lower values of the bandwidth, and high bias, for higher values of the bandwidth. We considered alternative values for the bandwidth, from a minimum of a one standard deviation of capital ratio to 10. Even though a larger size of the bandwidth makes the figure smoother, the qualitative results do not change for smaller sizes of the bandwidth. We use a third degree polynomial in the smoothing, as it provides a better fit than the zero-degree local polynomial.

[16] We only present results for a simple leverage ratio, i.e.capital to asset ratio.

Additional Tables

Table A1: Robustness analysis: Probability of acceptance - Unweighted (marginal effects)

Notes: The table shows probit estimates for the probability that a mortgage application is accepted (pre-approved) on bank capital ratio, other bank controls, borrower and contract characteristics. All variables are defined in Table A7 in the Appendix. All regressions include time fixed effects. Columns 2 and 4 include bank fixed effects. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). SHIW weights are not used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
Capital ratio	0.1647***	0.1691**		
	(0.0254)	(0.0745)		
Regulatory capital ratio			0.0636*	0.0793*
			(0.0337)	(0.0417)
Roa		-0.0518**		-0.0749***
		(0.0245)		(0.0196)
Liquidity ratio		-0.0107		-0.0110
		(0.0094)		(0.0118)
Loan Charge-Offs		0.0749*		0.0660
		(0.0430)		(0.0461)
Interbank		-0.0012		-0.0002
		(0.0053)		(0.0063)
Log bank assets	0.0129	-0.0953	-0.0654	-0.6600
	(0.0386)	(0.8143)	(0.0526)	(0.9110)
Fixed term contract	-0.4751***	-0.4644***	-0.4550***	-0.4642***
	(0.0491)	(0.0218)	(0.0549)	(0.0218)
Self-employed	0.0005***	0.0006***	0.0005***	0.0006***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Professional	-0.0092***	-0.0114***	-0.0076***	-0.0114***
	(0.0029)	(0.0032)	(0.0025)	(0.0032)
Retired	-0.0424**	-0.0484**	-0.0385**	-0.0484**
	(0.0203)	(0.0228)	(0.0186)	(0.0228)
Log income	0.0509***	0.0604***	0.0457***	0.0604***
	(0.0156)	(0.0195)	(0.0125)	(0.0195)
Age	0.0281***	0.0323***	0.0243***	0.0323***
	(0.0045)	(0.0048)	(0.0044)	(0.0048)
Age square	-0.0004***	-0.0004***	-0.0003***	-0.0004***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Duration	-0.0145***	-0.0161***	-0.0127***	-0.0161***
	(0.0028)	(0.0030)	(0.0028)	(0.0030)
Rate type	-0.0049	-0.0076	-0.0038	-0.0077
	(0.0154)	(0.0185)	(0.0139)	(0.0185)
Log amount	-0.1173***	-0.1336***	-0.1053***	-0.1337***
	(0.0284)	(0.0342)	(0.0225)	(0.0342)
Time FE	Y	Y	Y	Y
Bank FE	N	Y	N	Y
Observations	380160	380160	380160	380160

Table A2: Robustness analysis: APR - Unweighted (marginal effects)

Notes: The table shows OLS estimates of the offered APR on bank capital ratio, other bank controls, borrower and contract characteristics. All variables are defined in Table A7 in the Appendix. All regressions include a time fixed effect. Columns 2 and 4 include bank fixed effects. Data are from mortgage applications submitted to the online broker MutuiOnline in two dates (October 2014 and January 2015). SHIW Weights are not used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
Capital ratio	0.0134	-0.298***		
	(0.0239)	(0.0876)		
Regulatory capital ratio			-0.0116	-0.124***
			(0.0307)	(0.0399)
Roa		0.00887		0.0338
		(0.0555)		(0.0680)
Liquidity ratio		-0.0175***		-0.0148
		(0.00501)		(0.00873)
Loan charge-offs		-0.178***		-0.161***
		(0.0279)		(0.0522)
Interbank		-0.0131***		-0.0146**
		(0.00438)		(0.00651)
Log bank assets	0.0513	-1.761***	0.0637	-1.066
	(0.0372)	(0.569)	(0.0517)	(0.711)
Fixed term contract	-0.192***	-0.0786***	-0.161**	-0.0794***
	(0.0580)	(0.0155)	(0.0633)	(0.0160)
Self-employed	0.000319***	0.000321***	0.000317***	0.000322***
	(0.000103)	(9.73e-05)	(0.000103)	(9.75e-05)
Professional	0.00292***	0.00306***	0.00292***	0.00305***
	(0.000967)	(0.000949)	(0.000963)	(0.000950)
Retired	-0.0247	0.00363*	-0.0249	0.00349*
	(0.0212)	(0.00179)	(0.0206)	(0.00177)
Log income	-0.000805	-0.00132	-0.00296	-0.00117
	(0.00736)	(0.00158)	(0.00691)	(0.00155)
Age	0.0192***	0.0188***	0.0192***	0.0188***
	(0.00359)	(0.00338)	(0.00358)	(0.00338)
Age square	-0.000243***	-0.000245***	-0.000243***	-0.000244***
	(4.37e-05)	(4.04e-05)	(4.37e-05)	(4.04e-05)
Duration	0.00968***	0.00971***	0.00961***	0.00972***
	(0.00134)	(0.00126)	(0.00136)	(0.00126)
Rate type	1.651***	1.665***	1.654***	1.665***
	(0.0618)	(0.0602)	(0.0611)	(0.0602)
Log amount	-0.0939***	-0.0766***	-0.0890***	-0.0766***
	(0.0194)	(0.00683)	(0.0194)	(0.00684)
Time FE	Y	Y	Y	Y
Bank FE	N	Y	N	Y
Observations	152369	152369	152369	152369
R^2	0.897	0.940	0.897	0.940

Table A3: Robustness analysis: Regressions on the sample of individuals applying for mortgages whose amount does not exceed five times their annual net income.

Notes: The table shows estimates for the probability of that a mortgage application is accepted (pre-approved) and the offered APR using a restricted sample that excludes prospective borrowers that apply for a mortgage amount greater than five times their net income. All variables are defined in Table A7 in the Appendix. All regressions include a time fixed effect. Columns 2 and 4 include bank fixed effects. Data are from mortgage applications submitted to the online broker MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	P(acceptance)		APR	
	(1)	(2)	(3)	(4)
Capital ratio	0.112***	0.332***	0.00538	-0.325***
	(0.0336)	(0.109)	(0.0243)	(0.0886)
Roa		-0.0573		-0.0173
		(0.0548)		(0.0559)
Liquidity ratio		-0.0167		-0.0213***
		(0.0106)		(0.00587)
Loan charge-offs		0.133**		-0.193***
		(0.0656)		(0.0322)
Interbank		-0.00643		-0.0160***
		(0.0109)		(0.00464)
Log bank assets		-0.590		-1.439**
		(0.973)		(0.539)
Fixed term contract	-0.589***	-0.605***	-0.237***	-0.129***
	(0.0463)	(0.0248)	(0.0552)	(0.0253)
Self-employed	-0.00519	-0.00556	-0.000171	0.000768
	(0.00400)	(0.00453)	(0.00157)	(0.00142)
Professional	-0.0142**	-0.0160**	0.00185	0.00206
	(0.00602)	(0.00702)	(0.00220)	(0.00196)
Retired	-0.0418	-0.0477	-0.0218	0.00795
	(0.0289)	(0.0321)	(0.0247)	(0.00525)
Log income	0.0960***	0.108***	-0.0194*	-0.00399
	(0.0301)	(0.0330)	(0.0104)	(0.00393)
Age	0.0351***	0.0401***	0.0192***	0.0196***
	(0.00513)	(0.00623)	(0.00379)	(0.00387)
Age square	-0.000475***	-0.000539***	-0.000244***	-0.000251***
	(6.19e-05)	(7.50e-05)	(4.44e-05)	(4.39e-05)
Duration	-0.0185***	-0.0209***	0.00807***	0.00850***
	(0.00335)	(0.00403)	(0.00126)	(0.00119)
Rate type	-0.0195	-0.0221	1.626***	1.658***
	(0.0379)	(0.0431)	(0.0610)	(0.0560)
Log amount	-0.0711*	-0.0811*	-0.0937***	-0.105***
	(0.0411)	(0.0463)	(0.0180)	(0.0116)
Time FE	Y	Y	Y	Y
Bank FE	N	Y	N	Y
Observations	132000	132000	63304	63304

Table A4: Probability of acceptance with interactions and without bank*time fixed effects (marginal effects)

Notes: The table shows probit estimates for the probability that a mortgage application is accepted (pre-approved) on bank capital ratio, other bank controls, borrower and mortgage characteristics. The model also includes interactions between capital ratio and borrower and contract characteristics. All variables are defined in Table A7 in the Appendix. All regressions include time and bank fixed effects. Data are from mortgage applications submitted to the online broker MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
Capital ratio	0.788***	0.2318***	.36592***	0.2028***
	(0.2261)	(0.0779)	(.1088)	(0.0842)
Capital ratio*Income	-0.0724**			
	(0.0279)			
Capital ratio*Fixed term contract		0.2462		
		(0.1274)		
Capital ratio*Duration			-0.0072***	
			(.0030)	
Capital ratio*Fixed rate				0.0334**
				(0.0154)
Bank Controls	Y	Y	Y	Y
Borrower Controls	Y	Y	Y	Y
Contract Controls	Y	Y	Y	Y
Time FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
Observations	380160	380160	380160	380160

Table A5: APR with interacted variables without bank*time fixed effects

Notes: The table shows OLS estimates of the offered APR on bank capital ratio, and other bank, borrower and mortgage characteristics. The model also includes interactions between capital ratio and borrower and contract characteristics. All variables are defined in Table A7 in the Appendix. All regressions include bank and period fixed effects. Data are from mortgage applications submitted to MutuiOnline in two two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)
Capital ratio	-0.29821	-.2905	-.3019	-.3026
	(0.0857)	(.0864)	(.08258)	(.0909)
Captial ratio*Income	0.00099			
	(0.00186)			
Capital ratio*Fixed term contract		.0608		
		(.0200)		
Capital ratio*Duration			.00163**	
			(0.0008)	
Capital ratio*Fixed rate				.0259
				(.0484)
Bank Controls	Y	Y	Y	Y
Borrower Controls	Y	Y	Y	Y
Contract Controls	Y	Y	Y	Y
Time FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
Observations	152369	152369	152369	152369

Table A6: Cheapest

Notes: The table shows probit estimates for the probability that the offered APR to that borrower-contract type is the lowest among all those observed. Control variables are bank capital ratio, and other bank, borrower and mortgage characteristics, all defined in Table A7 in the Appendix. The model also include interaction terms between the capital ratio and borrower and contract characteristics. Regressions include a time fixed effect. Data are from mortgage applications submitted to MutuiOnline in two dates (October 2014 and January 2015). Weights based on the 2012 SHIW are used. Standard errors clustered at the bank*time level in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1)	(2)	(3)	(4)	(5)
Capital ratio	-0.00289	-0.201	0.258	-0.0622	0.590
	(0.404)	(0.131)	(0.175)	(0.151)	(0.479)
Capital ratio*Log income	-0.0250				-0.0199
	(0.0511)				(0.0573)
Capital ratio*Fixed term contract		1.627***			0.373***
		(0.343)			(0.0669)
Capital ratio*Duration			-0.0196***		-0.0265***
			(0.00484)		(0.00845)
Capital ratio*Fixed rate				-0.198	-0.228
				(0.124)	(0.154)
Bank Controls	Y	Y	Y	Y	Y
Borrower Controls	Y	Y	Y	Y	Y
Contract Controls	Y	Y	Y	Y	Y
Time FE	Y	Y	Y	Y	Y
Bank FE	N	N	N	N	N
Observations	152369	152369	152369	152369	152369

Table A7: Description of the variables used in the paper

Variable	Description
Acceptance	Dummy equal to 1 if the bank pre-approves the mortgage application, zero otherwise
APR	Annual percentage rate, inclusive of fees and commissions offered on pre-approved applications (%)
Cheapest	Dummy equal to 1 if the APR offered to the borrower-contract pair is the lowest, zero otherwise
Capital ratio	Tier 1 capital (Common equity tier 1 + Additional tier 1) to total assets (%)
Regulatory capital ratio	Tier 1 (Common equity tier 1 + Additional tier 1) capital to risk weighted assets (%)
Roa	Profits to total assets (%)
Liquidity ratio	Cash and government bonds to total assets (%)
Loan charge-offs ratio	Loan charge-offs to total loans (%)
Interbank	Interbank deposits and repos to total assets (%)
Log assets	Log of bank assets
Age	Prospective borrower's age (years)
Income	prospective borrower's net monthly income (euros)
Log amount	Log of the mortgage amount applied for
Duration	Length of the mortgage applied for (years)
Rate type	Dummy variable equal to 1 for a fixed rate mortgage, 0 for a variable rate mortgage
Fixed term contract	Dummy variable equal to 1 if the borrower has a fixed term job, 0 otherwise
Self-employed	Dummy variable equal to 1 if the borrower is self-employed, 0 otherwise
Professional	Dummy variable equal to 1 if the borrower has a professional job (lawyer, notary, etc.), 0 otherwise
Retired	Dummy variable equal to 1 if the borrower is retired, 0 otherwise

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