# BANCA D'ITALIA

## EUROSISTEMA

## Temi di Discussione

(Working Papers)

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*The views expressed in the articles are those of the authors and do not involve the responsibility of the Bank.*

# THE RISE OF RISK-BASED PRICING OF MORTGAGE INTEREST RATES IN ITALY

by Silvia Magri * and Raffaella Pico *

**Abstract**

The paper assesses the extent to which mortgage rates in Italy are priced according to credit risk as proxied by the probability of household mortgage delinquency estimated using the EU-Silc database. For reasons of data availability we restrict the analysis of mortgage pricing to Italian households. Consistent with the more extensive use of credit scoring techniques, our estimates indicate that Italian lenders have increasingly priced mortgage interest rates with reference to credit risk. For mortgages granted between 2000 and 2007, a 1 percentage point increase in the probability of default is associated with a 21 basis point rise in mortgage interest rates, less than the 38 basis point premium Edelberg (2006) estimated for the U.S. at the end of the '90s.

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# 1  Introduction[1]

This paper addresses how much household credit risk affects the price of a mortgage and whether this effect has increased over time. Mortgages are the most important component of household debt, accounting for roughly 70 per cent of total household loans in the euro-area countries (European Central Bank, 2009). Furthermore, the effect of household credit risk on the price of loans is likely to be stronger for mortgages than for consumer loans, because lenders have more detailed information about the borrower when granting a mortgage.

The literature on this topic has been concerned with the pricing of loans granted to firms more than households (Berger, Frame and Miller, 2005; Frame, Srinivasan and Woosley, 2001). The few papers analyzing the pricing of loans to households are focused on the United States, where the main result is that in the 1980s mortgage interest rates were not linked to the household characteristics that are proxy for their risk (Duca and Rosenthal, 1994). During the 1990s, following a drop in data storage costs and an improvement in credit scoring techniques, lenders started to estimate the specific default risk of each borrower (Bostic, 2002). Initially, they used credit scoring much more to select customers than to price loans (Frame et al., 2001). Subsequently, they also increasingly used this information to improve the pricing of their loans to households. Recent evidence for the United States is that easily collateralized household loans, such as mortgages, are those that have been most affected by these changes in pricing techniques: Edelberg (2006) finds that in the second part of the 1990s the spread between high- and low-risk mortgages was around 100 basis points, or roughly 38 basis points for a 1 percentage point increase in the probability of default.

In this paper we use EU Statistics on Income and Living Conditions (EU-Silc) data, gathered by Eurostat through national statistical institutes, to estimate a sort of credit scoring based on the probability of households being delinquent in repaying mortgages. The reason for this choice is that one of the most used indicators of indebted households' financial vulnerability is based on their difficulty in servicing debt, i.e., paying interests and paying back principal. A recent study by the European Commission (European Commission, 2008) proposes a common definition of household over-indebtedness based on households having difficulty in meeting their commitments, whether these are related to servicing secured or unsecured borrowing. Indicators based on delinquencies are actually widely tracked as they anticipate part of households' future insolvencies fairly well.

Bonaccorsi Di Patti and Felici (2008) consider mortgages granted by Italian lenders that were delinquent at the end of 2005: after two years, roughly 20 per cent had been declared bad loans. Banks should therefore closely monitor this information both when deciding whether to grant a loan to a household and when specifying the price and nonprice terms of the contract.

In order to estimate the probability of households being delinquent on their mortgages, we use the most recent waves of the EU-Silc survey (2005-2007). We estimate the probability of mortgage delinquency for Italian households and compare the results with those of selected European countries (Finland, France, Ireland, the Netherlands, Spain and the United Kingdom). Unfortunately, our main analysis concerning the pricing of mortgages is restricted to Italy, as information on mortgage contracts, and specifically the interest rate, is collected only in the supplementary EU-Silc questionnaire used by the Italian Institute of Statistics.

A specific contribution of this paper to the analysis of the probability of delinquency is that we focus on the percentage of households with mortgages who are late in making payments, while other studies tend to emphasize the frequency of delinquent households in relation to the total population (Duygan-Bump and Grant, 2009; Georgarakos, Lojschova and Ward-Warmedinger, 2009; European Commission, 2008). An interesting result of our analysis is that in Italy roughly 5 per cent of households with mortgages were delinquent in 2007, the highest value, together with Spain, among the seven European countries under analysis; similar results are found for the other waves, i.e., 2005 and 2006. However, since the percentage of households with a mortgage in Italy is the lowest among the countries analyzed (13 per cent), the ratio of delinquent households to the total population is 0.6 per cent, basically in line with the other countries. Earlier empirical studies have frequently referred to this ratio, but since the percentage of delinquent households among those with mortgages is rather high in Italy, we reckon that banks closely monitor this indicator in order to evaluate household credit risk.

As regards our results contributing to the scant analysis of the risk-based pricing of loans to households, we find that in Italy, as in the United States, there is a link between household credit risk, measured by the predicted probability of mortgage delinquency, and the loan interest rate. Using a linear estimation for mortgage interest rates, the spread between the lowest and the highest classes of credit risk is around 43 basis points for mortgages granted in the most recent period, between 2000 and 2007. The increase in the probability of delinquency between the lowest and the highest risk classes is around 10 percentage points. Given that 20 per cent of mortgage delinquencies are subsequently declared bad loans (Bonaccorsi Di Patti and Felici, 2008), this implies a 2

percentage point rise in the probability of default between low- and high-risk borrowers. Therefore, for mortgages granted between 2000 and 2007 this amounts to a roughly 21 basis point rise in mortgage interest rates for a 1 percentage point increase in the probability of default. This premium is lower than that estimated for the United States at the end of the 1990s (38 basis points). As in the United States, the link between credit scoring and mortgage pricing has increased overtime.

The rest of the paper is organized as follows. Section 2 explains the data and the variables used. Section 3 focuses on the probability of household mortgage delinquency, our measure of credit risk. Section 4 assesses the link between mortgage interest rates and household credit risk in Italy. Section 5 extends and verifies the robustness of the results, while Section 6 discusses them and concludes.

## 2 Data and definitions

Data on household mortgage delinquencies are not very widespread. The EU-Silc database has the great advantage of containing this information for many European countries. This survey provides data on household income distribution and social exclusion at the European level (Clemenceau and Museux, 2007). Data are harmonized and this facilitates cross-country comparison. In 2005 it covered the 25 EU member states plus Norway and Iceland; in 2007 it was extended to Bulgaria, Romania, Switzerland and Turkey. For our analysis on the probability of delinquency we select seven countries, from the EU-Silc database (2005-2007), for which we can satisfactorily identify households with a mortgage: Finland, France, Ireland, Italy, the Netherlands, Spain and the United Kingdom. Altogether around 80,000 households are considered (Table 1).[2]

Households with a mortgage can be identified in the database either by using the variable interest payment on mortgages (HY100G/N), which is not available for Spain, or the variable delinquencies on mortgages or on rent payments (HS010), when this variable is not missing and is crossed with home-ownership.[3] Actually, the percentages of households with a mortgage are very similar regardless of the variable chosen in all countries except France and the Netherlands where the two percentages are different. For France we use the percentage calculated with the second variable (delinquencies), which is more in line with statistics based on the Insee household survey; due to the same reason for the Netherlands we prefer to use the percentage calculated with the

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[2]The EU-Silc dataset for the years from 2005 to 2007 used in this paper is the 2007-1 release, available as of March 2009.

[3]As indicated in the variable description file, this question does not apply to outright owners or rent free occupiers. Therefore homeowners without a mortgage should not answer this question. By selecting homeowners who answer, we are able to identify households with a mortgage.

first variable (interests).

In the EU-Silc database mortgage delinquencies refer to the last 12 months at the date of the interview. This definition may therefore include households that have been delinquent for fewer than 90 days, the traditional threshold for determining delinquencies in bank supervisory reports. Accordingly, there may be a larger percentage of mortgage delinquency in each country than that found using information from lenders.

As mentioned in the Introduction, the mortgage contract variables needed to analyze loan pricing are unfortunately available only for Italy. In the supplement to the Survey on Income and Living Conditions, the Italian Institute of Statistics asks households about the interest rate on their mortgage, the year when the loan was granted and the amount of money borrowed when the contract was signed.

In this paper the head of the household, whose demographics such as age, education and working conditions are used in statistics and estimations, is the member of the household with the highest income. We follow Eurostat's recommendation to equivalize households' total disposable income using the OECD modified equivalence scale, which assigns a value of 1 to the first adult, 0.5 to any other household member aged 14 and over, and 0.3 to any household member younger than 14.

# 3 The estimation of household credit risk: mortgage delinquencies

## 3.1 Descriptive statistics

Figure 1 reports the frequency of mortgage delinquency for all households with a mortgage and for the total population. The data refer to the seven European countries previously mentioned and are calculated using the EU-Silc Survey for the year 2007.

The ratio of delinquent households to the total population (the dotted bars) is similar across the different countries, ranging from 0.5 to 1.7 per cent. These data are those reported and discussed in many other studies on this topic (Duygan-Bump and Grant, 2009; Georgarakos et al., 2009; European Commission, 2008). Nevertheless, they derive from very different situations. In Italy, for example, the ratio of 0.6 per cent derives from a high percentage of delinquent households among those having a mortgage (4.9 per cent) and a low percentage of households with a mortgage (13.1 per cent).[4] On the contrary, in the Netherlands a very similar ratio of 0.5 per cent derives from a

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[4]The frequency of delinquent mortgages for Italy is consistent with the figure reported in Bonaccorsi Di Patti and Felici (2008). Using data from the Central Credit Register, the authors find that, at the end of 2007, 3.5 per cent of the mortgage contracts signed between 2005 and 2006 were delinquent, i.e., payments were more than 90 days overdue. This figure is lower than that based on EU-Silc data because only payments more than 90 days overdue are

much lower percentage of delinquent households among those having a mortgage (1.1 per cent) and a much higher percentage of households with a mortgage (48.2 per cent). Overall, the two countries with the highest percentage of delinquent households among those with a mortgage (the dark bars) are Italy and Spain, where the figure is about 5 per cent. This ratio is lower in Finland, France, Ireland and the United Kingdom at 2-3 per cent and reaches its minimum in the Netherlands at 1.1 per cent (Figure 1). The differences between the ratios of these groups of countries are statistically significant; the results are similar for the years 2005 and 2006.

Table 1 reports the percentage of households with a mortgage that are delinquent according to some important household characteristics. This table helps to clarify which types of households are most likely to have difficulty in repaying their mortgages. Statistics for sub-groups need to be interpreted with caution, given that in some cells the number of observations is low and the confidence interval is large. In general, we only comment on the results whose differences are statistically significant. The percentage of households with a mortgage that are delinquent decreases with household disposable income: for the poorest households (in the lowest income quartile) this figure is very high in Ireland, Italy, and Spain, where more than 10 per cent of households with a mortgage are delinquent. Delinquencies are also more frequent among the unemployed, single parents and fixed-term employees. Finally, the percentage rises with the total housing cost ratio, i.e., the ratio of total housing costs to household disposable income.

## 3.2 The estimation of the probability of mortgage delinquency

The aim of this section is to estimate the probability of mortgage delinquency in order to obtain a predicted value for each household in the sample to be used as a measure of its credit risk in the interest rate estimation commented in the following section.

There is a growing empirical literature analyzing household mortgage delinquencies that was initially related to the United Kingdom (May and Tudela, 2005; May, Tudela and Young, 2004) and more recently extended to other European countries (Georgarakos et al., 2009; Duygan-Bump and Grant, 2009) and Canadian households (Dey, Djoudad and Terajima, 2008). We rely on this literature to identify the household characteristics to be used as explanatory variables to capture household credit risk. The models include the household head's age, gender, marital status, level of education, working status (self-employed, retired, unemployed or other non-working status), a dummy for the composition of the household (single, single with children, couple, couple with

considered and because only mortgages above 75,000 euro are included in the Central Credit Register.

children), a dummy if the head is an immigrant (citizenship outside the European Union) or is in bad health, the household's disposable equivalized income and the total housing cost ratio. By contrast with previous studies, in this paper we always analyze the probability of delinquency only for households with a mortgage.[5]

Estimations results for Italy are reported in Table 2. Findings for other selected European countries are also included in order to evaluate common dynamics. The most robust results across countries appear to be the negative impact of higher education and household income on mortgage delinquency. Furthermore, mortgage delinquency seems to be more likely when the household head is in bad health, unemployed or an immigrant. Finally, the total housing cost ratio is not significant in all countries: the marginal effect of a higher ratio on mortgage delinquency is by far the highest in Italy. The multivariate analysis thus appears to confirm the results of descriptive statistics. As for Italy, Table 2 also shows the coefficients of area dummies: households living in the Southern regions of Italy have a higher probability of mortgage delinquency (2 percentage points on an estimated probability of around 3.3 per cent).[6] [7]

By using the coefficients of the estimation reported in Table 2 for Italy, we obtain for each Italian household (roughly 62,000 observations) a probability of being mortgage delinquent.[8] The average probability of mortgage delinquency for all households is 6 per cent, while the median is 4 per cent; the 25 and 75 percentiles of this distribution are equal to 2 and 6.5 per cent respectively. The probability distribution calculated only for households with a mortgage (8,122 households) is not too different, excluding the tails of the distribution: the median is 3 per cent, while the mean is 4 per cent.[9] Figure 2 plots the kernel density of both distributions. These numbers are lower

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[5]We drop some outliers for household disposable income and the total housing cost ratio, i.e., all the observations for which the values of these variables are lower than the 1st percentile and higher than the 99th percentile.

[6]Area dummies are included in each estimation to control for the region where the household lives. This information is not available for Ireland, the Netherlands and the United Kingdom.

[7]As this regression is run only on households with a mortgage, there could be a sample selection problem and the results could be biased. We have therefore run for Italy a Heckman estimation, where we use a dummy for home ownership as the exclusion restriction. This variable should matter in the probability of having a mortgage, but should not be correlated with the probability of being mortgage delinquent. This unreported estimation shows that the bias is negligible, as the Mills ratio, i.e., the term that needs to be included in the estimation to adjust for the selection bias, is not significant. Furthermore, the marginal effects for the estimation of the probability of being mortgage delinquent are not too different from those reported in Table 2. Similar findings are obtained when we use the percentage of homeowners in the region of residence instead of the dummy for home ownership.

[8]We can obtain a probability of delinquency for each household in the sample, even those without a mortgage, as there are no variables in the estimation connected to the mortgage contract. This probability is essential for the Heckman estimation of interest rates, reported in the following section, where we consider the whole population.

[9]It is worth noting that for households that are not currently delinquent the median and the average probabilities of delinquency are 3 and 4 per cent, while for households currently delinquent the corresponding figures are twice as large, at 6 and 8 per cent respectively.

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than those reported in Edelberg (2003) for the United States, where at the end of the 1990s the median and the mean of the probability of being delinquent were respectively 6 and 9 per cent.

# 4 The link between mortgage interest rates and household credit risk in Italy

## 4.1 Theoretical framework

This section addresses the main question of the paper, i.e., how much the interest rate on a mortgage is correlated with the household credit risk, as measured by its predicted probability of mortgage delinquency calculated in the previous section.

In principle, loan terms, specifically interest rates, should reflect the risk of borrowers defaulting (Chatterjee, Corbae, Nakajima and Rios-Rull, 2007; Geanakoplos, 2002). If the probability of a borrower's default is higher the lender should try to reflect this in the loan's terms in order to cover the higher expected default loss. Therefore, due to the lower cost of processing information in recent years, credit scoring methods should have been increasingly used by lenders, not only to accept or reject an application, but also to price the loan. However, the adoption of credit scoring by banks started much later in Italy than in the United States. At the beginning of the 1990s, the use of this technology was still at an early stage, mainly because of a lack of comprehensive Credit Bureaus and the heavy use of "soft", i.e., qualitative, information, which make the adoption of automated credit scoring techniques more difficult (Bofondi and Lotti, 2006). However, the use of credit scoring has increased during the past decade: in the case of mortgages, in 2003 about a quarter of Italian banks used this methodology, while in 2006 more than half did (Rossi, 2008). However, it is true that still in the middle of the previous decade, in Italy credit scoring was considered more important for accepting or rejecting applications than for pricing loans, both for household mortgages (Rossi, 2008) and for loans to non-financial firms (Albareto, Benvenuti, Mocetti, Pagnini and Rossi, 2008).

One possible explanation for this attitude can be found in Stiglitz and Weiss (1981). According to their model, when the degree of asymmetric information between lenders and borrowers is high, so that there is no clear distinction between bad and good borrowers, if lenders increase interest rates too much, they end up attracting mainly the riskiest borrowers (adverse selection). In this case it is therefore rational for lenders to fix an upper-bound for the interest rate and reject the applications of borrowers who are perceived to be the riskiest. The result is an equilibrium credit rationing. However, this result should be less frequent for loans such as mortgages, where collateral

can be used to screen borrowers and alleviate the asymmetric information problem (Bester, 1985; Bester, 1987). This is especially true when the increasing use of credit scoring helps to reduce information asymmetries.

Some empirical analyses have recently addressed the issue of the link between the cost of credit and credit scoring. Edelberg (2006) studies the spread between the prices applied to high- and low-risk households in the United States in the second half of the 1990s. She finds that the risk component of prices has increased in the household loan market, but, as expected, only for collateralized credit such as mortgages and car loans. The results for unsecured loans are much less clear. Magri (2008), using the Survey of Household Income and Wealth (SHIW), also finds that interest rates on consumer loans seem to have a weak link with household credit risk in Italy. This appears to be a market with very few differentiated interest rates, mainly based on the area where households live and on the amount of the consumer loan. As in Edelberg (2006), the correlation is much stronger in the case of mortgages. However, Magri (2008) could not use a measure of the household probability of delinquency as the SHIW did not contain a question on this issue until the latest survey (2008). This paper therefore fills this gap by exploiting this information contained in the EU-Silc database.

## 4.2 Linear estimation results

In this section we report the results of the mortgage interest rate regressions. As a way of verifying the quality of the answers concerning interest rates given by households in the EU-Silc survey, we compare the average interest rates for the 2005-2007 waves of the survey with the interest rates on outstanding mortgages of a representative sample of Italian banks, collected in bank supervisory reports for the same years. For the year 2005 the average mortgage interest rate calculated in the EU-Silc database was 4.8 per cent, while the average interest rate on outstanding mortgages reported by Italian banks was 4.2 per cent. The corresponding figures for 2006 were 5 and 4.6 per cent, while for 2007 they were 5.2 and 5.4 per cent. It is important to keep in mind that the two sets of data are not perfectly comparable because households are likely to remember the interest rates including all fees, which are those reported in the contract, while the interest rates on the outstanding amounts of mortgage in bank supervisory reports are net of fees. This could explain the higher interest rates in the EU-Silc survey for 2005-2006. Overall, the difference between the interest rates from the two sources is not too large.

In Table 3 we report the results of OLS estimations of mortgage interest rates. The explanatory

variables are similar to those used in Edelberg (2003). First there is for each household the predicted probability of mortgage delinquency, calculated in the previous section. This variable should capture the household credit risk and therefore should embody all the information the lender needs to know in order to decide on the mortgage application. We also control for the amount of the mortgage when it was granted (expressed in real prices using the deflator of household consumption) and for the year when the mortgage was obtained through dummies. As we use three different EU-Silc waves (2005 to 2007), we also include year dummies in order to capture the shift in interest rates due to changes in monetary policy: as expected, these dummies signal that rates in 2006 and 2007 were higher than those in 2005.[10]

The second column of Table 3 shows the results for mortgages granted over the whole period under analysis: we limit our attention to the years 1985-2007 (8,069 observations), discarding the oldest mortgages granted before 1985 (less than 1 per cent of the total). The following columns contain results for the sub-periods 1985-1994, 1995-1999 and 2000-2007, respectively accounting for roughly 8, 24 and 68 per cent of the total mortgages granted in 1985-2007. In order to assess recent lenders' attitude to loan pricing, we focus primarily on the mortgages granted in the most recent period, which is therefore split further into two parts, 2000-2003 and 2004-2007. Given that the models include predicted regressors, standard errors are adjusted using the Murphy-Topel correction (Murphy and Topel, 1985).[11]

The main result deriving from this table is that the household credit risk, as measured by the predicted probability of delinquency, has a positive and significant impact on the mortgage interest rate. As for the other explanatory variables, larger mortgage loans are correlated with a lower interest rate, a result that was also found for consumer loans (Magri, 2008) and for mortgages in the United States (Edelberg, 2003).

To provide an indication of the economic impact of household credit risk on loan interest rates, the bottom panel of the table reports the average predicted mortgage interest rates for four classes of household credit risk.[12] These four classes are based on the quartiles of the distribution of predicted probabilities of mortgage delinquency for all Italian households. For mortgages granted

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[10]The dummy for the year when the mortgage was granted controls for changes in interest rates for fixed-rate mortgages. The dummies for the years 2006 and 2007, the years of the EU-Silc surveys, control for changes in interest rates for adjustable-rate mortgages. To save space, the coefficients of the dummies for the year in which mortgages were granted are not reported in the table.

[11]As the model for the prediction of mortgage delinquency and the model for interest rates are estimated from the same data, standard errors are adjusted by assuming contemporaneous covariance in the random components of these models.

[12]Interest rates are predicted for each household and then the averages are calculated for the different classes of risk.

in all the periods under analysis (1985-2007), the increase in the predicted interest rates from the lowest to the highest risk class is 31 basis points. This gap widens across the sub-periods analyzed: it was 31 basis points for mortgages granted between 1985 and 1994, 43 basis points for those granted in 2000-2007 and reaches 50 basis points for those granted in 2004-2007; similarly, the ratio between the interest rates in the highest and the lowest classes of risk rises over time.[13] Most of the increase in interest rates is concentrated in the last class of risk, i.e., from the third to the fourth quartile.

Therefore, this table clearly indicates that credit scoring matters for the pricing of mortgages in Italy and that its impact has increased over time. We have to keep in mind that for mortgages granted in the past, we are matching the interest rate of the contract with a credit scoring which is predicted on the basis of the *current* household characteristics, as reported in the 2005-2007 EU-Silc database. It is true that some of the most important determinants of the probability of mortgage delinquency in Italy are household characteristics that are likely to be time invariant, such as education, the status of immigrant and the area of residence, but this is not the case for all the variables (Table 2). Nevertheless, an increase in the difference between the lowest and the highest class of interest rates is observable even in the most recent period, from 2000-2003 to 2004-2007, when this problem is certainly less serious. Summing up, it is possible to infer a gradual increase in Italian lenders' use of risk-based pricing strategies for mortgages.

Focusing on mortgages granted between 2000 and 2007, the increase in interest rates between the lowest and the highest class is, as mentioned earlier, 43 basis points. For this sub-period, Figure 3 shows the predicted interest rates over the entire distribution of household credit risk, with all the other variables set at their mean values in the sample. In the upper panel of Figure 3, which only considers the relevant range of the probabilities of delinquencies, i.e., excluding all the values above the 95th percentile, the variation of the predicted interest rates is similar to that in column 5 of Table 3, i.e., roughly between 4.6 per cent and more than 5 per cent. Moreover, the bottom panel shows the increasing impact of credit risk on mortgage interest rates over time.

From the lowest to the highest risk class the probability of delinquencies increases by 10 percentage points. Furthermore, as mentioned in the Introduction, it has been calculated that roughly one fifth of the Italian households that are delinquent after two years are in default. Overall, from the lowest to the highest risk class there is an increase of roughly 2 percentage points in the probability

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[13]In most of the estimations the differences between the increase in interest rates in the most recent sub-period (2004-2007) and that in the earlier sub-periods (1985-1994, 1995-1999, and 2000-2003) are statistically significant. In Table 3 and in the following tables, when the difference is statistically significant, the increase in the interest rates is in bold.

of default. We can therefore conclude that for a 1 percentage point increase in the probability of default, the interest rate rises by about 21 basis points for mortgages granted in 2000-2007 (43 points/2 p.p.) and by about 25 basis points for those granted in 2004-2007 (50 points/2 p.p.). This risk premium is still lower than that found in Edelberg (2006) for the United States: in the second half of the 1990s, with an increase in bankruptcy risk of 1 percentage point, the rise in the interest rate on first mortgages was 38 basis points.[14]

## 4.3 Heckman estimation

In the previous linear estimation of mortgage interest rates we ignore the fact that we are working with a sample made up only of households with mortgages, which could be non-random. The results could therefore be biased. In this section we tackle this issue and run a Heckman estimation to solve the problem of sample selection.

In the selection equation of the Heckman estimation we need to include some variables that are not considered in the interest rate regression (exclusion restrictions). Therefore, we include in the selection equation many household characteristics that could reflect mainly *demand* factors for being a household with a mortgage (e.g. age, education and working status), while for *supply* factors we introduce the household prediction of mortgage delinquency, which should be the essential statistic for the lender. The other household characteristics are not included in the interest rate estimation because when we try to do that (see Table 6 in the robustness exercises) the result is that most of them have no residual explanatory power. Hence, it seems that the measure of credit risk, i.e., the prediction of mortgage delinquency, mainly captures the effect of the most important household characteristics in the lender's interest rate decision; no more household characteristics need to be included. This is essentially our identification strategy. [15]

From Section 3 we can predict mortgage delinquency for *all* households given that in the equation reported in Table 2 there are no variables connected with the mortgage contract. This allows us to run a Heckman estimation on all the Italian households in the survey. Results with Heckman models are reported in Table 4 for mortgages granted in the whole period 1985-2007 and in the most recent sub-period 2000-2007. The evidence is very similar to that in Table 3: the difference

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[14]In Edelberg (2003) the highest- and lowest-risk groups are the 20 per cent most and least likely to declare bankruptcy respectively.

[15]We also tried another Heckman estimation in which we keep all the household characteristics in the interest rate estimation and where the exclusion restriction is a variable that measures on a regional basis the share of homeowners. This share should be relevant in influencing the probability that a household takes a mortgage, but it should have no impact on the interest rates. The results are similar to those presented in Table 4.

between the predicted interest rates in the highest and lowest risk classes is 32 basis points over the whole period and 43 basis points for mortgages granted in 2000-2007. For the most recent sub-period we are even able to reject the hypothesis that the error terms in the two equations are correlated (LR test at the bottom of the table). Therefore the results of the OLS estimation reported in Table 3 are unlikely to be biased, at least for the latest period.

Furthermore, this table shows that the probability of mortgage delinquency had a negative and significant impact in the selection equation on being a household with a mortgage for the whole period 1985-2007. This means that a higher-risk household had less chance of being granted a mortgage. This negative effect is no longer significant in the selection equation for the most recent period 2000-2007. However it is worth to underline that, although the probability of mortgage delinquency, i.e., our proxy of credit scoring, is no longer significant, there are other household characteristics reflecting household credit risk that still have explanatory power in the selection equation for having a mortgage. Even more importantly, given that in the selection equation household income was highly correlated (-0.41) with our proxy of credit scoring, we run an unreported Heckman model excluding income. The results show that in this case the probability of mortgage delinquency retains a negative effect in the selection equation even in the period 2000-2007; however, the economic effect on the probability of having a mortgage is smaller than the one calculated over the entire period (1985-2007). Finally, caveats need to be kept in mind as we are not considering a rationing equation, where you can see which borrowers are accepted or rejected by lenders in the selection process. This is just an equation that identifies households with and without mortgages.

Nevertheless, taken together these results are consistent with a framework where lenders, compared to the past, seem to rely a bit less on credit scoring for selecting borrowers. This enlarges the group of households that are offered credit. However, credit scoring is more used by lenders for deciding interest rates and this enables more information-based pricing of mortgages that more accurately reflects household credit risk.

# 5   Extensions and robustness

This section is aimed at extending and assessing the results reported in the previous section when we either modify the terms of the estimations or use different samples or specifications.

## 5.1   Interest rate estimation with risk aversion among lenders

In Table 3 we report the results of a linear estimation of mortgage interest rates, i.e., we consider the link between mortgage interest rates and household credit risk to be equal in the different classes or quartiles of risk, by imposing a linear restriction on the coefficient of the predicted probability of delinquency. We proceed in a similar way for the interest rate equation in the Heckman estimation reported in Table 4. These estimations are based on the assumption that lenders are risk neutral or are diversified enough to behave as if they were risk neutral.

In order to allow for risk aversion among banks, in this subsection we permit the increase in the interest rate for a similar rise in borrower risk to vary across different classes of risk. In the estimations reported in Table 5 the previous restriction is therefore released by estimating the same interest rate regression separately across the four classes of household credit risk as previously defined. For the sake of clarity, Table 5 only reports the prediction of mortgage interest rates for the four different classes or quartiles of risk and the increase in the rate from the lowest to the highest classes of risk. This is done for the same periods as considered in Table 3. Even though the coefficients of the explanatory variables are not reported in the table, when we run the regressions split by quartiles of risk the effect is that the intercept of the estimation line increases as we move towards higher risk classes, while the slope clearly becomes steeper only in the highest quartile of risk. Plotting the graph of the predicted interest rates in the four classes of risk for the period 2000-2007 gives a clear representation of this trend (Figure 4).

The results in Table 5 show that for the whole period 1985-2007 the total increase in predicted mortgage interest rates from the lowest to the highest risk class is 42 basis points, compared with 31 basis points in Table 3. As before, this table clearly shows that the differences between the mortgage interest rates of the lowest and highest risk classes have increased over time: for mortgages granted in 2000-2007 and 2004-2007 they are respectively 55 and 64 basis points.[16]

Overall, the main message is similar to that of the previous section. Italian lenders take household credit risk into account in pricing mortgages and this risk-based pricing has become more widespread in recent years.

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[16]The number of households in the four quartiles of risk reported in the lower panel of Table 5 is not similar as these quartiles are calculated on the basis of the distribution of predicted mortgage delinquency for all Italian households, while in the table the results are reported only for households with a mortgage.

## 5.2 Interest rate estimation with more explanatory variables

In this section we discuss the results of an interest rate estimation, reported in Table 6, with almost all the other household characteristics included. We run these regressions in order to verify whether any of these household characteristics have a residual explanatory power for the mortgage interest rate, after controlling for the household credit risk through the prediction of mortgage delinquency, which should be the essential statistic for the lender. Furthermore, we want to verify whether there are any differences in the predicted interest rates across risk classes, compared to the previous tables.

The evidence is that very few household characteristics are still significant. Besides, household income and immigrant status are significant, but with the opposite sign to the one expected. This is likely an indication of over-controlling in the estimation as these household characteristics are probably already fully captured by the prediction of household mortgage delinquency. On the contrary, the dummies for the area where the household lives, which measure a sort of background credit risk that lenders often take into great account in order to decide mortgage interest rates, are significant, with higher interest rates in the Central and Southern regions. From the bottom panel, we also verify that there are no major differences in the predicted interest rates across the four quartiles of household credit risk. The increases in mortgage interest rates from the lowest to the highest risk classes are a bit smaller than those reported in Table 3. However, the pattern of increasing risk-based pricing is still clear: for mortgages granted in the latest period 2004-2007 the increase in interest rates from the lowest to the highest risk class is 41 basis points, compared with 21 basis points for mortgages granted in 1985-1994.[17]

## 5.3 Robustness exercises

In this sub-section we run some regressions primarily to assess the robustness of our earlier findings.

In previous models we calculated the predictions of mortgage delinquency for *all* households, regardless of whether they had a mortgage or not. We proceed in this way essentially because we need a prediction of delinquency for all households in order to estimate the selection equation in the Heckman model, reported in Table 4. In the first robustness exercise, the results of which are reported in Table 7, we rerun the same estimation using only predictions of delinquency for households with mortgages. This has an impact only on the definition of risk classes, based on the

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[17]We also run an interest rate regression that includes the same variables as in the baseline estimation and the area dummies, which appear to have a residual explanatory power: the results are very similar to those in Table 3.

quartiles of the distribution of predicted delinquencies. As mentioned earlier, the two distributions are similar, at least excluding the tails (Figure 2). The results show that the increase in interest rates from the lowest to the highest risk classes is a bit smaller than in Table 3, though overall the evidence is broadly unaffected.

Moreover, the results reported in Table 3 are obtained using the whole distribution of mortgage interest rates as reported in the EU-Silc survey. In the second exercise, contained in Table 7, we replicate the same estimations after dropping the outliers of the interest rate distribution, i.e., the rates lower than the 1st percentile and higher than the 99th percentile. Compared to Table 3, the findings are virtually unchanged.

We also substitute predicted delinquencies with actual delinquencies in the estimation. Edelberg (2006) argues that if lenders have rational expectations, they are able to predict delinquencies correctly on average. We focus on mortgages granted in the latest period, 2000-2007, because they are of greater interest. Furthermore, the first period of mortgages, when instalments are higher, is the one most likely to be characterized by delinquencies: 67 per cent of actual delinquencies in the survey refer to mortgages granted in 2000-2007. The predicted interest rates for delinquent households (230 observations) are 56 basis points higher than those for households who are not delinquent (5233 observations) and the difference is statistically significant. All in all, using both predicted and actual delinquencies there is evidence of risk-based pricing for mortgages granted in the latest period.

In the third exercise of Table 7 we also use the biannual SHIW dataset from 2004 to 2008 waves. Unlike the EU-Silc database, this includes household wealth, which could be an important variable to control for in the estimation of mortgage delinquencies. The SHIW also contains an indication of loan-to-value, which is another important element of the mortgage contract that should be considered in the interest rate estimation. Unfortunately, the number of observations decreases markedly because the sample of households in the SHIW is roughly equal to 8,000, while in the EU-Silc more than 20,000 Italian households are interviewed; furthermore, for 2004 and 2006 interest rates in the SHIW are available only for mortgages for primary residence. We estimate the probability of delinquency on the basis of the SHIW 2008, where the question on delinquencies is available for the first time. The results show that there is a significant increase of 26 basis points in interest rates from the lowest to the highest risk class only for mortgages granted between 2004-2007 (around 400 observations). For the earlier periods it seems that risk-based pricing was not used for mortgages. Furthermore, the results for the period 2004-2007 are unaffected, both when household

wealth is included in the estimation of delinquencies and when loan-to-value is considered in the interest rate estimation; we also include household wealth in the interest rate regression and obtain the same results.

In the estimation discussed in the previous section, the quartiles or classes of risk are obtained starting from a unique distribution of the predicted probability of delinquency, calculated for the three EU-Silc waves (2005-2007). We also redefine the four classes of risk in a more detailed way, using three different distributions of predicted delinquency, one for each wave of the EU-Silc used in our calculation. The evidence is still for an increase in the differences between the average predicted interest rate from the lowest to the highest class of risk. The difference was equal to 39 basis points for mortgages granted between 1985-1994, 44 basis points for those granted between 2000-2007 and 51 basis point for those granted in 2004-2007.

We also refine the classes of risk essentially to see better where the increase in interest rates is concentrated. We consider ten classes of risk, based on the deciles, rather than quartiles, of the mortgage delinquency probability distribution. From this estimation, it is clear that most of the rise in the interest rate occurs among the riskiest borrowers. For mortgages granted in the latest period, 2004-2007, the total increase in the rate from the lowest to the highest risk decile is 70 basis points, with 57 basis points concentrated in the three highest classes of risk, i.e., in the last 30 per cent of the distribution. For mortgages granted in 2000-2007 the corresponding figures are 62 and 48 basis points.

As a further test of robustness, in the interest rate estimation we introduce the classes of risk rather than the specific probability of mortgage delinquency for each household. It is highly likely that banks operate in this way, by reclassifying households in groups of borrowers with different credit risk. In our exercise, households are classified in four classes of risk, based on the quartiles of the mortgage delinquency probability distribution. This exercise should also reduce the endogeneity problem connected with the use in the estimation of a *specific* household prediction of mortgage delinquency given that in this case we work with predictions referring to *groups* of households. The results are very similar to those shown in Table 3. If any thing, the increase in interest rates from the lowest to the highest risk class is even larger: for mortgages granted in 2000-2007 it is 53 basis points, compared to 43 basis points in the baseline specification.

To tackle the problem of endogeneity of the prediction of mortgage delinquency, we also run the estimation for the delinquency probability only for the 2005 data of the EU-Silc survey. Then we use the coefficients from this regression to obtain a prediction of mortgage delinquency just

for households that obtained a mortgage in the period 2006-2007. The evidence confirms that the increase in interest rates from the lowest to the highest risk class is more than 30 basis points and concentrated in the highest risk group of borrowers.

We finally check the significance of our results when we adjust the standard errors of the estimated coefficient in the interest rates estimation, which contains predicted values, by using bootstrapped standard errors rather then relying on Murphy-Topel correction. The evidence is unaffected.

# 6    Discussion and conclusions

In this paper we have explored whether and to what extent household credit risk, measured by the predicted probability of delinquency, affects the price of a mortgage. This could be a surprising question because an affirmative answer is generally expected. However, as Stiglitz and Weiss (1981) noted, when lenders do not know their borrowers very well, i.e., they are not able to classify them in the two categories of good and bad borrowers, they tend to use the scant information they have on the borrower's credit risk only for the selection process. They tend to avoid using the borrower's specific credit risk to tailor the price of the loan because this price strategy could end up in adverse selection, i.e., in attracting bad customers. This is true for all borrowers, but it is more applicable to households than firms, because lenders tend to know households less well, especially for small loans, such as consumer loans.

However, in the Stiglitz and Weiss (1981) screening model, if lenders can partially distinguish across the riskiness of borrowers, they will charge interest rates that vary according to some observed differences in risk. The rise of the new technology of credit scoring has increased and improved the information available on the borrowers. This has enabled lenders to screen better them, thereby spurring a widening of the differences between interest rates for riskier versus safer loans.

During the last decade, credit scoring techniques became less costly and more reliable. Italian lenders increasingly use them, even for loans granted to households. Therefore, we are basically asking where we are in terms of using credit scoring to define pricing strategy.

In this paper we find that Italian lenders take account of household credit risk, as measured by the predicted probability of delinquency, when deciding on the price of a mortgage. This risk-based pricing has become more widespread among Italian lenders, as in the United States, the other country for which this issue has been analyzed. Furthermore, it seems that most of the increase in the interest rate concerns the highest classes of risk, such as the last quartile of households ordered

by their predicted probability of delinquency. The risk-premium required by Italian lenders is such that a rise in the probability of default by 1 percentage point would be reflected in an increase of 21 basis points in the interest rate for mortgages granted between 2000 and 2007 and of 25 basis points for those granted between 2004 and 2007. Robustness exercises show that, for the most recent period, 2004-2007, the range of the increase is between 32 basis points, with the estimation that takes into account of risk aversion among lenders, and 13 basis points when using SHIW data with fewer observations.

The risk premium required by Italian lenders is still lower than that of their counterparts in the United States, where Edelberg estimates that at the end of the 1990s an increase of 1 percentage point in the probability of default would be linked to an increase in interest rates of 38 basis points. One plausible reason for the larger risk premium found in the United States is that investors in Freddie Mac and Fannie Mae mortgage-backed securities are insured by these government-sponsored enterprises against the default losses on the underlying conforming mortgages. This helps lower the cost of funding conforming U.S. mortgages and lower mortgage interest rates on them, ceteris paribus, thereby widening the spread between interest rates on riskier and safer (i.e., conforming) mortgages relative to spreads in other countries, such as Italy.

Along with an increase in risk-based pricing strategies, we also find initial and tentative evidence that household credit risk has become a bit less important in the loan approval process. This result could be consistent with a model where lenders have more detailed and less costly information about households, enlarge their pool of customers to include some riskier borrowers and therefore tailor the price of loans to household credit risk to a greater extent. The fact that Italian banks have enlarged the pool of mortgagors is confirmed by some recent evidence from the biannual SHIW: in the recent period (2006-2008), the percentage of households with a mortgage has increased more for households with lower income.

Risk-based pricing could produce a more efficient allocation of resources and complete a truncated credit market by reducing rationing (Collins, Belsky and Karl, 2004). Specifically, with more detailed information about borrowers, lenders are able to offset the greater riskiness of some high-risk households by the higher risk-premium required in deciding the mortgage interest rates. This can have positive effects on bank's stability and profitability. Moreover, cross-subsidization decreases. However, efficiency gains are only realized if lenders are able to accurately measure and price the credit risk. On the other hand, if the risk is not accurately evaluated the result could be very costly and inefficient. Regulators and policymakers have therefore important tasks in this

field. Two aspects appear particularly important: a careful oversight of the measurement of risk by lenders and an increase in financial literacy that helps consumers understanding their different mortgage options. This is an interesting and important topic that deserves more theoretical and empirical analysis in the future.

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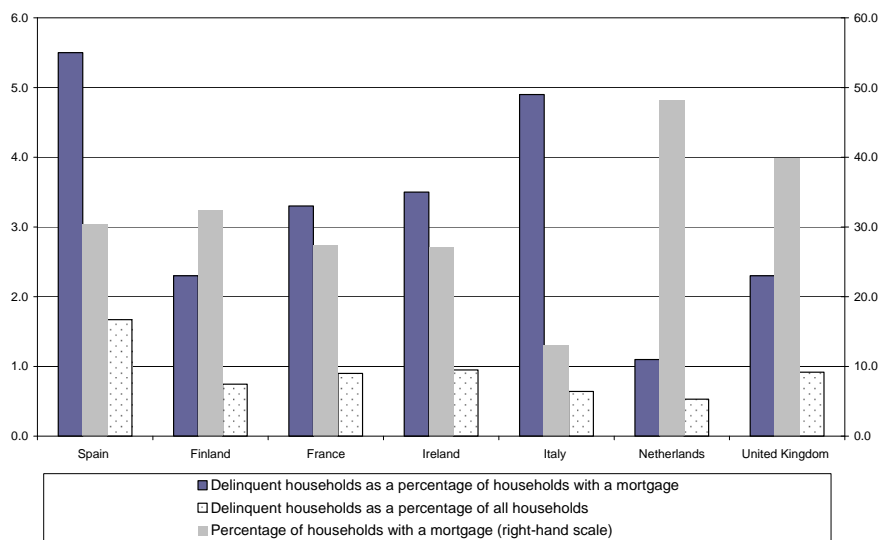Figure 1: Statistics on the frequency of mortgages and mortgage delinquency - Eu-Silc 2007



■ Delinquent households as a percentage of households with a mortgage
□ Delinquent households as a percentage of all households
▨ Percentage of households with a mortgage (right-hand scale)

Table 1: Percentage of mortgage delinquent households

(descriptive statistics - only households with a mortgage are considered)

| Household characteristics | Spain | Finland | France | Ireland | Italy | Netherlands | Uk |
|---|---|---|---|---|---|---|---|
| Total | 5.5 | 2.3 | 3.3 | 3.5 | 4.9 | 1.1 | 2.3 |
| *Age* | | | | | | | |
| Less than 35 | 5.8 | 1.5 | 4.3 | 5.6 | 2.8 | 2.1 | 2.6 |
| 35-44 | 5.6 | 3.9 | 3.4 | 1.7 | 5.8 | 1.3 | 3.1 |
| 45-54 | 4.9 | 2.1 | 3.4 | 4.4 | 6.1 | 1.1 | 1.9 |
| 55-64 | 6.5 | 1.2 | 2.5 | 0.4 | 3.7 | 0.3 | 0.8 |
| 65 and over | 3.1 | 0.9 | 2.3 | 7.7 | 3.7 | 0.2 | 0.0 |
| *Household income quartile* (1) | | | | | | | |
| 1st | 11.7 | 9.5 | 8.3 | 11.2 | 14.5 | 2.0 | 4.4 |
| 2nd | 7.3 | 4.2 | 5.3 | 9.0 | 8.0 | 1.9 | 3.4 |
| 3td | 5.1 | 1.3 | 2.7 | 2.4 | 3.4 | 1.1 | 2.2 |
| 4th | 2.4 | 0.8 | 0.9 | 0.4 | 2.1 | 0.3 | 1.3 |
| *Household size* | | | | | | | |
| 1 | 6.1 | 1.8 | 2.6 | 2.9 | 2.8 | 1.3 | 1.4 |
| 2 | 3.9 | 2.0 | 1.2 | 6.0 | 3.2 | 0.6 | 2.0 |
| 3 | 5.5 | 2.7 | 4.5 | 5.1 | 4.2 | 1.8 | 2.4 |
| 4 | 5.4 | 1.9 | 3.9 | 1.7 | 6.8 | 1.1 | 2.0 |
| 5 or more | 11.3 | 4.0 | 5.9 | 2.3 | 12.1 | 0.9 | 5.4 |
| *Household type* | | | | | | | |
| One adult,no children | 6.1 | 1.8 | 2.6 | 2.9 | 2.8 | 1.3 | 1.4 |
| Two adults,no children | 3.5 | 2.1 | 1.2 | 4.2 | 3.1 | 0.6 | 1.5 |
| Single parent | 19.9 | 7.5 | 1.6 | 6.0 | 10.1 | 1.5 | 8.0 |
| Couple with children | 5.4 | 2.4 | 4.4 | 1.7 | 6.3 | 1.2 | 2.1 |
| Other households | 7.0 | 1.6 | 4.9 | 10.9 | 5.1 | 1.6 | 4.2 |
| *Working status* | | | | | | | |
| Full-time | 4.7 | 2.1 | 3.4 | 1.5 | 4.5 | 1.2 | 2.2 |
| Part-time | 11.0 | 1.9 | 4.3 | 15.0 | 8.5 | 0.9 | 5.1 |
| Unemployed | 18.1 | 5.8 | 5.4 | 10.8 | 19.0 | 7.7 | 27.6 |
| Retired | 2.9 | 0.9 | 2.5 | 0.0 | 3.5 | 0.2 | 0.0 |
| Other non working | 15.5 | 6.7 | 3.9 | 28.8 | 11.2 | 1.5 | 2.2 |
| *Job contract* (2) | | | | | | | |
| Permanent | 4.0 | 1.9 | 3.1 | 2.6 | 4.4 | 1.0 | 1.9 |
| Temporary | 5.9 | 3.5 | 1.8 | 7.6 | 7.9 | 3.7 | 10.1 |
| *Total housing cost ratio quartile* | | | | | | | |
| 1st | 4.9 | 1.2 | 3.5 | 1.9 | 1.3 | 0.5 | 1.5 |
| 2nd | 3.9 | 1.6 | 3.4 | 1.4 | 3.0 | 0.6 | 1.8 |
| 3td | 4.7 | 4.0 | 2.7 | 4.1 | 4.7 | 1.4 | 2.0 |
| 4th | 7.4 | 3.5 | 2.5 | 8.1 | 8.1 | 2.7 | 4.5 |
| | | | | | | | |
| No. all households | 12,329 | 10,624 | 10,498 | 5,608 | 20,982 | 10,219 | 9,275 |
| No. hs. with a mortgage | 3,291 | 4.042 | 3,243 | 1,195 | 2,705 | 6,414 | 3,599 |
| No. hs. delinquent on a mortgage | 200 | 112 | 94 | 38 | 120 | 49 | 75 |

Source: Eu-Silc database for the year 2007, version 2007-1 available from 01-03-09; sample weights are used.

(1) Equivalized disposable income, OECD modified equivalence scale; (2) only for employees.

Table 2: Probability of mortgage delinquency

(Pooled probit estimation on households with a mortgage in each country - marginal effects)

| Variables | Spain | Finland | France | Ireland | Italy | Netherlands | Uk |
|---|---|---|---|---|---|---|---|
| Age | -0.001 | 0.002* | 0.000 | -0.002* | 0.002 | 0.001** | 0.000 |
| | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) | (0.001) |
| Age sq (divided by 1000) | -0.008 | -0.022* | -0.006 | 0.009 | -0.025 | -0.021** | -0.007 |
| | (0.014) | (0.012) | (0.009) | (0.010) | (0.015) | (0.006) | (0.008) |
| Man | -0.003 | 0.000 | -0.005 | -0.008 | -0.007 | -0.001 | -0.003 |
| | (0.005) | (0.003) | (0.004) | (0.005) | (0.005) | (0.002) | (0.002) |
| Married | -0.021 | -0.008 | 0.000 | -0.015* | 0.001 | -0.001 | -0.016*** |
| | (0.010) | (0.009) | (0.008) | (0.010) | (0.007) | (0.003) | (0.007) |
| Single | -0.022*** | -0.000 | -0.004 | -0.001 | -0.024*** | 0.003 | -0.005 |
| | (0.006) | (0.07) | (0.007) | (0.008) | (0.005) | (0.006) | (0.003) |
| Single with children | 0.007 | -0.008 | -0.012 | 0.005 | 0.000 | 0.000 | -0.005 |
| | (0.013) | (0.005) | (0.007) | (0.013) | (0.013) | (0.005) | (0.003) |
| Couple | -0.015** | 0.003 | -0.015*** | -0.006 | -0.012** | 0.005 | -0.001 |
| | (0.006) | (0.009) | (0.004) | (0.006) | (0.005) | (0.006) | (0.004) |
| Couple with children | -0.009 | 0.033 | -0.009 | -0.006 | -0.005 | 0.002 | 0.003 |
| | (0.007) | (0.008) | (0.005) | (0.007) | (0.006) | (0.005) | (0.004) |
| High school | -0.002 | -0.008** | -0.004 | -0.005 | -0.017*** | -0.003** | -0.004 |
| | (0.005) | (0.004) | (0.004) | (0.004) | (0.004) | (0.001) | (0.003) |
| College | -0.024 | | -0.002 | 0.001 | -0.011* | -0.005* | -0.003 |
| | (0.011) | | (0.010) | (0.006) | (0.006) | (0.001) | (0.004) |
| Post college | -0.023*** | -0.004 | -0.013*** | -0.015*** | -0.019*** | 0.001 | -0.014*** |
| | (0.005) | (0.004) | (0.004) | (0.006) | (0.005) | (0.002) | (0.003) |
| Self employed | 0.010 | 0.003 | 0.020*** | -0.004 | 0.010* | 0.003 | 0.015*** |
| | (0.008) | (0.004) | (0.008) | (0.006) | (0.006) | (0.003) | (0.005) |
| Retired | -0.013 | -0.000 | 0.005 | 0.006 | 0.009 | 0.001 | -0.005 |
| | (0.011) | (0.009) | (0.008) | (0.019) | (0.011) | (0.005) | (0.007) |
| Unemployed | 0.050*** | 0.019** | 0.076*** | 0.042*** | 0.016 | 0.015** | 0.105*** |
| | (0.016) | (0.014) | (0.021) | (0.025) | (0.022) | (0.012) | (0.050) |
| Other non working | -0.011 | -0.002 | 0.024** | 0.037*** | 0.005 | 0.008* | 0.014** |
| | (0.010) | (0.006) | (0.015) | (0.019) | (0.011) | (0.006) | (0.009) |
| Bad health | 0.029*** | 0.029*** | 0.018** | 0.020 | 0.024** | 0.021*** | 0.005 |
| | (0.013) | (0.013) | (0.010) | (0.019) | (0.013) | (0.012) | (0.007) |
| Immigrants | 0.039*** | | 0.014 | | 0.064*** | | 0.038*** |
| | (0.018) | | (0.015) | | (0.020) | | (0.015) |
| Total housing cost ratio | 0.038** | 0.039*** | 0.007 | 0.005 | 0.103*** | 0.006* | 0.019*** |
| | (0.015) | (0.012) | (0.021) | (0.023) | (0.015) | (0.004) | (0.005) |
| Hs. income (10,000 euro) | -0.021*** | -0.026*** | -0.015*** | -0.013*** | -0.006 | -0.006*** | -0.004*** |
| | (0.005) | (0.003) | (0.003) | (0.003) | (0.004) | (0.002) | (0.001) |
| Centre of Italy | | | | | -0.003 | | |
| | | | | | (0.005) | | |
| South of Italy | | | | | 0.020*** | | |
| | | | | | (0.007) | | |
| No. observations | 9,356 | 5,494 | 9,126 | 3,762 | 8,122 | 8,776 | 9,938 |
| Pseudo R$^2$ | 0.060 | 0.140 | 0.087 | 0.170 | 0.076 | 0.119 | 0.119 |
| Estimated probability | 0.043 | 0.015 | 0.022 | 0.016 | 0.033 | 0.005 | 0.012 |
| Surveys | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 |

Estimations on Eu-Silc data, waves from 2005 to 2007 (Version 2007-1 from 01-03-09). Robust standard errors are in brackets.* significant at 10%, ** at 5% and *** at 1%. For Spain, Finland, France and Italy area dummies are included in the estimation; information about the area of the country where the household lives is not available for Ireland, the Netherlands and the United Kingdom; year dummies are always included. Household income is equivalized. Missing values are a consequence of variables dropped due to collinearity.

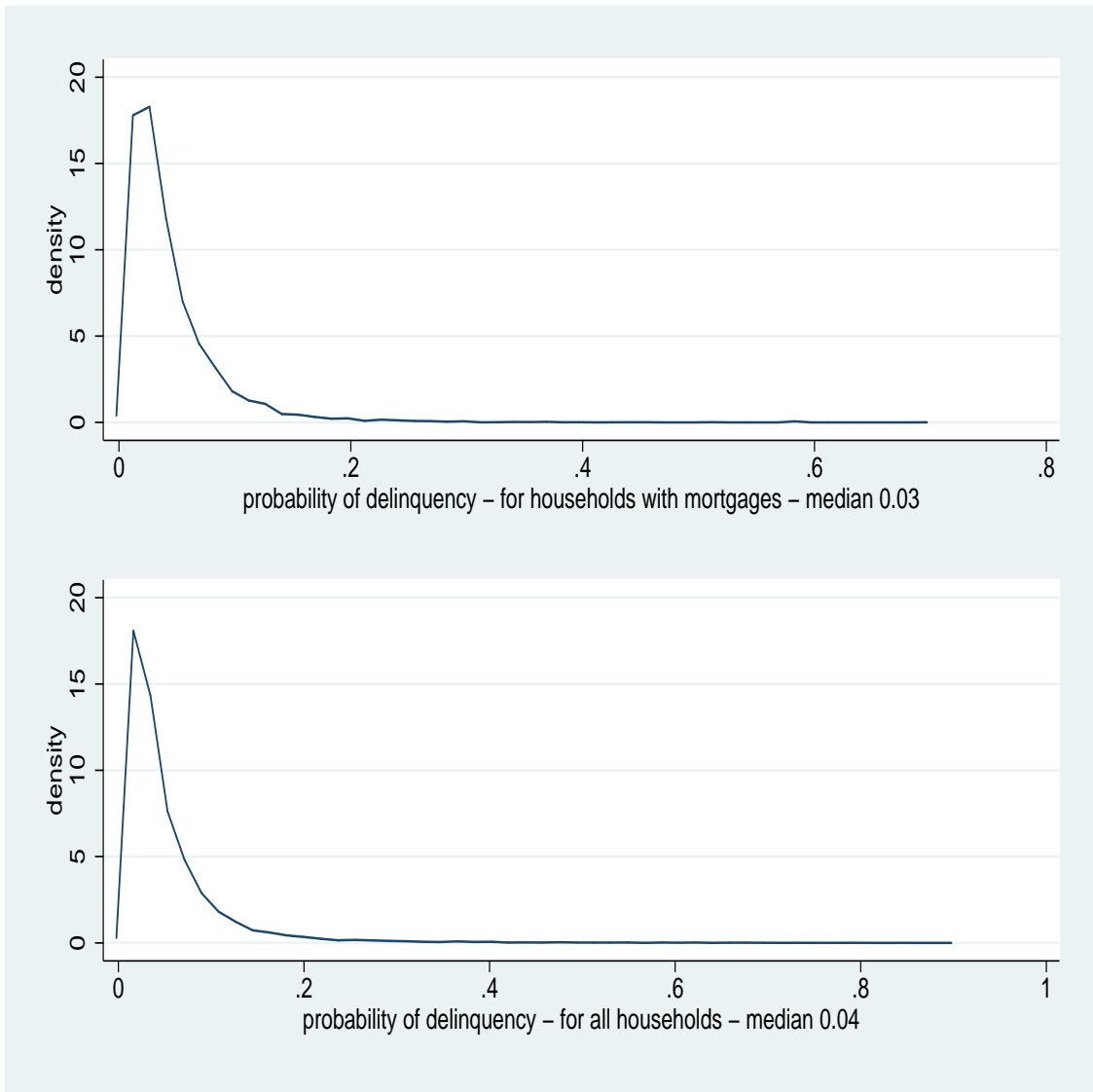Figure 2: Kernel densities of the probability of mortgage delinquency

Table 3: Mortgage interest rates and probability of mortgage delinquency
(OLS estimation on Italian households with a mortgage)

| Variables | Mortgages 1985-2007 | Mortgages 1985-1994 | Mortgages 1995-1999 | Mortgages 2000-07 | Mortgages 2000-03 | Mortgages 2004-07 |
|---|---|---|---|---|---|---|
| Pred. of delinquency | 4.948*** | 4.747* | 4.455*** | 5.082*** | 5.233*** | 4.968*** |
| | (0.634) | (2.815) | (1.495) | (0.719) | (1.004) | (0.785) |
| Mortgage amount (10,000 euro) | -0.066*** | -0.049*** | -0.087*** | -0.066*** | -0.073*** | -0.057*** |
| | (0.005) | (0.012) | (0.011) | (0.006) | (0.009) | (0.006) |
| Year dummy 2006 | 0.375*** | 0.515*** | 0.637*** | 0.243*** | 0.332*** | 0.080 |
| | (0.050) | (0.198) | (0.096) | (0.057) | (0.069) | (0.086) |
| Year dummy 2007 | 0.618*** | 0.844*** | 0.740*** | 0.525*** | 0.538*** | 0.449*** |
| | (0.056) | (0.230) | (0.105) | (0.062) | (0.078) | (0.088) |
| | | | | | | |
| Prediction of interest rates | | | | | | |
| 1quartile of risk | 4.89 | 5.44 | 5.32 | 4.66 | 4.81 | 4.44 |
| 2quartile of risk | 4.96 | 5.61 | 5.33 | 4.75 | 4.90 | 4.53 |
| 3quartile of risk | 5.03 | 5.61 | 5.42 | 4.83 | 4.99 | 4.61 |
| 4quartile of risk | 5.20 | 5.75 | 5.67 | 5.09 | 5.25 | 4.93 |
| Total increase (4q-1q) | 0.31*** | **0.31**\*** | **0.35**\*** | 0.43*** | 0.44*** | 0.50*** |
| Ratio 4q/1q | 1.06*** | 1.06*** | 1.07*** | 1.09*** | 1.09*** | 1.11*** |
| | | | | | | |
| No. observations | 8,069 | 682 | 1,941 | 5,446 | 3,098 | 2,348 |
| $R^2$ | 0.111 | 0.058 | 0.091 | 0.092 | 0.079 | 0.090 |
| Surveys | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 |

Estimations on Eu-Silc data, waves from 2005 to 2007 (Version 2007-1 from 01-03-09). Standard errors are calculated using Murphy-Topel correction method and are in brackets.* significant at 10%, ** at 5% and *** at 1%. Dummies for the year the mortgage was granted, from 1985 to 2007, are also included, but not reported. Quartiles of risk are based on the distribution of the prediction of mortgage delinquencies calculated on the whole sample of Italian households. The amount of mortgage is that granted at the time the contract was signed, expressed at constant prices using the household consumptions deflator. For the sub-periods 1985-1994, 1995-1999 and 2000-03, the total increase in the interest rates from the lowest to the highest classes of risk in bold is meant to indicate that the difference between this rise and that in 2004-2007 is statistically significant at least at the 10% level.

Figure 3: Household credit risk and mortgage interest rates - linear estimation
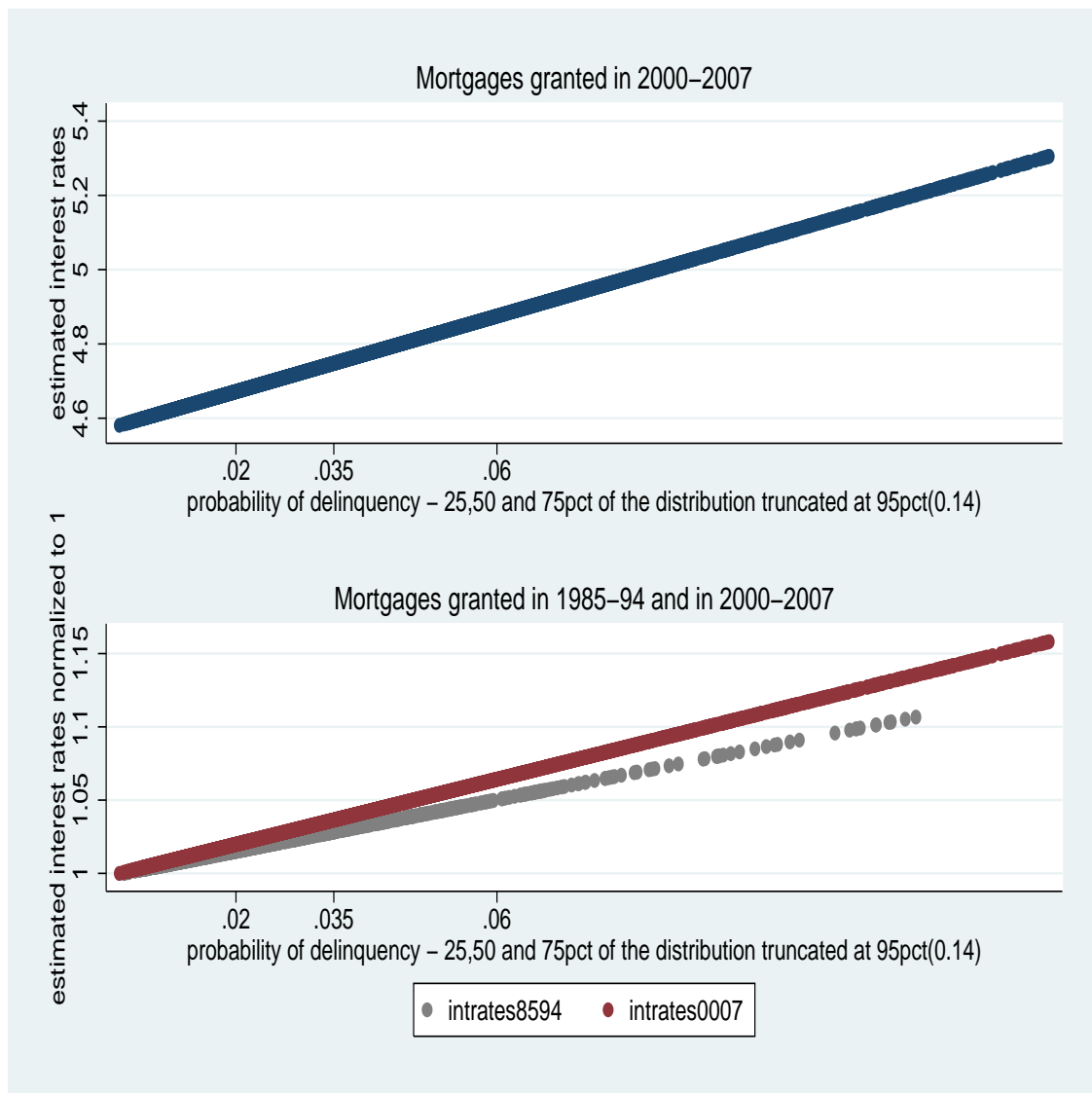
Table 4: Mortgage interest rates and probability of mortgage delinquency

(Heckman estimation on Italian households with a mortgage - marginal effects for selection estimations)

| Variables | Mortgages 1985-2007 rate estimation | Mortgages 1985-2007 selection estimation | Mortgages 2000-2007 rate estimation | Mortgages 2000-2007 selection estimation |
|---|---|---|---|---|
| Pred. of delinquency | 4.620*** | -0.156*** | 4.894*** | -0.019 |
| | (0.598) | (0.027) | (0.527) | (0.017) |
| Mortgage amount (10,000 euro) | -0.064*** | | -0.064*** | |
| | (0.006) | | (0.004) | |
| Age | | 0.008*** | | 0.002*** |
| | | (.001) | | (0.000) |
| Age sq (divided by 1000) | | -0.115*** | | -0.055*** |
| | | (0.007) | | (0.004) |
| Man | | -0.007*** | | -0.004*** |
| | | (0.003) | | (0.001) |
| Married | | 0.058*** | | 0.045*** |
| | | (0.003) | | (0.002) |
| Hs. size | | -0.002** | | -0.005*** |
| | | (0.001) | | (0.001) |
| High school | | 0.011*** | | 0.004** |
| | | (0.002) | | (0.002) |
| College | | 0.035*** | | 0.019*** |
| | | (0.006) | | (0.004) |
| Post college | | 0.018*** | | 0.013*** |
| | | (0.003) | | (0.003) |
| Work full time | | 0.019*** | | 0.016*** |
| | | (0.003) | | (0.002) |
| Bad health | | 0.012* | | 0.008 |
| | | (0.007) | | (0.005) |
| Hs. income (10,000 euro) | | 0.022*** | | 0.016*** |
| | | (0.001) | | (0.001) |
| Central Italy | | -0.011*** | | -0.004 |
| | | (0.003) | | (0.002) |
| South Italy | | -0.042*** | | -0.026*** |
| | | (0.003) | | (0.002) |
| Year dummy 2006 | 0.375*** | 0.002 | 0.247*** | 0.010*** |
| | (0.045) | (0.003) | (0.049) | (0.002) |
| Year dummy 2007 | 0.617*** | -0.000 | 0.531*** | 0.013*** |
| | (0.046) | (0.003) | (0.061) | (0.002) |
| Prediction of interest rates | | | | |
| 1quartile of risk | 4.89 | | 4.65 | |
| 2quartile of risk | 4.96 | | 4.75 | |
| 3quartile of risk | 5.03 | | 4.83 | |
| 4quartile of risk | 5.20 | | 5.09 | |
| Total increase (4q-1q) | 0.32*** | | 0.43*** | |
| Ratio 4q/1q | 1.06*** | | 1.09*** | |
| No. uncensored observations | 8,069 | | 5,446 | |
| No. observations | | 61,848 | | 59,225 |
| LR test (rho=0 - pvalue) | | 0.064 | | 0.2064 |
| Estimated probability | | 0.084 | | 0.054 |
| Surveys | 2005-07 | 2005-07 | 2005-07 | 2005-07 |

Estimations on Eu-Silc data, waves from 2005 to 2007 (Version 2007-1 from 01-03-09). Bootstrapped standard errors are in brackets.* significant at 10%, ** at 5% and *** at 1%. Dummies for the year the mortgage was granted are included. Quartiles of risk are based on the distribution of the prediction of mortgage delinquencies calculated on the whole sample of Italian households. The amount of mortgage is that granted at the time the contract was signed, expressed at constant prices using the household consumptions deflator. Household income is equivalized.

Table 5: Mortgage interest rates and probability of mortgage delinquency
(OLS estimation on Italian households with a mortgage split by quartiles of risk)

| Variables | Mortgages 1985-2007 | Mortgages 1985-1994 | Mortgages 1995-1999 | Mortgages 2000-07 | Mortgages 2000-03 | Mortgages 2004-07 |
|---|---|---|---|---|---|---|
| Prediction of interest rates | | | | | | |
| 1quartile of risk | 4.79 | 5.36 | 5.22 | 4.56 | 4.70 | 4.35 |
| 2quartile of risk | 4.96 | 5.51 | 5.33 | 4.75 | 4.93 | 4.50 |
| 3quartile of risk | 5.13 | 5.89 | 5.53 | 4.91 | 5.08 | 4.68 |
| 4quartile of risk | 5.22 | 5.69 | 5.65 | 5.11 | 5.24 | 4.99 |
| Total increase (4q-1q) | 0.42*** | **0.34***** | **0.42***** | 0.55*** | **0.54***** | 0.64*** |
| Ratio 4q/1q | 1.09*** | 1.06*** | 1.08*** | 1.12*** | 1.11*** | 1.15*** |
| | | | | | | |
| Number of observations | | | | | | |
| 1q of risk | 2,312 | 217 | 584 | 1,511 | 890 | 621 |
| 2q of risk | 2,332 | 215 | 627 | 1,490 | 874 | 616 |
| 3q of risk | 2,077 | 178 | 515 | 1,384 | 797 | 587 |
| 4q of risk | 1,348 | 72 | 215 | 1,061 | 537 | 524 |
| Total sample | 8,069 | 682 | 1,941 | 5,446 | 3,098 | 2,348 |
| Surveys | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 |

Estimations on Eu-Silc data, waves from 2005 to 2007 (Version 2007-1 from 01-03-09). Standard errors are calculated using Murphy-Topel correction method and are in brackets. * significant at 10%, ** at 5% and *** at 1%. Estimations are run separately for households belonging to the four different quartiles of risk. Quartiles of risk are based on the distribution of the prediction of mortgage delinquencies calculated on the whole sample of Italian households. For the sub-periods 1985-1994, 1995-1999 and 2000-03, the total increase in the interest rates from the lowest to the highest classes of risk in bold is meant to indicate that the difference between this rise and that in 2004-2007 is statistically significant at least at the 10% level.

Figure 4: Household credit risk and mortgage interest rates - estimations by quartiles of risk
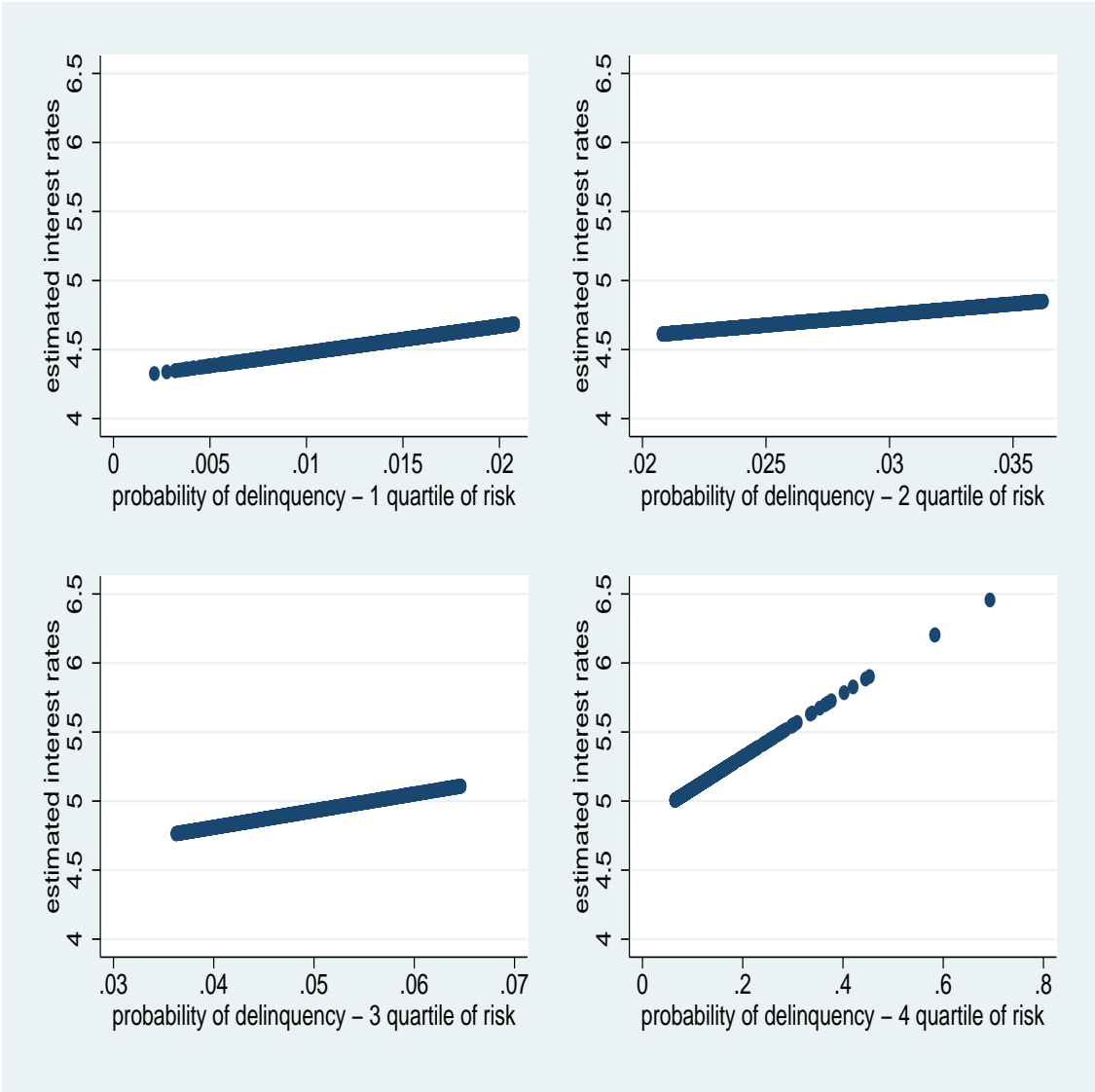Mortgages granted in 2000-2007

Table 6: Mortgage interest rates and probability of mortgage delinquencies: inclusion of other explanatory variables

(OLS estimation on Italian households with a mortgage)

| Variables | Mortgages 1985-2007 | Mortgages 1985-1994 | Mortgages 1995-1999 | Mortgages 2000-2007 | Mortgages 2000-2003 | Mortgages 2004-2007 |
|---|---|---|---|---|---|---|
| Pred. of delinquency | 6.621*** | 6.88*** | 6.796* | 6.744*** | 6.534*** | 7.002*** |
| | (1.584) | (4.055) | (3.950) | (1.764) | (1.758) | (2.389) |
| Mortgage amount (10,000 euro) | -0.064*** | -0.051*** | -0.089*** | -0.063*** | -0.069*** | -0.058*** |
| | (0.005) | (0.011) | (0.012) | (0.006) | (0.010) | (0.007) |
| Age | -0.018 | 0.080 | -0.037 | -0.011 | -0.018 | -0.007 |
| | (0.020) | (0.064) | (0.049) | (0.019) | (0.022) | (0.027) |
| Age sq (divided by 1000) | 0.233 | -0.399 | 0.404 | 0.129 | 0.225 | 0.062 |
| | (0.217) | (0.624) | (0.511) | (0.211) | (0.237) | (0.312) |
| Man | 0.057 | 0.238 | 0.170 | (-0.004) | 0.004 | (0.003) |
| | (0.053) | (0.202) | (0.106) | (0.059) | (0.072) | (0.079) |
| Married | -0.009 | -0.001 | 0.021 | -0.052 | -0.121 | 0.037 |
| | (0.064) | (0.253) | (0.127) | (0.070) | (0.089) | (0.090) |
| Hs. size | 0.023 | 0.096 | 0.055 | 0.017 | 0.019 | 0.016 |
| | (0.023) | (0.094) | (0.050) | (0.025) | (0.032) | (0.034) |
| High school | 0.054 | 0.166 | 0.063 | 0.047 | 0.128* | -0.062 |
| | (0.063) | (0.212) | (0.131) | (0.068) | (0.077) | (0.105) |
| College | 0.192** | 0.160 | 0.293* | 0.155 | 0.189 | 0.102 |
| | (0.087) | (0.293) | (0.159) | (0.102) | (0.123) | (0.138) |
| Post college | 0.033 | 0.513* | 0.139 | -0.052 | -0.021 | -0.062 |
| | (0.089) | (0.303) | (0.209) | (0.086) | (0.104) | (0.119) |
| Work full time | 0.057 | 0.413* | -0.039 | 0.026 | -0.041 | 0.123 |
| | (0.084) | (0.241) | (0.151) | (0.092) | (0.110) | (0.125) |
| Bad health | 0.038 | 0.290 | 0.169 | -0.042 | 0.031 | -0.157 |
| | (0.155) | (0.330) | (0.282) | (0.171) | (0.201) | (0.214) |
| Immigrants | -0.427** | 0.138 | -1.100** | -0.394** | -0.356 | -0.459* |
| | (0.172) | (0.350) | (0.467) | (0.191) | (0.236) | (0.252) |
| Hs. income (10,000 euro) | 0.112*** | -0.119 | 0.096 | 0.155*** | 0.148*** | 0.160*** |
| | (0.039) | (0.130) | (0.076) | (0.044) | (0.056) | (0.055) |
| Central Italy | 0.331*** | 0.044 | 0.401*** | 0.333*** | 0.479*** | 0.151** |
| | (0.053) | (0.211) | (0.100) | (0.058) | (0.072) | 0.076 |
| South Italy | 0.154* | -0.156 | 0.003 | 0.226** | 0.270** | 0.177 |
| | (0.085) | (0.224) | (0.161) | (0.100) | (0.112) | (0.136) |
| Prediction of interest rates | | | | | | |
| 1q of risk | 4.89 | 5.42 | 5.32 | 4.68 | 4.82 | 4.47 |
| 2q of risk | 4.92 | 5.44 | 5.27 | 4.73 | 4.87 | 4.53 |
| 3q of risk | 4.98 | 5.48 | 5.33 | 4.80 | 4.94 | 4.60 |
| 4q of risk | 5.14 | 5.63 | 5.62 | 5.01 | 5.15 | 4.88 |
| Total increase (4q-1q) | 0.24*** | **0.21*** | 0.30*** | 0.33*** | 0.33*** | 0.41*** |
| Ratio 4q/1q | 1.05*** | 1.04*** | 1.06*** | 1.07*** | 1.07*** | 1.09*** |
| No. observations | 7,962 | 665 | 1.914 | 5,383 | 3,060 | 2,323 |
| R² | 0.123 | 0.111 | 0.106 | 0.111 | 0.106 | 0.109 |
| Surveys | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 |

Estimations on Eu-Silc data, waves from 2005 to 2007 (Version 2007-1 from 01-03-09). Standard errors are calculated using Murphy-Topel correction method and are in brackets.* significant at 10%, ** at 5% and *** at 1%. Dummies for the year the mortgage was granted are included, but not reported. Quartiles of risk are based on the distribution of the prediction of mortgage delinquencies calculated on the whole sample of Italian households. The amount of mortgage is that granted at the time the contract was signed, expressed at constant prices using the household consumptions deflator. Household income is equivalized. For the sub-periods 1985-1994, 1995-1999 and 2000-03, the total increase in the interest rates from the lowest to the highest classes of risk in bold is meant to indicate that the difference between this rise and that in 2004-2007 is statistically significant at least at the 10% level.   36

Table 7: Mortgage interest rates and probability of mortgage delinquency
(OLS estimation on Italian households with a mortgage)

| Variables | Mortgages 1985-2007 | Mortgages 1985-1994 | Mortgages 1995-1999 | Mortgages 2000-07 | Mortgages 2000-03 | Mortgages 2004-07 |
|---|---|---|---|---|---|---|
| | | | 1 exercise | | | |
| Prediction of interest rates | | | | | | |
| 1quartile of risk | 4.89 | 5.46 | 5.31 | 4.66 | 4.81 | 4.44 |
| 2quartile of risk | 4.93 | 5.55 | 5.31 | 4.72 | 4.87 | 4.50 |
| 3quartile of risk | 5.03 | 5.63 | 5.41 | 4.81 | 4.99 | 4.59 |
| 4quartile of risk | 5.16 | 5.70 | 5.61 | 5.04 | 5.18 | 4.89 |
| Total increase (4q-1q) | 0.27*** | **0.24**** | **0.30**** | 0.38*** | **0.37**** | 0.46*** |
| Ratio 4q/1q | 1.06*** | 1.04*** | 1.06*** | 1.08*** | 1.08*** | 1.10*** |
| | | | | | | |
| No. observations | 8,069 | 682 | 1,941 | 5,446 | 3,098 | 2,348 |
| Surveys | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 |
| | | | 2 exercise | | | |
| Prediction of interest rates | | | | | | |
| 1quartile of risk | 4.88 | 5.31 | 5.28 | 4.68 | 4.81 | 4.45 |
| 2quartile of risk | 4.94 | 5.48 | 5.29 | 4.73 | 4.90 | 4.54 |
| 3quartile of risk | 5.01 | 5.48 | 5.39 | 4.80 | 4.98 | 4.62 |
| 4quartile of risk | 5.19 | 5.59 | 5.66 | 5.01 | 5.22 | 4.94 |
| Total increase (4q-1q) | 0.31*** | **0.28**** | 0.38*** | 0.40*** | **0.40**** | 0.48*** |
| Ratio 4q/1q | 1.06*** | 1.05*** | 1.07*** | 1.09*** | 1.08*** | 1.11*** |
| | | | | | | |
| No. observations | 7,962 | 665 | 1,914 | 5,383 | 3,060 | 2,323 |
| Surveys | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 | 2005-07 |
| | | | 3 exercise | | | |
| Prediction of interest rates | | | | | | |
| 1quartile of risk | 4.88 | | 4.89 | 4.80 | 4.77 | 4.85 |
| 2quartile of risk | 4.90 | | 5.07 | 4.80 | 4.72 | 4.90 |
| 3quartile of risk | 4.82 | | 4.95 | 4.77 | 4.66 | 4.92 |
| 4quartile of risk | 4.91 | | 5.03 | 4.87 | 4.70 | 5.11 |
| Total increase (4q-1q) | 0.03 | | 0.14 | 0.07* | **-0.07** | 0.26*** |
| Ratio 4q/1q | 1.01 | | 1.03 | 1.02* | 0.98 | 1.05*** |
| | | | | | | |
| No. observations | 1668 | | 417 | 1,046 | 638 | 408 |
| Surveys | 2004-08 | | 2004-08 | 2004-08 | 2004-08 | 2004-08 |

Estimations on Eu-Silc data, waves from 2005 to 2007 (Version 2007-1 from 01-03-09). Standard errors are calculated using Murphy-Topel correction method and are in brackets.* significant at 10%, ** at 5% and *** at 1%. Quartiles of risk are based on the distribution of the prediction of mortgage delinquencies calculated on the whole sample of Italian households. In the first exercise the probability of being delinquent is calculated only for households with mortgages and the quartiles of risk are consequently redefined. In the second exercise the interest rates outliers (lower than 1 percentile and higher than 99 percentile) of the distribution in each of the three waves of the survey are discarded. In the third exercise we use data from the biannual Survey of Household Income and Wealth (2004-2008); data for the sub-period 1985-1994 are not reported owing to the very few observations. For the sub-periods 1985-1994, 1995-1999 and 2000-03, the total increase in the interest rates from the lowest to the highest classes of risk in bold is meant to indicate that the difference between this rise and that in 2004-2007 is statistically significant at least at the 10% level.

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