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THE RISK-TAKING CHANNEL OF MONETARY POLICY – EXPLORING ALL AVENUES

Diana Bonfim
Carla Soares

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Please address correspondence to
Banco de Portugal, Economics and Research Department
Av. Almirante Reis 71, 1150-012 Lisboa, Portugal
Tel.: 351 21 313 0000, email: estudos@bportugal.pt

Banco de Portugal
EUROSYSTEM

BANCO DE PORTUGAL

Av. Almirante Reis, 71

1150-012 Lisboa

www.bportugal.pt

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The risk-taking channel of monetary policy - exploring all avenues *

Diana Bonfim† Banco de Portugal

Carla Soares‡ Banco de Portugal

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Abstract

It is well established that when monetary policy is accommodative, banks tend to grant more credit. However, only recently attention was given to the quality of credit granted and, naturally, the risk assumed during those periods. This article makes an empirical contribution to the analysis of the so-called risk-taking channel of monetary policy. We use bank loan level data and different methodologies to test whether banks assume more credit risk when monetary policy interest rates are lower. Our results provide evidence in favor of this channel through different angles. We show that banks, most notably smaller banks, grant more loans to non-financial corporations with recent defaults or without credit history when policy interest rates are lower. We also find that loans granted when interest rates are low are more likely to default in the hiking phase of the interest rate cycle. However, the level of policy interest rates at the moment of loan concession does not seem to be relevant for the ex-post probability of default of the overall loan portfolio.

JEL Codes: E44, E5, G21.

Keywords: risk-taking channel, monetary policy transmission, credit risk.

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†Email: dbonfim@bportugal.pt.

‡Email: csoares@bportugal.pt.

1 Introduction

Since the onset of the financial crisis, there has been an increasing interest on the links between the financial system and monetary policy. One of the recent avenues of research has focused on the transmission of monetary policy through banks' risk-taking behavior, usually labeled as the risk-taking channel (Adrian and Shin, 2008, 2010a and b, Jiménez, Ongena, Peydró and Saurina, 2014). The basic idea is that in an environment of low policy interest rates, the incentive for banks to take more risk into their balance sheets increases. In the last few years, the literature on this channel has flourished. Several authors have found a negative relationship between the level of monetary policy interest rates and bank risk-taking. Generally, the results suggest that in the short-run lower policy interest rates decrease the total credit risk of the banking sector, since the impact via the increase in borrowers' repayment capacity for outstanding loans is more significant. However, in the medium-term, the higher risk-taking may eventually materialize in a deterioration of banks' asset quality, especially when a period of low policy interest rates is followed by a recession or by a severe monetary policy contraction.

The main goal of this paper is to explore different mechanisms through which the risk-taking channel may operate. Indeed, the identification of this channel is not straightforward. For instance, risk-taking behaviors may be observable ex-ante (e.g., when banks grant loans to borrowers with bad credit history) or only ex-post (i.e., if loans granted during periods of low interest rates turn out to have higher default rates). It is also important to ensure that this risk-taking channel is not confused with the "traditional" credit channel. As credit is expected to increase when interest rates are low (Bernanke and Blinder, 1988), it may happen that both good and bad borrowers have more access to credit when interest rates are lower. Given this, it is important to assess the overall impact on portfolio quality of the loans granted in these periods.

In this paper, we use a unique loan level Portuguese dataset, with loan, firm and bank information, to provide a thorough and comprehensive assessment of the different transmission mechanisms through which the risk-taking channel of monetary policy may operate. Our analysis is built around two main blocks. First, we assess the risk-taking channel at the moment a loan concession decision is taken (ex-ante), both at the extensive and intensive margins. More specifically, we test whether riskier firms obtain more credit when policy interest rates are lower and whether these firms are more likely to obtain a loan in such periods. Second, we evaluate changes in the loan portfolio quality, in terms of probabilities of default. We start by looking at the relationship between the overall quality of the loan portfolio and the level of the policy interest rates, by means of a duration model. After-

wards, we test whether loans granted in a low interest rate environment are more likely to default when interest rates increase, using a differences-in-differences (DID) estimator.

Testing all these hypothesis requires an adequate identification strategy. It is possible to argue that there may be common (unobservable) effects that simultaneously influence the monetary policy stance and banks' risk-taking decisions. If that is the case, it is not possible to infer causality, thereby hindering the correct identification of the risk-taking channel. Our setup allows to overcome this challenging identification problem given that monetary policy decisions can be considered as fully exogenous during the period analyzed (1999-2007). The influence of Portuguese monetary and economic conditions on the decisions taken by the Eurosystem should be negligible. This is the same argument used by Jiménez et al. (2012, 2014) and, to some extent, by Ioannidou et al. (2009) and Geršl et al. (2012).

Our empirical results broadly support the existence of a risk-taking channel. When monetary policy interest rates are lower, banks increase lending to ex-ante riskier borrowers. Moreover, loans granted when interest rates were low are more likely to default in the hiking phase of the interest rate cycle. However, the level of interest rates at the moment of the loan concession does not seem to be relevant for the ex-post default probabilities of the overall loan portfolio. Thus, our results support the risk-taking channel hypothesis, but the impact of the risk-taking channel on financial stability seems to be rather limited.

Our paper contributes to the expanding empirical literature on the risk-taking channel of monetary policy by looking simultaneously at different transmission mechanisms. By exploring a rich and detailed dataset, with loan, firm and bank information, and by taking advantage of a quasi-experimental setting in which monetary policy decisions can be considered as fully exogenous, we explore several possible transmission mechanisms of the effect of interest rates on banks' risk-taking behaviors. As far as we know, such detailed analysis and, in particular the use of a DID estimator, is unique in this branch of the literature.

The paper is organized in the following way. In section 2 we briefly summarize the theoretical and empirical discussions in the literature on the risk-taking channel. Section 3 describes the dataset used and section 4 details the identification strategy and methodologies followed. In section 5, we assess the risk-taking channel with ex-ante information at the extensive and intensive margins. We focus on the effects of policy interest rates on loan concession by testing two hypotheses: (1) Do firms, and in particular riskier firms, get more credit when policy rates are lower? (section 5.1) and (2) Are banks more likely to lend to ex-ante riskier borrowers when policy rates are lower? (section 5.2). In section 6, we assess the risk-taking channel through changes in loan portfolio quality. Again, two hypotheses are tested: (1) Does the level of the policy rate at loan concession influence the (ex-post) probability of default? (section 6.1) and (2) Are loans granted when policy rates are lower

more likely to default when interest rates increase? (section 6.2). Section 7 summarizes our main findings.

2 An overview of the literature on the risk-taking channel

Since the onset of the financial crisis, there has been an increasing interest on the links between financial stability and monetary policy. One of the recent avenues of research has focused on the transmission of monetary policy through banks' risk-taking behavior (risk-taking channel). The basic idea is that in an environment of persistently low policy interest rates, the incentive for banks to take more risk into their balance sheets increases.

The theoretical research on this channel has been expanding significantly during the last few years (Dell'Ariccia et al., 2011, Borio and Zhu, 2012, Adrian and Shin, 2008, 2010a and b, De Nicolò et al., 2010). These authors have identified some mechanisms through which this channel operates. One of these mechanisms is the search for yield, which occurs mainly through the asset side of financial institutions' balance sheet. A decrease in policy rates decreases their portfolio income and then decreases the incentive to monitor, or similarly, increases search for yield and then risk-taking (Dell'Ariccia et al., 2011).

The risk-taking channel may also operate through risk-shifting, occurring mainly via the liability side of financial institutions' balance sheet. A decrease in policy rates decreases the cost of banks' liabilities, raising the incentive to increase leverage (Dell'Ariccia et al., 2011, Valencia, 2011). Moreover, a prolonged period of low interest rates can affect asset and collateral valuations, as it is associated to lower market volatility, thus reducing risk perception (Gambacorta, 2009). Adrian and Shin (2008, 2010a and b) argue that banks that actively manage their balance sheets target a leverage ratio. When asset prices increase, the balance sheet gets stronger and the leverage ratio decreases. This can be considered equivalent to "surplus capacity" relative to manufacturing firms. Then, banks use their surplus capacity by increasing their market funding and by expanding credit. With low policy rates, short-term funding is cheaper. In this setting, banks tend to increase the reliance on short-term funding, while expanding credit to cover riskier projects, thus implying an increase in the risk they assume. This mechanism reinforces itself, since banks increase demand for assets, increasing their price and consequently expanding further their balance sheet and lowering the leverage ratio.

Other authors highlight a distortion of incentives in an environment of very low interest rates. In the model of Acharya and Naqvi (2012), an agency problem between the bank

manager and the principal induces the bank manager to take excessive risk when the bank is awash with liquidity. This usually occurs in situations of high macroeconomic risk, which usually lead the central bank to loosen its monetary policy. Thus, these authors find an argument in favor of a "leading against the wind" policy, even if the central bank is not aware of where the economy is in the business cycle.

It should be noted that the risk-taking channel differs from the credit channel. The credit channel encompasses two different transmission mechanisms: the bank lending channel and the balance sheet channel. In the former, a loosening of monetary policy via an expansion in bank reserves would raise deposits and, consequently, the amount of bank loans (Bernanke and Blinder, 1988, Disyatat, 2011). The balance sheet channel is based on the financial accelerator concept and works through the demand side of the credit market (Bernanke and Gertler, 1989, 1995). In this case, a monetary policy contraction reduces the net worth of borrowers, amplifying the spending and production effects of the initial shock.

During the last few years, there were several relevant empirical contributions to the literature on the risk-taking channel (Paligorova and Jimenez, 2012). Most of these empirical studies have found evidence that banks increase lending to riskier borrowers when interest rates are low. For instance, using an extensive database on loans applications and granted by Spanish credit institutions, Jiménez et al. (2014) find robust evidence that lower short-term interest rates imply that less capitalized banks soften their lending standards and increase loans to ex-ante risky borrowers. Moreover, by taking into account time-varying bank heterogeneity, they conclude that risk-taking is influenced not only by the capital level of the banks but it is also consistent with risk-shifting. Using a Bolivian loans database, Ioannidou et al. (2009) also find evidence that banks increase risk-taking when monetary policy rates are lower. This behavior is apparent in the increase in new loans with a higher probability of default, granted to riskier borrowers and with lower loan spreads. There is also evidence of a risk-taking channel in the US, as Paligorova and Santos (2012) show that banks offer relatively lower spreads when lending to riskier borrowers in periods of lower short-term rates. In contrast, Buch et al. (2011) do not find evidence of increased risk-taking during such periods in the US, for the banking sector as a whole, even though they find important differences between different types of banks. Altunbas et al. (2010) use an interest rate gap in order to measure the effect of monetary policy stance on banks risk-taking, using balance sheet data for a sample of banks from 16 countries. They find that banks indeed tend to take more risk when interest rates are below the rate given by a Taylor rule. Using data from bank lending surveys of the euro area and the US, Maddaloni and Peydró (2011) conclude that low short-term interest rates induce a softening in lending standards and that this effect is more pronounced the longer is the period of low interest

rates. Gaggl and Valderrama (2011) use data on Austrian firms and banks to find that in relatively long periods of low policy interest rates banks loan-portfolio risk increases, controlling for macroeconomic conditions, bank and industry characteristics. Finally, Delis and Kouretas (2011) also find a negative relationship between the level of interest rates and bank risk-taking.

Available empirical evidence suggests that there is some heterogeneity in bank risk-taking behavior, in line with agency theories (Kashyap and Stein, 2000, Freixas and Rochet, 2008). As mentioned, Jiménez et al. (2014) find that the risk-taking channel is more acute for lowly capitalized banks. Brissimis and Delis (2010) find that the reaction of credit risk of US and euro area banks with higher liquidity and capitalization to monetary policy changes is approximately null, while on average banks' credit risk increases (although marginally) with expansionary monetary policy. Altunbas et al. (2010) also find that banks involved more in non-traditional banking activities take more risk. Buch et al. (2011) find that only small domestic banks adopt risk-taking behaviors during periods of low interest rates, while foreign banks decrease their risk-taking and large banks do not show a meaningful change in behavior. Ioannidou et al. (2009) also observe a riskier behavior from banks more prone to agency problems, i.e., larger banks, banks with a lower capital ratio or a higher non-performing loans ratio, as well as banks with more liquid assets. Furthermore, Maddaloni and Peydró (2011) find evidence of agency problems in excessive risk-taking, given that the impact of low monetary policy rates on lending standards is amplified when supervision standards for bank capital are weaker.

Financial innovation also seems to impact on banks' lending standards. Maddaloni and Peydró (2011) find that securitization leads to softer lending standards in both the euro area and the US, amplifying the effects coming from low policy rates (see also Delis and Kouretas, 2011).

Finally, there has been also some literature more focused on macro data. Angeloni, Faia and Lo Duca (2010) present time series evidence for the US and the euro area about the effect of monetary policy on measures of banks' leverage and balance sheet risk. They found stronger evidence for the US than for the euro area on the negative effect of monetary policy on banks' risk.

Our paper contributes to the expanding empirical literature on the risk-taking channel of monetary policy by looking simultaneously at different transmission mechanisms. By exploring a rich and detailed dataset and by taking advantage of the exogeneity monetary policy decisions, we test the effect of policy rates on banks' risk-taking behaviors. We do this through several different perspectives, thereby providing a unique and thorough analysis of transmission channels.

3 Data

We collect data for the period between 1999 and 2007. As discussed below, the identification strategy relies on the exogeneity of monetary policy, thus requiring using only data for the period after Portugal joined the euro area. We chose to use data only up to 2007, as the transmission of monetary policy has been severely impaired by the global financial crisis (and, more importantly, by the euro area sovereign crisis). As such, we want to test the existence of a risk-taking channel of monetary policy in "normal" conditions, while exploring the exogeneity of the interest rates set by the ECB Governing Council. The period under analysis also allows us to cover a full business cycle.

The most important data source for this article is the Portuguese Central Credit Register (CRC), which is a database managed by Banco de Portugal, covering virtually all bank loans granted in Portugal (all financial institutions granting credit in Portugal are required to, on a monthly basis, report to the CRC all loans granted above 50 euros). The register includes loans granted to firms and households, as well as potential credit liabilities associated with irrevocable commitments. We consider only loans granted to non-financial corporations, as default rates tend to be more cyclical than for households. All financial institutions are allowed to consult information on their current and prospective borrowers, with their previous consent, thus making the CRC a key information-sharing mechanism between banks. The CRC has information on the type of loan, the debtor and the amount, while also including information on loan defaults and renegotiations.

To address our research question, we have to identify episodes of default. We consider that there is a default when a loan is overdue or in litigation during an entire quarter. This avoids mining the data with very short-lived episodes, possibly related to reporting errors or problems in bank payments, for instance.

We also use information on banks' characteristics coming from supervisory quarterly balance sheet data. From all credit institutions with activity during at least one year between 1999 and 2007, we select institutions with a market share of at least 0.1 per cent in the corporate loan market. After this first selection, we have a sample of 89 out of 346 credit institutions. From these, we select only monetary financial institutions, keeping in the end 52 institutions, including 30 banks, 10 mutual agricultural credit banks ("*caixas de crédito agrícola mútuo*"), 1 savings bank ("*caixa económica*") and 11 branches of credit institutions with head office in the EU.

In order to control for firms' characteristics, we also used data from Central Balance-Sheet Database (CBSD). From 2005 onwards, the CBSD has detailed accounting information on all firms operating in Portugal. This information is based on a unique report submitted

by firms to the Ministry of Finance, Ministry of Justice, Statistics Portugal and Banco de Portugal. Until 2005, this database was based on an annual survey, covering a sample of firms. During this period, the database was somewhat biased towards larger firms, which are better represented in the sample. The voluntary nature of the survey during this period explains the smaller number of observations in the regressions that use firm characteristics.

Our unit of observation is a firm-bank relationship in a given quarter. We consider that there is a new loan when there is an increase in the amount of credit granted by a bank to a firm or when there is a new firm-bank relationship.[1] Using quarterly data for the period 1999-2007, we have almost 12 million observations, representing 933 611 different firm-bank relationships. Default episodes account for 7.95 per cent of total observations. On average, each firm has a relationship with three banks and has credit history for 12 quarters.[2] The average amount of each firm's credit per bank is around 234 thousand euro, thus suggesting that we are dealing mainly with micro and small enterprises.

Table 1 presents the definitions of all the explanatory variables considered in the analysis, as well as some descriptive statistics. As discussed below, our analysis relies on several different methodologies, in order to ensure the robustness of the results. These methodologies consider different dependent variables, all of which related to borrower's credit quality: having recent default history (*bad_hist*), currently being in default in any loan (*D_default*), currently being in default with that specific bank (*D_default_bank*), having a loan for the first time (*new_rel*) or having a default in the future (*fut_def*). The most relevant explanatory variable for our analysis is the monetary policy interest rate. Several concepts are considered: the ECB main refinancing rate at the end of each quarter, its quarterly average, and the quarterly average of the EONIA. We also used a measure of the adequacy of the policy stance given by a gap between the main ECB policy rate and the policy rate implied by a Taylor rule.

We also control for a broad set of bank, firm and loan characteristics. Regarding bank characteristics, we control for bank size (*ln(assets)*), liquidity (defined as liquid assets as a percentage of total assets - *liq ratio*), credit quality (the non-performing loans ratio of the bank relative to the ratio for the entire banking sector – *rel npl/assets*), solvency (*capital/assets*). We also control for the bank type (deposit taking financial institution, *savings* bank, agricultural cooperative banks (*CCAM*) and subsidiaries from EU countries (*ICUE*)), for mergers and acquisitions (*M&A*) and for the change to International Accounting Stan-

[1] Unlike Jiménez et al. (2012, 2014), we do not have individual loans data, i.e., we cannot exactly identify when a new loan contract is established or when an old one matures. Nevertheless, we consider that the relevant unit of analysis would still be the relationship between the bank and the firm and not strictly the loan contract.

[2] To compute the duration of credit histories we used data since 1995.

dards (*IAS*). Borrower characteristics are based on the information available in the CRC: number of bank relationships (*#rel*), total amount of credit granted to the firm (*credit*), and number of quarters with credit history (*age*). Further, we control for the logarithm of loan amount (*loan*) and for the share of long term credit (*Credit_LT_prop*). Firms' characteristics are based on the CBSD and include sectoral dummies[3], the age of the firm (*age_firm*), dummies for the size of the firm (*micro*, *small* and *large*, *medium* excluded), the leverage ratio of the firm (*leverage*), the interest over debt ratio (*interest/debt*), the growth rate of sales (*sales*) and the logarithm of the total assets of the firm (*ln(firm_assets)*) Finally, besides including a time trend in many regressions, we also consider the effect of macroeconomic conditions, in particular GDP growth and inflation. Table 1 also includes the description of additional variables used for robustness analysis.

4 Identification strategy and methodology

Our main objective is to test the existence of a risk-taking channel in a bank-based financial system. In other words, we want to assess whether banks grant riskier credit when policy interest rates are lower, either due to very low risk aversion or due to search for yield strategies. Taken at face value, this would mean regressing variables that capture bank risk-taking on the level of interest rates. However, to correctly identify the causal effect of monetary policy on bank risk-taking, monetary policy decisions need to be exogenous. Otherwise, it is possible that there are (omitted) variables that simultaneously affect monetary policy and bank risk-taking decisions. Our setup allows us to avoid this potentially serious endogeneity problem, as monetary policy is fully exogenous during the period analyzed. Portugal is a small open economy that joined the euro area in 1999. The impact of macroeconomic and financial conditions specific to the Portuguese economy on euro area interest rates should be negligible. As such, it is easy to argue that monetary policy is exogenous, thus allowing for the correct identification of this causal effect.

This is the same argument used by Jiménez et al. (2012, 2014) and, to some extent, by Ioannidou et al. (2009) and Geršl. et al. (2012). Indeed, this article follows to some extent part of their empirical strategy but adds extra layers of analysis, with the objective of testing from different perspectives whether there is a risk-taking channel.

Our methodological strategy lies on the following two grand blocks. In the first block, we assess the risk-taking channel with ex-ante information at the intensive and extensive margins. In other words, we assess loan growth to risky borrowers and the probability of

[3]We considered the following sectors: agriculture, fishing, mining, industry (excluded), utilities, construction, commerce, tourism, transports, real estate, other services, education, health and other.

granting new loans to these borrowers, respectively. As such, we focus on the effects of policy interest rates on loan concession by testing two hypotheses: (1) Do firms, and in particular, riskier firms get more credit when policy rates are lower? (section 5.1) and (2) Are banks more likely to lend to ex-ante riskier borrowers when policy rates are lower? (section 5.2). To answer the first question, we run a panel regression with fixed effects on firm loan growth against the policy rate and the recent credit history of the firm, controlling for bank, firm, loan characteristics and macro conditions. In order to test the second hypothesis, we use discrete choice models to assess the probability of borrowers with recent episodes of default or no credit history being granted loans. Granting loans to borrowers with limited historical data increases the expected profitability of banks, while fostering innovation, as shown by Thakor (2013). However, it also increases the risk held by banks. This approach allows us to test whether banks grant more loans to risky borrowers during periods of lower policy interest rates. Our dependent variable takes the value one when a new loan is granted to a borrower defined as risky (and zero when a new loan is granted to any other borrower). It is important to note that the information in the CRC is shared between participating institutions, so that a bank is able to know whether a firm is currently defaulting on any loan, as well as whether the firm has any other outstanding loans.

Positive answers to these questions would mean that there is an expansion of credit to riskier borrowers during the low phase of the interest rate cycle. But will the ex-ante risky borrowers reveal themselves as riskier ex-post? What is the impact in the overall risk assumed by banks and, in the end, what are the consequences in terms of financial stability? Based on previous evidence that shows that firms that have defaulted are more likely to default in the future (Bonfim et al., 2012), we assess the ex-post performance of the loans granted during periods of low interest rates. Again, two hypotheses are tested here: (1) Does the level of the policy rate at loan concession influence the (ex-post) probability of default? (section 6.1) and (2) Are loans granted when policy rates are lower more likely to default when interest rates increase? (section 6.2). In order to test the first hypothesis, we conduct a survival analysis to assess the impact of monetary policy rates at the moment of loan concession on the time until a firm defaults. For the second hypothesis, we use a differences-in-differences (DID) analysis, where we define the loans "treated" as the ones that were granted during a period of low interest rates and we compare the probability of default of these loans against all the others when interest rates increase.

With this broad array of identification strategies, we look at the risk-taking channel of monetary policy from different angles. Our main contribution is thus to shed some light on how different transmission mechanisms of this channel operate.

5 The risk-taking channel assessed with ex-ante information

5.1 Do riskier firms get more credit when policy rates are lower?

Table 2 presents the results of the panel regression with fixed effects on firm loan growth against the monetary policy rate, the recent credit history of the firm and an interaction term between these two, controlling for bank, firm and loan characteristics and macro conditions. The recent credit history of the firm is assessed by the dummy *bad_hist*. We consider that there is a recent bad credit history when the borrower has some credit overdue in the current and in the previous quarter. Since borrowers' credit situation can be verified by any bank through the CRC, we consider that there is bad credit history when the firm is defaulting on any bank loan, i.e., not only on the bank offering the new loan.

With these regressions, we intend to briefly characterize one of the possible transmission mechanisms of the risk-taking channel: do loans to bad borrowers increase more when interest rates are lower? We find that the total amount of credit grows more when interest rates are lower and when the firm has a good track record in terms of credit quality (column I), as expected. The risk-taking channel should be captured by the coefficient associated with the interaction of these two variables. The positive coefficient obtained suggests that the two effects mentioned above are smaller when interest rates are higher. This means that when interest rates are lower, credit granted generally increases, but less for riskier firms. Moreover, riskier firms get even less credit when interest rates are lower. These results work against the risk-taking channel hypothesis, though corroborating the credit channel hypothesis. There is more credit flowing to firms when interest rates decrease, but not specifically to riskier firms.

The risk-taking channel should only capture supply side behaviors in credit markets. Therefore, it is important to control specifically for demand effects, thereby trying to adequately identify supply and demand. This is done by including detailed data at the firm and sectoral level, in addition to the macroeconomic variables (column II). When we include these controls, the statistical significance of the results is weakened.[4]

In sum, we do not find evidence of a risk-taking channel at the intensive margin. Moreover, it is important to note that this methodology does not allow us to fully disentangle the effects of the risk-taking channel from the credit channel. Indeed, these results may simply

[4]The size of the sample decreases substantially when we include bank, loan and firm characteristics fixed at the moment prior to the loan concession mainly due to two reasons: (i) we do not have the lagged data in the beginning of the sample or (ii) there are some periods for which we do not have data on banks or firms, implying the exclusion of the entire loan during its life if it was granted when this data was not available.

imply that banks increase overall lending when interest rates are lower, including also to firms with a higher net worth, under a low interest rate environment. This result is in line with previous evidence obtained for Portugal by Farinha and Marques (2003) on the credit channel. Against this background, the next step in our analysis is to test the existence of the risk-taking channel at the extensive margin.

5.2 Are riskier firms more likely to obtain a loan when interest rates decrease?

In this section, our analysis is based on the estimation of discrete choice models for new bank loans. Given that a new loan is being granted, we evaluate the probability that the borrower has a recent bad credit history or has no credit history. We are interested in studying how monetary policy rates in the quarter prior to loan origination influence the probability of granting loans to these higher risk borrowers. To more accurately identify this effect, we control for several bank, borrower and loan characteristics and also for macro variables.

Table 3 presents the results of the estimation. Overall, we find that lower short-term interest rates increase the probability of banks granting a loan to a borrower with recent episodes of default on loans (columns I to V) or to a new borrower (columns VI to VIII). This result is quite robust to different specifications of the interest rate, namely if one considers either the ECB main reference rate, at end-of-quarter or average, or the EONIA rate.[5]

We also find a negative relationship between bank size, measured by the log of assets, and the probability of granting a loan to a riskier borrower. Indeed, the direct effect of monetary policy on this probability is more pronounced when we include an interaction term between the short-term interest rate and the size of the bank and the negative coefficient obtained from the log of assets is also reinforced (column II). Thus, the probability of granting a loan to a risky borrower is higher for smaller banks (Buch et al., 2011, Kashyap and Stein, 2000).

There are contradictory results in the literature regarding the effect of bank capital. On the one hand, several authors find that banks with higher capital buffers grant more credit (Gambacorta and Mistrulli, 2004, Kishan and Opiela, 2006, Altunbas et al., 2010) or take more risk (Dell'Ariccia et al., 2011), as these banks are less constrained in terms of lending decisions. On the other hand, there is evidence that banks closer to minimum regulatory ratios may take more risk, as they do not fully internalize the potential consequences of the risks taken (Jiménez et al., 2014, Diamond and Rajan, 2012). Our results are consistent

[5] The latter results are not shown here but are available upon request.

with the first line of arguments: banks with more capital are more likely to grant loans to bad quality borrowers.

From the literature, one could also expect that banks with more liquidity would show a riskier behavior, given that managers' incentives to monitor risks decrease (Acharya and Naqvi, 2012, Altunbas et al., 2010). However, our results show the contrary, i.e., less liquid banks are more likely to grant a new loan to an ex-ante risky borrower. This suggests that there is a positive correlation between liquidity and credit risk.

When we include firms' characteristics, thereby controlling for loan demand, the effect of the policy rate is still negative but no longer statistically significant (column III). Thus, we find evidence that when the level of monetary policy rates is lower, banks extend lending at the extensive margin to firms that were riskier in the recent past.

In case one considers the probability of granting credit to firms defaulting in the current quarter instead of in the current and previous quarter (column IV and V), the results remain broadly unchanged. The effect of the monetary policy variable on risk-taking continues to be non-significant when including firm variables.

When assessing the probability of a new firm-bank relationship being established (columns VI to VIII), the results are broadly consistent. The coefficients for the log of assets and for the interaction term are higher (in absolute terms). This may suggest that mostly smaller banks take more risk on granting loans to new borrowers when monetary policy rates are lower.

It is possible to argue that what matters for the risk-taking decision of the bank is not the absolute level of the interest rate, but a relative measure. If monetary policy is too accommodative, banks can have an incentive to engage in riskier activities. Thus, we could look at a measure of the policy stance instead of the level of interest rates (Altunbas et al., 2010). Against this background, we estimated the same regressions using an interest rate gap of the ECB main policy rate against a Taylor rule[6]. The results are presented in Table 4. In case monetary policy is too accommodative, the gap is positive. A positive coefficient on the interest rate gap variable would imply an increase in the probability of granting a new loan to a riskier borrower when monetary policy is over accommodative, thus supporting the existence of a risk-taking channel. We obtain a negative coefficient on the interest rate gap when looking at firms with recent episodes of default (columns I to III), thereby contradicting this hypothesis. On the other hand, when assessing the probability of granting a loan to a new firm, the evidence is in favor of the risk-taking channel, i.e., when policy is over accommodative, the probability of granting a loan to a new firm increases (columns IV

[6] Computed as a forward-looking rule (6 quarters forward for inflation and 4 quarters forward for output gap), based on the Eurosystem macroeconomic projections, with a 1.5 coefficient for inflation and a 0.8 coefficient for the output gap.

to VI). Nonetheless, the size of the coefficient is relatively small. In sum, risky borrowers are not more likely to obtain new loans when monetary policy is too accommodative, though banks seem to be more likely to lend to new borrowers in such periods. However, it should be noted that the use of any measure of monetary conditions is subject to many caveats, as it is very difficult to measure the adequate level of policy rates, even ex-post.

5.2.1 Are small banks riskier?

We also conduct a within borrower comparison in order to further explore whether smaller banks tend to have a riskier behavior (Buch et al., 2011, Kashyap and Stein, 2000). Given that many firms borrow from more than one bank, we are able to explore changes in lending behavior by small and large banks, when at least two banks are lending to the same borrower (Khwaja and Mian, 2008). In this approach, the dependent variable is the quarterly change in the difference between the percentages of loans from small and large banks[7]. In case the firm's funding needs changes, *ceteris paribus*, there is no reason to expect a change in the share of credit obtained from large or small banks. Thus, this change is expected to be null in case only borrowers' demand changes. Otherwise, we would have evidence of a group of banks with a clear risk-taking behavior.

Table 5 presents the results of the panel data estimations with fixed effects at the borrower level and robust standard errors. The table presents two specifications, one including all borrowers with multiple bank relationships (first column) and another including only borrowers with relationships with at least one large and one small bank (second column). The coefficient on the ECB interest rate is negative and significant, but low, thus suggesting that there is a slight increase in loan supply by small banks to all borrowers following an expansion in monetary policy (first column). This effect is more relevant for firms that have loans outstanding with both small and large banks (second column). The coefficient for the *bad_hist* dummy goes along the same lines: it is only significant for firms with loans from both small and large banks and it is positive, confirming that small banks take more risk than large banks. The interaction term between the interest rate and the recent bad credit history does not reinforce the risk-taking effect when monetary policy rates are lower. It is only significant for the regression including all borrowers with multiple relationships and it has a positive coefficient, thus mitigating the risk-taking effect (first column). In sum, the evidence of a more aggressive behavior of small banks on loan granting activity is confirmed, which tends to increase slightly in periods of lower monetary policy rates.

[7] We define a small/large bank as being below/above the median asset size in each quarter.

All in all, the results from the ex-ante analysis do not reject the hypothesis of a risk-taking channel in Portugal, as there is an increased lending activity, at least at the extensive margin, to ex-ante riskier borrowers in periods in which monetary policy rates are lower.

6 The risk-taking channel assessed ex-post

In the previous section we found evidence supporting the risk-taking channel at the extensive margin, but not at the intensive margin. Riskier firms are more likely to obtain a loan when interest rates are lower. But what happens to the loans granted in such periods? Even if bad quality borrowers are more likely to obtain a loan, does that imply an overall deterioration on loan portfolio quality ex-post? To answer these questions, in this section, we turn our attention to the assessment of the effect of policy rates on credit portfolio quality. We do that in two parts. First, we examine the ex-post performance of loans granted to firms, taking into account the level of policy rates at the moment of the loan concession, using a duration analysis framework. Our goal is to test to what extent the level of policy rates when a new loan is granted influences the probability of default of the loan. Second, we distinguish the loans granted when policy rates were low from all the others and analyze what happens to these loans when interest rates increase. We do this by relying on a differences-in-differences approach.

6.1 Does the level of the policy rate at loan concession influence the (ex-post) probability of default?

Using survival analysis, we are able to model the hazard rate of the loans granted to the firms, considering that the failure event is the occurrence of default. The hazard function is defined as the instantaneous probability of a firm defaulting on the bank, conditional on having no default up to time t.

Recall that we consider that a new loan is granted whenever the credit outstanding increases or a new firm-bank relationship is established. A default occurs when the bank classifies a loan as being overdue or in litigation. The time at risk is defined as the time elapsed between these two events. However, it is important to note that it is possible that the default occurs with respect to another loan previously granted by the same bank. We consider that the relevant unit of analysis is the firm-bank relationship instead of the individual loan, given that default in a loan, under certain conditions, may represent also a credit event at the borrower level, from the banks' risk management and provisioning perspectives.

Taking into account the shape of the hazard function of the sample, we estimate a parametric model with a Weibull distribution, which allows for a monotonic hazard function, i.e., the hazard rate either increases or decreases over time according to the Weibull distribution parameter. The Weibull hazard function is given by

$$h(t) = p\lambda t^{p-1}$$

where λ is parameterized as $\lambda_{ij} = \exp(x_{ij}\beta)$. In case $p > 1$ ($p < 1$), the hazard function is monotonically increasing (decreasing). For robustness, we also estimated a Cox proportional hazard model.

Table 6 presents the results of the survival estimation. Columns I to VI present the specifications with time invariant covariates. We also estimated the equations with time varying covariates (columns VII to IX).

The most striking observation is that lower policy interest rates prior to loan concession decrease the hazard rate in most specifications. The effect is more pronounced in the most simple specifications, i.e. when only macro controls and bank variables are included (columns I and II) than when we include firm and loan characteristics (columns III to VI). The most complete specifications do not show a significant effect of the policy interest rate, either taking into account borrower heterogeneity or not (columns III to VI).

The survival analysis results do not support the hypothesis of a risk-taking channel in Portugal, as short-term interest rates at the moment of concession do not seem to significantly influence the loan default probabilities over time. The only exception to these results comes from the specifications with time-varying covariates (columns VII to IX). However, in these cases, we are explicitly considering the role of changing firm, bank and macro characteristics over the life of the loan. As these changes could not be fully anticipated by the bank when deciding to grant a loan, it is not reasonable to argue that banks were taking more risk based solely on these specifications.

Even though the survival analysis is not generally supportive of the existence of a credit risk-taking channel in Portugal, it is important to note that these results are not in contradiction with the previous ones. In the first part, we used discrete choice models to assess how monetary conditions influence loan concession to observable ex-ante riskier borrowers. In this section, we are evaluating how monetary policy rates at loan concession affect borrowers' ex-post probability of default, increasing the credit risk implicit in banks' balance sheet. As banks do not have perfect foresight on borrower quality, the risk-taking behavior on these two situations is quite different: whereas in the former banks were granting loans to borrowers which clearly had poor quality, the decision might not have been so clear in the

latter case. Therefore, results are not contradictory.[8] A possible interpretation is that even though Portuguese banks grant credit to riskier borrowers, which are more likely to default in the future, when monetary policy rates are lower, and loans granted with low policy rates are riskier, the overall risk of banks' loan portfolio does not increase significantly. Thus, these arguments are in favor of the existence of a risk-taking channel in Portugal, but with limited impact in terms of financial stability.

Regarding bank characteristics, we find that banks with a higher liquidity ratio and a lower capital ratio tend to grant loans with lower probability of default, in line with what we found in section 5.2.

Given that Portuguese banks can observe in the CRC the current credit status of borrowers in their outstanding loans and that we do not follow exactly each loan but a borrower-bank relationship, we also conducted the survival analysis considering as the failure event a default of the firm with any bank. This would also be more in line with the previous methodologies, where the relevant default episode is of the firm against any bank. One can also consider that, from a macro perspective, it is more relevant to assess default with any bank, given the possibility of information sharing through the CRC. In this case, the coefficient of the interest rate turns out positive and significant, implying that higher policy rates at the moment of concession lead to a higher likelihood of default in any loan the firm has (columns X to XII).

We also performed additional robustness tests which we do not report, since the main conclusions are not significantly affected. When we include interaction terms between the policy rate and some bank or firms' characteristics the effect of the policy rate continues to be not relevant in any of these specifications. We also controlled for other macro variables, namely credit growth, house prices growth, euro area GDP forecasts and long-term rates, but results are similar to the reported ones. The results of the Cox regression do not provide any relevant addition to our results.

Similarly to section 5.2, we also looked deeper into the behavior of small banks, as there is evidence suggesting that these banks have a more aggressive behavior (Buch et al., 2011). Thus, Table 7 shows the results of the survival analysis considering only loans granted by smaller banks. The coefficient on the interest rate at the moment of loan concession is positive and also significant in the most complete specifications, i.e., when we control for firm characteristics besides bank, loan and macro variables. Thus, from these results we

[8] For robustness purposes, we ran a probit with an interpretation closer to the survival analysis. The dependent variable is a dummy that takes the value one when the firm defaults on a loan. As in other regressions, we control for loan, firm and bank characteristics, as well as for the monetary policy interest rate at the moment the loan was granted. The level of the policy rate prior to loan concession has a positive coefficient. This is, thus, in line with the results of the survival analysis.

cannot argue that smaller banks take on more risk into their loan portfolio than all the other banks when policy rates are lower.

Finally, as in the discrete choice models, we also assessed the impact of using an interest rate gap, instead of the absolute level of interest rates. The results are presented in Table 8, and are more in favor of the existence of a risk-taking channel. The coefficient on the interest rate gap is positive, meaning that the credit risk of the loan portfolio increases when policy is overly accommodative. Nonetheless, one should note that the coefficient is not significant as we introduce controls at the firm level.

We conclude that the results from the survival analysis are not robust enough to support the argument that a risk-taking channel has relevant consequences in terms of financial stability. Though we find significant evidence of this channel when using time-varying covariates or an interest rate gap, the result does not survive an extensive robustness analysis. In the next subsection we look at another possible way to identify the impact of the risk-taking channel on ex-post loan performance.

6.2 Are loans granted when policy rates are lower more likely to default when interest rates increase?

The results of the previous sub-section suggest that loans granted during periods of lower interest rates do not imply a significant deterioration in the overall loan portfolio quality. In this section, we explore a related issue. Instead of analyzing how default probabilities evolve generally for loans granted when interest rates are lower, we focus our attention specifically on what happens when interest rates increase. It should be expected that riskier borrowers are more sensitive to interest rate hikes, which may stretch their debt servicing capacity. Instead of looking at the whole interest rate cycle, we distinguish the loans granted when policy rates were low and stable for a considerable period of time from all the other loans, with the objective of finding what happens to these two groups of loans when rates increase. The mechanism we want to test here is that what matters for banks' risk-taking decision is not only the low level of interest rates, but a prolonged period of low and stable rates with corresponding expectations of maintenance of this more accommodative policy. The period we analyze allows us to do this comparison, as the Eurosystem maintained the main policy interest rate fixed at the historical minimum of 1 per cent during a period of more than two years (between June 2003 and December 2005). As far as we know, this is a mechanism that has not been tested in the literature and that can provide us with relevant information to better understand the effects of monetary policy.

Against this background, we use a differences-in-differences approach (DID). We compare two groups of loans: the "treatment" group includes the loans granted during a period of low interest rates (2003-Q3 to 2005-Q4) and the "non-treated" group which includes all other loans (granted before 2003-Q3 and after 2005-Q4). These two groups are compared in two different moments: before and after the interest rate starts to increase (*post-treatment*), in 2006.

Table 9 presents the results of the DID estimation, where we estimate a probit model for the probability of default of the firm[9] against the DID variables and bank, firm, loan and macro controls. We obtain a negative coefficient on the *treatment* variable (column I). This means that loans granted when interest rates are low are less likely to default, what is somewhat in line with the evidence obtained using duration models. The coefficient on the *post-treatment* variable is also negative, thus suggesting that when interest rates increase, default probabilities are actually lower, in contrast to what could be expected. It should be noted that this result holds even when controlling for bank, loan, firm, sector and macro variables (column II).

The coefficient on the interaction term provides the main test to our hypothesis. The coefficient is positive and significant, meaning that loans granted in the period of low interest rates are more likely to default when interest rates increase than firms with loans granted before the low interest rate period. Thus, this suggests that indeed Portuguese banks take more credit risk when policy rates are low relative to other phases of the cycle.

These regressions include the entire sample of loans, which includes short-term loans and rollovers, which can contaminate our results. To overcome this, we restricted the regressions only to loans classified as long-term (loans with initial maturity of above one year). Results are presented in columns III and IV and are again in favor of a risk-taking channel. The most relevant difference is that, when we control for bank, loan and macro variables (column III), long-term loans granted when policy rates were low are always more likely to default and even more when policy rates increase. So indeed we can argue that banks tend to take on more risk during prolonged periods of low and stable interest rates. When we control also for firm characteristics (column IV), the *treatment* coefficient is no longer significant, i.e., there is no significant difference in the probability of default, unconditional to any period, between loans granted during low policy rates periods and all other loans.

As such, this result provides strong support to the existence of a risk-taking channel in prolonged periods of low interest rates. Nonetheless, the overall impact of this channel

[9]For consistency reasons with previous sections, we considered default episodes in two consecutive quarters. The results are robust to the consideration of default in only one quarter.

may be of a relatively limited dimension, as the overall quality of the loan portfolio is not threatened by the loans granted in periods of low interest rates.

7 Concluding remarks

In this paper, we tested whether banks take more risk in their balance sheets when monetary policy interest rates are lower. We try to address this issue through different angles, to capture different possible transmission mechanisms of the risk-taking channel. Our analysis was based on four blocks: (i) a panel regression on the firm loan growth to assess its determinants, in particular the level of interest rates (intensive margin), (ii) discrete choice models to assess the probability of borrowers with bad credit history or no credit history being granted loans (extensive margin), (iii) a survival analysis to assess the impact of monetary policy rates at the moment of loan concession on the time until a firm defaults, and (iv) a DID estimation to compare the likelihood of default between loans granted when interest rates are low and in other periods when interest rates increase.

We obtain consistent evidence that banks increase their risk at the extensive margin when interest rates are lower. Bad quality borrowers have a higher probability of being granted a loan in such periods. Smaller banks tend to be slightly more aggressive in loan concession activity in these periods. However, the results are not significant at the intensive margin.

Do these decisions on grating loans to ex-ante risky borrowers really imply an increase in the ex-post risk of the banks' balance sheet? To test this hypothesis, we proceeded to a different type of analysis, focused on the impact of policy rates on the loan portfolio quality. Survival models do not generally support the risk-taking hypothesis. The level of interest rates at the moment of the loan concession does not have a significant impact on the overall loan portfolio quality. However, the DID estimation provides evidence in favor of a risk-taking channel, as loans granted when interest rates were low have a higher likelihood of default than loans granted in other periods, in the hiking phase of the interest rate cycle.

In sum, our results suggest that the risk-taking channel works through two main mechanisms. First, we find consistent evidence that in periods of lower policy interest rates banks are more likely to grant loans to borrowers with worse credit quality. Second, the loans granted when policy rates were low for a relatively long period are more likely to default when interest rates increase. Jointly, these results suggest that there is a risk-taking channel operating in Portugal. However, in terms of the overall ex-post quality of the loan portfolio, there is no significant impact from the level of policy rates. Indeed, our results show that increased risk-taking is more associated with a prolonged period of low interest rates rather

than to its level *per se*. Interactions between monetary policy and financial stability should be especially taken into account during these periods.

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Table 1
Variables description and some descriptive statistics

	Description	Unit	Obs	Mean	Std. Dev.	Min	Max
Dependent variables							
Probit							
bad_hist	Dummy =1 if the borrower had overdue credit in the current and in the previous quarter; = 0 otherwise	-	11772002	0.109	0.311	0	1
D_default	Dummy =1 if the borrower had overdue credit in the current quarter; = 0 otherwise	-	10806094	0.155	0.362	0	1
new_rel	Dummy =1 if the borrower started a new bank relationship with the specific bank; = 0 otherwise	-	11772002	0.057	0.233	0	1
fut_def	Dummy =1 if the borrower has overdue credit in future quarters; =0 otherwise	-	11772002	0.168	0.373	0	1
Condition							
new_loan	Dummy =1 if the borrower had an increase in the total amount or a new bank relationship; = 0 otherwise	-	11772002	0.305	0.461	0	1
Survival							
D_default_bank	Dummy =1 if the borrower had overdue credit in the current quarter with the specific bank; = 0 otherwise	-	11772002	0.080	0.271	0	1
Independent variables							
Monetary Policy Rates							
i ECB eoq	ECB main refinancing rate at the end of the quarter	%	11772002	2.978	0.885	2	4.75
i ECB av	Quarterly average of the ECB main refinancing rate	%	11772002	2.963	0.869	2	4.75
i EONIA av	Quarterly average of the EONIA	%	11772002	3.025	0.877	2.01	4.84
i gap eoq	Interest rate gap computed using a Taylor rule	p.p.	11772002	1.708	1.515	0	4
Bank characteristics							
ln(assets)	Logarithm of the total assets of the bank	EUR	11536811	23.419	1.662	16.70	25.19
liq ratio	The amount of liquid assets over total assets. Included in total assets: cash, balances with the central bank, loans and advances to credit institutions, loans and advances to the public sector, gold and other precious metals for the old accounting standards; cash, loans and advances to credit institutions and other loans and advances for the IAS.	%	11536811	18.475	10.809	0.00	82.87
rel npl/assets	Difference between the bank ratio of non performing loans over total assets and the average ratio for all banks	%	11536811	-1.953	2.250	-3.79	22.55
capital/assets	Ratio of the balance sheet capital over total assets	%	11432772	4.819	2.462	0.07	37.99
savings	Dummy = 1 if the bank is a saving bank; = 0 otherwise	-	11772002	0.033	0.179	0	1
CCAM	Dummy = 1 if the bank is a mutual agricultural credit bank; = 0 otherwise	-	11772002	0.023	0.150	0	1
ICUE	Dummy = 1 if the bank is a branch of a credit institution with head office in the EU; = 0 otherwise	-	11772002	0.037	0.189	0	1
M&A	Dummy = 1 if the banks was involved in a merger in the respective quarter; = 0 otherwise	-	11772002	0.051	0.220	0	1
IAS	Dummy = 1 for the quarter for which the bank switched from the old accounting standards to the IAS	-	11772002	0.032	0.175	0	1
Borrower characteristics							
#rel	Number of bank relationships of the firm		11772002	3.057	2.424	1	38
credit	The total amount of credit of the firm	EUR	11772002	1,040,303	12,800,000	0	4,520,000,000
age	Number of quarters that the firm has credit		11772002	23.785	13.510	0	51
ln(1+#rel)	Logarithm of 1 plus the number of bank relationships of the firm		11772002	1.264	0.499	0.693	3.66
ln(credit)	Logarithm of the total amount of credit of the firm		10806094	11.139	2.763	-29.934	22.23
ln(2+age)	Logarithm of 2 plus the number of quarters that the firm has credit		11772002	3.048	0.730	0.693	3.97
Firm characteristics							
sectoral dummies	13 dummies for economic sectors: agriculture, fishing, mining, industry (excluded), utilities, construction, commerce, tourism, transports, real estate, other services, education, health and other						
age_firm	Number of years as a firm		1319075	22.800	17.552	2	251
micro	Dummy = 1 if it is a micro firm		1319075	0.236	0.425	0	1
small	Dummy = 1 if it is a small firm		1319075	0.388	0.487	0	1
large	Dummy = 1 if it is a large firm		1319075	0.097	0.296	0	1
leverage	Ratio between the amount of loans and bonds over total assets	%	1319075	21.150	18.342	0	83
interest/debt	Ratio of interest over debt	%	1306803	2.821	2.157	0	12
sales	Growth rate of sales	%	1072734	3.280	31.862	-100	251
ln(firm assets)	Logarithm of the total assets of the firm		1319075	14.841	1.832	3.970	23
Loan characteristics							
loan	Total credit granted by the bank to the borrower		11772002	234,358	4,398,536	0	4,520,000,000
ln(1+loan)	Logarithm of 1 plus the total credit granted by the bank to the borrower		11772002	8.457	4.201	0	22.23
Cred_LT_prop	Share of long term credit on the sum of short and long-term credit	%	10222954	48.769	39.713	0	100
Macro controls							
BLS	Portuguese banks replies to the BLS question about changes in the perception of NFC overall loans demand relative to the previous quarter (diffusion index)	%	7739212	-0.001	0.102	-0.20	0.20
GDP PT	Portuguese GDP y-o-y quarterly growth rate	%	11772002	1.612	1.592	-1.90	5.10
π PT	Quarterly inflation rate (HICP)	%	11772002	2.926	0.702	1.90	4.40
trend	Time trend						
Difference-in-difference							
treatment	Dummy = 1 if the loan was granted when interest rates were low (2003Q3-2005Q4)		11772002	0.358	0.479	0	1
post-treatment	Dummy =1 for the period following the low interest rate period (from 2006Q1 onwards)		11772002	0.263	0.440	0	1
interaction	treatment*post-treatment		11772002	0.165	0.371	0	1
Robustness							
10y PT av	Quarterly average of the 10-year Portuguese Government bond yield	%	11772002	4.427	0.684	3.17	5.75
10y PT eoq	10-year Portuguese Government bond yield at the end of the quarter	%	11772002	4.424	0.700	3.12	5.62
NFC credit PT	Quarterly growth of credit to non financial corporations in Portugal	%	11772002	10.939	8.788	0.80	29.00
house p PT	Quarterly growth in house prices in Portugal	%	11772002	2.922	2.943	0.00	9.83
GDP EA	One year ahead forecast for the euro area GDP based on the Eurosystem MPE	%	11772002	2.204	0.464	1.21	3.40

Table 2
Results of the panel regression with fixed effects

	Dependent variable: credit_growth	
	I	II
	Coef.	Coef.
	S.e.	*S.e.*
i ECB eoq $_{t-1}$	-0.008 ***	-0.006 **
	0.001	*0.003*
bad_hist $_{t-1}$	-0.045 ***	-0.030
	0.006	*0.020*
i*bad_hist $_{t-1}$	0.009 ***	0.004
	0.002	*0.007*
liq_ratio $_{t-1}$	-0.001 ***	-0.001 ***
	0.000	*0.000*
capital/assets $_{t-1}$	-0.001	-0.003 **
	0.000	*0.001*
bank variables	yes	yes
loan variables	yes	yes
firm variables	no	yes
sectoral dummies	no	yes
macro variables	yes	yes
Nº obs.	7,030,429	862,560
R^2 overall	0.0599	0.0583
Prob > F	0	0

Note: * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.
All variables defined in Table 1.

Table 3
Results of the probit estimation

	Dependent variable: bad_hist			Dependent variable: default		Dependent variable: new_bor		
	I	II	III	IV	V	VI	VII	VIII
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	S.e.	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*
i ECB eoq $_{t-1}$	-0.043 ***	-0.208 ***	-0.012	-0.146 ***	0.024	-0.028 ***	-0.280 ***	0.405
	0.003	*0.032*	*0.152*	*0.027*	*0.109*	*0.002*	*0.019*	*0.330*
i*ln(assets) $_{t-1}$		0.007 ***	-0.000	0.005 ***	-0.001		0.011 ***	-0.021
		0.001	*0.006*	*0.001*	*0.005*		*0.001*	*0.014*
ln(assets) $_{t-1}$	-0.042 ***	-0.064 ***	-0.007	-0.069 ***	-0.013	-0.055 ***	-0.089 ***	-0.009
	0.002	*0.005*	*0.023*	*0.004*	*0.016*	*0.001*	*0.003*	*0.051*
liq_ratio $_{t-1}$	-0.007 ***	-0.007 ***	0.001	-0.006 ***	0.000	-0.007 ***	-0.007 ***	-0.008 ***
	0.000	*0.000*	*0.001*	*0.000*	*0.001*	*0.000*	*0.000*	*0.003*
capital/assets $_{t-1}$	0.021 ***	0.022 ***	0.021 ***	0.023 ***	0.019 ***	0.009 ***	0.010 ***	-0.005
	0.001	*0.001*	*0.005*	*0.001*	*0.004*	*0.001*	*0.001*	*0.013*
bank variables	yes	yes	yes	yes	yes	yes	yes	yes
loan variables	yes	yes	yes	yes	yes	yes	yes	yes
firm variables	no	no	yes	no	yes	no	no	yes
sectoral dummies	no	no	yes	no	yes	no	no	yes
macro variables	yes	yes	yes	yes	yes	yes	yes	yes
Nº obs.	2,655,604	2,655,604	319,023	2,655,604	319,023	3,320,469	3,320,469	349,484
Log pseudolikel.	-660,740	-660,710	-31,429	-859,839	-53,272	-634,716	-634,808	-2,073
Prob > chi2	0	0	0	0	0	0	0	0

Note: * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

All variables defined in Table 1.

Table 4
Results of the probit estimation - interest rate gap

	Dependent variable: bad_hist			Dependent variable: new_bor		
	I	II	III	IV	V	VI
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	S.e.	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*
i gap eoq $_{t}$	-0.043 ***	-0.062 ***	-0.024 *	0.012 ***	0.006 **	0.011
	0.003	*0.003*	*0.014*	*0.002*	*0.002*	*0.036*
i*ln(assets) $_{t-1}$		-0.003 ***	-0.002		-0.001 ***	-0.003
		0.000	*0.001*		*0.000*	*0.002*
ln(assets) $_{t-1}$	-0.044 ***	-0.034 ***	-0.003	-0.055 ***	-0.052 ***	-0.065 ***
	0.002	*0.002*	*0.009*	*0.001*	*0.001*	*0.021*
liq_ratio $_{t-1}$	-0.006 ***	-0.007 ***	0.001	-0.007 ***	-0.007 ***	-0.008 ***
	0.000	*0.000*	*0.001*	*0.000*	*0.000*	*0.003*
capital/assets $_{t-1}$	0.024 ***	0.023 ***	0.022 ***	0.010 ***	0.009 ***	-0.003
	0.001	*0.001*	*0.005*	*0.001*	*0.001*	*0.013*
bank variables	yes	yes	yes	yes	yes	yes
loan variables	yes	yes	yes	yes	yes	yes
firm variables	no	no	yes	no	no	yes
sectoral dummies	no	no	yes	no	no	yes
macro variables	yes	yes	yes	yes	yes	yes
Nº obs.	2,655,604	2,655,604	319,023	3,320,469	3,320,469	349,484
Log pseudolikel.	-660,642	-660,330	-31,425	-634,869	-634,824	-2,073
Prob > chi2	0	0	0	0	0	0

Note: * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

All variables defined in Table 1.

Table 5
Within borrower comparison analysis

	All borrowers	Borrowers with small and large banks
	Coef. *S.e.*	Coef. *S.e.*
i ECB eoq $_{t-1}$	-0.001 *** *0.000*	-0.005 *** *0.001*
i*bad_hist $_{t-1}$	0.001 *** *0.000*	-0.004 *0.002*
bad_hist $_{t-1}$	0.000 *0.001*	0.025 *** *0.007*
ln(credit) $_{t-1}$	0.003 *** *0.000*	0.045 *** *0.002*
GDP PT $_{t-1}$	-0.003 *** *0.000*	0.010 *** *0.001*
trend	-0.002 *** *0.000*	0.001 *0.001*
trend^2	0.000 *** *0.000*	-0.000 *** *0.000*
constant	-0.014 *** *0.002*	-0.440 *** *0.028*
Nº obs.	3,035,927	390,103
R^2 overall	0.0004	0.0006
Prob > F	0	0

Note: * significance at 10 per cent; ** significance at 5 per cent; ***
The dependent variable is the quarterly change in the difference between the percentages of borrowing from small and large banks. The first column regression includes all borrowers with multiple bank relationships; the
All variables defined in Table 1.

Table 6
Survival analysis results

	non-time varying						time-varying			default with any bank		
	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.
	S.e.	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*	*S.e.*
i ECB eoq (loan) $_{t-1}$	0.107 ***	0.071 ***	0.016	0.019	0.103	0.103	-0.013 ***	-0.055 ***	-0.009	0.151 ***	0.451 ***	0.311 ***
	0.006	*0.005*	*0.017*	*0.022*	*0.114*	*0.134*	*0.005*	*0.005*	*0.021*	*0.009*	*0.082*	*0.087*
bad_hist $_{t-1}$			1.821 ***	2.350 ***	1.788 ***	2.390 ***	1.483 ***	1.515 ***	2.308 ***			
			0.036	*0.059*	*0.214*	*0.345*	*0.013*	*0.013*	*0.054*			
liq_ratio $_{t-1}$		-0.011 ***	-0.007 ***	-0.004 ***	-0.006	-0.006	-0.011 ***	-0.014 ***	-0.010 ***	-0.007 ***	-0.009 **	-0.011 *
		0.000	*0.001*	*0.001*	*0.007*	*0.008*	*0.001*	*0.001*	*0.003*	*0.001*	*0.004*	*0.007*
capital/assets $_{t-1}$		0.035 ***	0.067 ***	0.106 ***	0.109 **	0.123 **	0.034 ***	0.045 ***	0.043 ***	0.021 ***	0.085 ***	0.016
		0.001	*0.007*	*0.009*	*0.047*	*0.060*	*0.001*	*0.001*	*0.008*	*0.005*	*0.031*	*0.051*
trends	yes	yes	yes	yes	yes	yes	yes	no	no	yes	yes	yes
bank variables	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
loan variables	no	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
firm variables	no	no	no	no	yes	yes	no	no	yes	no	yes	yes
sectoral dummies	no	no	no	no	yes	yes	no	no	yes	no	yes	yes
macro variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
shared frailty bank	yes	no	no	no	no	no	no	no	no	no	no	no
shared frailty NFC	no	no	no	yes	no	yes	yes	yes	no	no	no	yes
Nº obs.	5,523,670	7,087,951	1,384,696	1,384,696	81,737	81,737	5,833,210	5,833,210	629,146	1,178,375	68,768	68,768
Log pseudolikel.	-262,155	-358,391	-46,713	-44,823	-1,506	-1,472	-224,247	-224,696	-9,617	-64,843	-2,964	-2,758
Prob > chi2	0	0	0	0	0	0	0	0	0	0	0	0

Notes: * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

t refers to the moment when the loan is granted. i ECB eoq (loan) and GDP PT (loan) are fixed to the moment prior to the loan concession.

All variables defined in Table 1.

Table 7
Survival analysis results - small banks (below median) only

	non time-varying				
	I	II	III	IV	V
	Coef.	Coef.	Coef.	Coef.	Coef.
	S.e.	*S.e.*	*S.e.*	*S.e.*	*S.e.*
i ECB eoq (loan) $_{t-1}$	0.060 ***	0.064 ***	0.008	0.472 ***	0.536 ***
	0.008	*0.008*	*0.034*	*0.178*	*0.204*
bad_hist $_{t-1}$			2.536 ***	1.948 ***	2.274 ***
			0.085	*0.347*	*0.459*
liq_ratio $_{t-1}$		-0.010 ***	-0.004 *	0.009	0.010
		0.001	*0.002*	*0.010*	*0.010*
capital/assets $_{t-1}$		0.033 ***	0.078 ***	0.032	0.011
		0.001	*0.011*	*0.076*	*0.091*
trends	yes	yes	yes	yes	yes
bank variables	no	yes	yes	yes	yes
loan variables	no	no	yes	yes	yes
firm variables	no	no	no	yes	yes
sectoral dummies	no	no	no	yes	yes
macro variables	yes	yes	yes	yes	yes
shared frailty bank	yes	no	no	no	no
shared frailty NFC	no	no	yes	no	yes
Nº obs.	2,494,751	3,225,573	749,933	30,101	30,101
Log pseudolikel.	-126,182	-173,926	-26,136	-530	-529
Prob > chi2	0	0	0	0	0

Notes: * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.
t refers to the moment when the loan is granted. i ECB eoq (loan) and GDP PT (loan) are fixed to the moment prior to the
All variables defined in Table 1.

Table 8
Survival analysis results - interest rate gap

	non-time varying				
	I	II	III	IV	V
	Coef.	Coef.	Coef.	Coef.	Coef.
	S.e.	*S.e.*	*S.e.*	*S.e.*	*S.e.*
i gap eoq (loan) $_{t-1}$	0.045 **	0.048 **	0.106 ***	0.017	-0.071
	0.022	*0.020*	*0.027*	*0.126*	*0.147*
bad_hist $_{t-1}$			2.351 ***	1.785 ***	2.400 ***
			0.059	*0.214*	*0.347*
liq_ratio $_{t-1}$		-0.008 ***	-0.004 ***	-0.006	-0.005
		0.001	*0.001*	*0.007*	*0.008*
capital/assets $_{t-1}$		0.064 ***	0.105 ***	0.108 **	0.125 **
		0.006	*0.009*	*0.047*	*0.060*
trends	yes	yes	yes	yes	yes
bank variables	no	yes	yes	yes	yes
loan variables	no	no	yes	yes	yes
firm variables	no	no	no	yes	yes
sectoral dummies	no	no	no	yes	yes
macro variables	yes	yes	yes	yes	yes
shared frailty bank	yes	no	no	no	no
shared frailty NFC	no	no	yes	no	yes
Nº obs.	1,175,254	1,504,279	1,384,696	81,737	81,737
Log pseudolikel.	-40,074	-53,660	-44,816	-1,521	-1,487
Prob > chi2	0.007	0	0	0	0

Notes: * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

t refers to the moment when the loan is granted. i ECB eoq (loan) and GDP PT (loan) are fixed to the moment prior to th

All variables defined in Table 1.

Table 9

Results of the differences-in-differences approach (dependent variable bad_hist)

	All loans		Only long-term loans	
	I	II	III	IV
	Coef.	Coef.	Coef.	Coef.
	S.e.	*S.e.*	*S.e.*	*S.e.*
treatment $_t$	-0.052 ***	-0.109 ***	0.215 ***	-0.042
	0.006	*0.025*	*0.011*	*0.082*
post_treatment $_t$	-0.280 ***	-0.175 ***	-0.201 ***	-0.242 **
	0.008	*0.043*	*0.015*	*0.116*
interaction $_t$	0.230 ***	0.250 ***	0.128 ***	0.276 ***
	0.007	*0.031*	*0.014*	*0.095*
liq_ratio $_{t-1}$	0.001 ***	0.002 **	0.004 ***	0.008 ***
	0.000	*0.001*	*0.000*	*0.003*
capital/assets $_{t-1}$	0.009 ***	0.008 **	0.022 ***	0.015 *
	0.001	*0.003*	*0.001*	*0.008*
bank variables	yes	yes	yes	yes
loan variables	yes	yes	yes	yes
firm variables	no	yes	no	yes
sectoral dummies	no	yes	no	yes
macro variables	yes	yes	yes	yes
Nº obs.	8,781,008	948,702	1,504,717	56,827
Log pseudolikel.	-2,343,619	-112,753	-426,345	-7,428
Prob > chi2	0	0	0	0

Note: * significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 per cent.

All variables defined in Table 1.

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