IS THERE A RISK-TAKING CHANNEL OF MONETARY POLICY IN 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, by testing whether Portuguese banks grant more risky loans when monetary policy interest rates are lower. Our results show that banks grant more loans to non-financial corporations with recent defaults or without credit history when policy interest rates are lower. Even though these loans turn out to have higher *ex-post* default probabilities, as expected, the overall loan portfolio does not show an increase in the likelihood of default in the aftermath of a period of lower monetary policy rates. All in all, the evidence on the risk-taking channel in Portugal is not as strong as in other countries where similar methodologies were implemented. The results obtained are generally more supportive of the credit channel hypothesis than of a pure risk-taking channel.

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 behaviour, usually labelled as the risk-taking channel. 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, most notably in what concerns empirical studies. 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 increased 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.

This article intends to test whether there is a risk-taking channel in Portugal, adapting the methodology proposed by Jiménez, Ongena, Peydró and Saurina (2008). Using data on loans to non-financial corporations from the Portuguese Central Credit Register for the period between 1999 and 2007, we

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assess whether banks grant riskier credit when policy interest rates are lower. This is a relevant issue for central banks, as it allows analyzing the impact of its policy decisions in a broader perspective, while also illustrating the links between financial stability and monetary policy. Our results partly support the existence of a risk-taking channel in Portugal, at least *ex-ante*. When monetary policy interest rates are lower, banks are more likely to grant credit to borrowers currently perceived as riskier. However, the loans granted during periods of low interest rates do not show overall higher default probabilities, thus not supporting the existence of a fully-fledged risk-taking channel in Portugal. As such, although there is some increased risk-taking behaviour of banks when policy rates are at a lower level, this does not translate into a worse *ex-post* performance of overall loan quality, thus suggesting that Portuguese banks were not less prudent in their lending decisions. All in all, our results are more supportive of the credit channel hypothesis than of a pure risk-taking channel.

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. Section 5 presents and discusses the results. These are built on three blocks. First, we use discrete choice models to assess the probability of borrowers with bad credit history or no credit history being granted loans when policy interest rates are lower. Second, we test whether smaller banks are more prone to risk-taking in these periods. Third, we conduct a survival analysis to assess the impact of monetary policy rates at the time of loan concession on the time until a firm defaults. Section 6 summarizes our main findings.

2. LITERATURE REVIEW

Since the onset of the financial crisis, there has been an increasing interest on the links between financial stability and monetary policy.¹ One of the recent avenues of research has focused on the transmission of monetary policy through banks' risk-taking (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, with some contributions coming from Dell'Ariccia *et al.* (2011), Borio and Zhu (2012), Adrian and Shin (2008, 2010), 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). This is especially the case for financial institutions with long-term commitments such as pension funds. When policy interest rates are low and expected to remain low for an extended period of time, these institutions have incentives to invest in riskier assets in order to increase their return and be able to meet their commitments. Otherwise they would have to renegotiate or default (Brunnermeier, 2001, and Rajan, 2006). For instance, a bank may increase loan spreads, thus ending up with a larger percentage of riskier borrowers (Freixas and Rochet, 2008).

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. The lower cost of funding gives them an incentive to increase leverage, the degree of which depends on whether the capital structure is determined endogenously (because higher leverage increases funding costs) (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, 2010) argue that banks that actively manage

¹ See Gameiro et al. (2011) for a literature review on these issues.

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. In the Diamond and Rajan (2012) model, this mechanism operates solely with expectations of low interest rates at times of financial stress, raising the same need for central bank intervention. Such expectations create incentives to increase short-term leverage and illiquid loans, which increases banks' vulnerability in case households' deposits withdrawals increase in the future. This happens in a model where banking sector liquidity difficulties come from the mismatch between the long maturity of loans and the demandable nature of households' deposits, together with uncertainty about households' future endowments (Diamond and Dybvig, 1983).

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 may also lead the central bank to loosen its monetary policy. When macroeconomic risk is high, there is a 'flight to quality' in the sense that agents prefer deposits in banks instead of direct investment in projects, flooding the bank with liquidity. In this situation, the bank manager sensitivity to the credit risk of loans decreases, leading to excessive credit. This is equivalent to loans' rate falling below its first best and asset prices rising above fundamentals. If the central bank loosens monetary policy in this scenario, it is fuelling the asset price bubble and inducing the excessive risk-taking by banks.

It should be noted that the risk-taking channel differs from the credit channel in several important dimensions. 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. As more loans are granted, more risky projects get financed, so the risk taken into banks' balance sheet rises (Bernanke and Blinder, 1988, Disyatat, 2011). In turn, the balance sheet channel is based on the financial accelerator concept (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. 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 granted by Spanish credit institutions, Jiménez et al. (2008) find robust evidence that low short-term interest rates imply a softening in lending standards and an increase in loans to borrowers with bad or no credit history. Moreover, they find that banks approve loans that have a higher ex-ante and ex-post probability of default. Using a similar methodology for a Bolivian loans database, loannidou et al. (2009) also find evidence that banks increase risk-taking when monetary policy rates are lower. This behaviour 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.

From a broad risk perspective on the economy, there is evidence that in the short-run lower interest rates decrease the total credit risk of the banking sector, since the impact via the decrease in the credit risk of outstanding loans is more significant (Jiménez *et al.*, 2008, Altunbas *et al.*, 2010). However, in the medium-term, the total credit risk may increase, especially when a period of low interest rates is followed by a severe recession or monetary contraction (Jiménez *et al.*, 2008, Altunbas *et al.*, 2010).

Available empirical evidence suggests that there is some heterogeneity in bank risk-taking behaviour. Jiménez *et al.* (2008) find that this behaviour is more pronounced for small and commercial banks, while banks with more own funds and more liquidity are usually more precautionary regarding the loans granted. 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 that are involved in more non-traditional banking activities take more risk. Buch *et al.* (2011) find that only small domestic banks adopt risk-taking behaviours during periods of low interest rates, while foreign banks decrease their risk-taking and large banks do not show a meaningful change in behaviour. Ioannidou *et al.* (2009) observe some heterogeneity among Bolivian banks. They find that the risk-taking effect when policy interest rates are low is stronger for 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 relevance 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 also been 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 article contributes to this literature by empirically testing the existence of a risk-taking channel in the Portuguese banking system, using micro data on bank loans to non-financial corporations.

3. Data

We collect data for the period between 1999 and 2007. As discussed below, the identification strategy used 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 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, on a monthly basis to 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. In this article, 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 using 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.

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 relationship². 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 quarters³. 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 above, our analysis relies on several different methodologies, in order to ensure the robustness of the results. These methodologies consider on 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*) or currently being in default with that specific bank (*D_default_bank*). 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 control for a broad set of bank, borrower and loan characteristics. Regarding bank characteristics, we control for bank size (*In(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 Standards (*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*). Finally, besides including a time trend in many regressions, we also

² Unlike Jiménez *et al.* (2008), 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.

³ To compute the duration of credit histories we used data since 1995.

Table 1 (continue)

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		
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		
Independen	t variables								
Monetary Po	licy 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		
Bank charact	eristics								
ln(assets) liq ratio	Logarithm of the total assets of the bank The amount of liquid assets over total assets. Included in total assets: cash, balances with the central bank, loans and advances to credit	EUR	11536811	23.419	1.662	16.70	25.19		
	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 in which the bank switched from the old accounting standars to the IAS	-	11772002	0.032	0.175	0	1		

VARIABLES DESCRIPTION AND SOME DESCRIPTIVE STATISTICS									
	Description	Unit	Obs.	Mean	Std. Dev.	Min	Max		
Borrower cha	aracteristics								
#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	12.8 x 10 ⁶	0	4.5 x 10 ⁹		
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		
In(credit)	Logarithm of the total amount of credit of the firm		10806094	11.139	2.763	-29.934	22.23		
In(2+age)	Logarithm of 2 plus the number of quarters that the firm has credit		11772002	3.048	0.730	0.693	3.97		
Loan charact	eristics								
loan	Total credit granted by the bank to the borrower		11772002	234 358	4.4 x 10 ⁶	0	4.5 x 10 ⁹		
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_pro	o Share of long term credit on the sum of short and long-term credit	%	10222954	48.769	39.713	0	100		
Macro contro	ols								
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		
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 P1	C 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 1 (continuation)

Sources: Banco de Portugal and authors' calculations.

consider the effect of Portuguese GDP growth and inflation.⁴ Table 1 also includes the description of additional variables used for robustness analysis.

4. IDENTIFICATION STRATEGY

Our main objective is to test if there is a risk-taking channel in Portugal. 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 analysed. 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.* (2008) and, to some extent, by Ioannidou *et al.* (2009) and Geršl. *et al.* (2012). Indeed, this article closely replicates their empirical strategy, with the objective of testing whether there is a risk-taking channel in the Portuguese economy. As such, our methodological strategy lies on three main blocks, as in Jiménez et al. (2008).

First, we use discrete choice models to assess the probability of borrowers with bad credit history or no credit history being granted loans.⁵ This approach allows us to test whether banks grant more loans to riskier borrowers during periods of lower policy interest rates⁶. 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.

Second, we explore the results of within borrower regressions, to test whether smaller banks are more prone to risk-taking when policy interest rates are lower. We are able to do this because most borrowers have more than one bank relationship, thus allowing us to test the behaviour of different banks towards the same firm.

Third, we conduct a survival analysis to assess the impact of monetary policy rates on the time until a firm defaults. Whereas in the first two parts we examine the probability of granting a loan to borrowers that show recent evidence of acute financial distress, materialized in a default, or for which there is no credit history available, in this part we examine the *ex-post* credit quality of the borrowers. In other words, we examine whether loans granted in periods of lower policy interest rates display higher future default probabilities.

⁴ We also computed a country risk measure (the spread between 10-year Portuguese and German government bond yields), but this variable was not included in the results presented in this article due to its high correlation with GDP growth.

⁵ 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.

⁶ It should be noted that this analysis may be somewhat biased due to selection issues, as the data includes only approved loans. However, our dataset does not allow us to overcome this problem.

5. RESULTS

5.1 Granting loans to (ex-ante) risky borrowers

In this section, our analysis is based on the estimation of discrete choice models for new bank loans. We evaluate the probability of a new loan being granted given that the borrower has a recent bad credit history or that the borrower has no credit history. 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. We are interested in studying how monetary policy rates in the quarter prior to loan origination influences 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 (defined in detail in Table 1).

Table 2 presents the results of the estimation using as dependent variable the dummy *bad_hist*, which equals one when the borrower has credit overdue in the current and previous quarter. 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. This result is quite robust to different specifications, namely if one considers either the ECB main reference rate, in end-of-quarter (columns I and II), average quarter values (column III), or the quarterly average of the EONIA rate (column IV). This impact is slightly higher than the one found by Jiménez *et al.* (2008). We find consistent evidence that banks increase lending to firms that were riskier in the recent past when the level of monetary policy rates is lower. If this corresponds truly to bank risk-taking, then, from a prudential viewpoint, it suggests that loose monetary policy may contribute to the increase of risks in banks' balance sheets, thus sowing the seeds for a potential future deterioration of banks' asset quality. However, it is possible that this result does not necessarily imply a risk-taking channel, but may rather be evidence of a credit channel. Indeed, these results may simply 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.

There seems to be 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 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 (column II). Indeed, the coefficient of this term is slightly positive and the coefficient for the policy variable decreases further, meaning that the probability of granting a loan to a risky borrower is higher for smaller banks, *i.e.*, these banks tend to take on more risk when monetary policy rates are lower. Under this specification, the negative coefficient obtained from the log of assets is also reinforced.

Regarding banks' balance sheets, we find that more capitalised banks have a larger probability of granting loans to riskier borrowers. This result is somewhat counterintuitive, but it may suggest that these banks may have a greater leeway for taking on more risk. We also observe that banks with a higher liquidity ratio tend to take less risk on granting loans. Moreover, banks with a relatively higher share of non-performing loans also tend to be more careful. In what concerns the type of banks, we see that mutual agricultural credit banks are relatively more prudent in their lending decisions.

Regarding borrower characteristics, the results are broadly in line with Jiménez *et al.* (2008): borrowers with more outstanding credit, more bank relationships and a longer credit history have a higher probability of being granted a new loan when they have a recent bad credit history.⁷ Regarding loan characteristics,

⁷ This result is also consistent with Bonfim *et al.*, (2012), who find that, after default, banks are willing to extend credit faster to larger and older firms, as well as those with more bank relationships.

Table 2

RESULTS OF THE PROBIT ESTIMATION								
	Dependent variable: bad_hist				Dependent defa	variable: ult	Dependent new	: variable: _rel
	I.	П	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***			-0.029***	-0.146***	0.087***	-0.871***
	0.003	0.032			0.003	0.027	0.002	0.014
i ECB av _{t-1}			-0.033*** <i>0.004</i>					
i EONIA av _{t-1}				-0.031*** <i>0.003</i>				
i*In(assets) _{t-1}		0.007*** <i>0.001</i>				0.005*** <i>0.001</i>		0.041*** <i>0.001</i>
In(assets) _{t-1}	-0.042***	-0.064***	-0.042***	-0.042***	-0.054***	-0.069***	-0.132***	-0.262***
	0.002	0.005	0.002	0.002	0.002	0.004	0.001	0.002
liq ratio _{t-1}	-0.007***	-0.007***	-0.007***	-0.007***	-0.006***	-0.006***	-0.015***	-0.015***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
rel npl/assets	-0.008**	-0.010**	-0.008**	-0.008**	-0.004	-0.005	-0.029***	-0.037***
	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001
capital/assets	0.021***	0.022***	0.021***	0.021***	0.022***	0.023***	0.020***	0.023***
	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.000
savings _{t-1}	0.296***	0.299***	0.296***	0.296***	0.250***	0.252***	-0.130***	-0.115***
	0.014	0.014	0.014	0.014	0.013	0.013	0.006	0.006
CCAM t-1	-0.070***	-0.071***	-0.070***	-0.070***	-0.086***	-0.087***	-0.093***	-0.108***
	0.021	0.021	0.021	0.021	0.017	0.017	0.008	0.008
ICUE t-1	-0.057	-0.051	-0.057	-0.057	-0.191***	-0.186***	-0.296***	-0.275***
	0.029	0.029	0.029	0.029	0.025	0.025	0.008	0.008
M&A _t	-0.075***	-0.071***	-0.075***	-0.075***	-0.082***	-0.079***	0.022***	0.040***
	0.005	0.005	0.005	0.005	0.005	0.005	0.004	0.004
IAS t	-0.055***	-0.053***	-0.052***	-0.051***	-0.016***	-0.015***	0.398***	0.409***
	0.007	0.007	0.007	0.00/	0.006	0.006	0.005	0.005
In(crealt) _{t-1}	0.021***	0.021^^^	0.021^^^	0.021^^^	0.021^^^	0.021^^^		
l= (1 : 11== 1)	0.002	0.002	0.002	0.002	0.002	0.002		
$In(1 + #rel)_{t-1}$	0.357 ****	0.357 " " "	0.350"""	0.350"""	0.380***	0.380***		
10/2 . 000)	0.070	0.010	0.070	0.070	0.009	0.009		
$m(2+age)_{t=1}$	0.111	0.112	0.112	0.112	0.055	0.055		
ln(1, loon)	0.004	0.004	0.004	0.004	0.004	0.004	0 160***	0 170***
$III(1+IOaII)_t$	-0.082	-0.082	-0.082	-0.082	-0.070	-0.070	-0.109	-0.170
share IT credit	0.007	0.007	0.007	0.007	0.007	0.007	0.000	0.000
	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.002
GDP PT	-0.019***	-0.019***	-0.023***	-0 024***	-0.011***	-0.012***	-0.005***	-0 004***
GDI III t-1	0.015	0.015	0.025	0.024	0.001	0.012	0.005	0.004
π PT	0.078***	0.002	0.002	0.002	0.007	0.10//***	0.026***	0.007
it i t	0.004	0.077	0.004	0.004	0.003	0.003	0.020	0.002
trend	-0.014***	-0 014***	-0.013***	-0.012***	-0.011***	-0.010***	-0.018***	-0.015***
i chù	0.002	0.002	0.002	0.002	0.001	0.001	0.001	0.001
trend ²	0.000***	0.002	0.002	0.002	0.000***	0.000***	0.000***	0.000***
a chu	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
constant	-0.929***	-0.432***	0.939***	-0.940***	-0.474***	-0.117***	3.804***	6.818***
constant	0.058	0.119	0.058	0.058	0.050	0.101	0.023	0.052
N° obs.	2 655 604	2 655 604	2 655 604	2 655 604	2 655 604	2 655 604	3 320 469	3 320 469
Log pseudolikel.	-660 740	-660 710	-660 807	-660 810	-859 858	-859 839	-1 342 552	-1 339 995
Prob > chi2	0	0	0	0	0	0	0	0

Sources: Banco de Portugal and authors' calculations.

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

riskier borrowers are more likely to be given a new loan when the amount of the loan is smaller and when they have a larger share of long-term credit.

In case one considers the probability of granting credit to firms defaulting in the current quarter instead of in the current and previous quarter (columns V and VI), the results remain broadly unchanged. None-theless, the effect of the monetary policy variable on risk-taking is slightly smaller.

However, when assessing the probability of a new firm-bank relationship being established (columns VII and VIII), the results differ slightly. When estimating solely with the ECB interest rate in the previous quarter (column VII), there seems to be no risk-taking channel operating. However, when we include the interaction term of the interest rate with bank size (column VIII), the coefficient on the ECB interest rate becomes negative and much higher (in absolute terms) than in the regression with bad history as a dependent variable. The coefficients for the log of assets and for the interaction term are also higher (in absolute terms). This may suggest that mostly smaller banks take on more risk on granting loans to new borrowers when monetary policy rates are lower.

The GDP growth coefficient is negative. When economic activity is stronger, there should be a larger pool of "good" borrowers. As such, banks can increase lending volumes mainly through these higher quality borrowers, reducing the overall likelihood of granting loans to riskier borrowers. On the contrary, when inflation is higher, one might expect that the increased costs of debt leads to a higher proportion of riskier borrowers, thus increasing the probability of granting a loan to a riskier borrower. Finally, the trend coefficient is negative, meaning that over time banks tend to grant fewer loans to riskier borrowers.

For robustness purposes, we considered another empirical test of the risk-taking channel.⁸ Instead of focusing on the probability of granting loans to borrowers with weaker credit quality, we focused on the determinants of loan growth, at the firm level. We found that loan growth is higher when interest rates are lower and when the firm has a good track record in terms of credit quality, as expected. However, the interaction between these two variables provides some evidence in favour of a risk-taking channel, *i.e.*, when interest rates are lower bad quality borrowers face less discrimination in terms of access to credit.⁹

All in all, the results of the discrete choice models do not reject the hypothesis of a risk-taking channel in Portugal, as there is an increased lending activity to *ex-ante* riskier borrowers in periods during which monetary policy rates are lower.

5.2 Within borrower comparison

Following the empirical strategy of Jiménez *et al.* (2008), we also conduct a within borrower comparison in order to test whether smaller banks tend to have a riskier behaviour, as also suggested by the results of Buch *et al.* (2011). Given that many firms borrow from more than one bank, we are able to explore changes in lending behaviour by small and large banks, when banks are lending to the same borrower. In this approach, the dependent variable is the quarterly change in the difference between the percentages of loans from small and large banks.¹⁰ 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 incentive to increase risk.

Table 3 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

⁸ The results are not reported, but are available upon request.

⁹ The coefficients on the policy interest rate, on the bad credit history and on the interaction term between the two previous are -0.008, -0.045 and 0.009, respectively.

¹⁰ We define a small/large bank as being below/above the median asset size in each quarter.

Table 3

RESULTS OF THE WITHIN BORROWER COMPARISON ANALYSIS							
	All borrowers with multiple bank relationships	Borrowers with small and large banks					
	Coef.	Coef.					
	S.e.	S.e.					
i ECB eoq t-1	-0.001***	-0.005***					
	0.000	0.001					
i*bad_hist _{t-1}	0.001***	-0.004					
	0.000	0.002					
bad_hist _{t-1}	0.000	0.025***					
	0.001	0.007					
In(credit) _{t-1}	0.003***	0.045***					
	0.000	0.002					
GDP PT t-1	-0.003***	0.010***					
	0.000	0.001					
trend	-0.002***	0.001					
	0.000	0.001					
trend ²	0.000***	0.000***					
	0.000	0.000					
constant	-0.014***	-0.440***					
	0.002	0.028					
N° obs.	3 035 927	390 103					
Log pseudolikel.	0.0004	0.0006					
Prob > chi2	0	0					

Sources: Banco de Portugal and authors' calculations.

Notes: *significance at 10 per cent; ** significance at 5 per cent; *** significance at 1 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 second column includes only borrowers with relationships with at least one large and one small bank.

bank relationships (first column with results) 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 very 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, suggesting 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).

All in all, there is some evidence of a more aggressive behaviour of small banks on loan granting activity, which tends to amplify slightly in periods of lower monetary policy rates.

5.3 Granting loans to (ex-post) risky borrowers

Whereas in the previous two subsections we explored the existence of a risk-taking channel of monetary policy in Portugal by assessing how the likelihood of banks granting loans to new borrowers or to borrowers with a recent bad credit history is affected by a low interest rate environment, in this subsection we look for another dimension of bank risk-taking, relating to the probability of granting loans when policy interest rates are lower to borrowers that eventually default in the future. To assess this we use survival analysis, modelling the hazard rate of the loans granted to the firms, where 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.

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.

Following Jiménez *et al.* (2008), 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 $\lambda_i = \exp(x_i\beta)$. In case p>1 (p<1), the hazard function is monotonically increasing (decreasing). For robustness, we also estimated a Cox proportional hazard model.

Even though we observe the beginning of the time at risk for all firm-bank relationships (*i.e.*, when a new loan is granted), there is naturally a lot of right censoring, as the majority of loans do not record any default during the sample period. This was taken into account in the estimations.

Table 4 presents the results of the survival estimation. Columns I to IV present the specifications with time invariant covariates.¹¹ We also estimated the equations with time varying covariates (columns V and VI) and only with macro variables (GDP and inflation) varying over time (columns VII and VIII).

The most striking observation is that lower policy interest rates prior to loan concession decrease the hazard rate, in most specifications (the only exceptions are columns V and VI, where all the variables vary over time). The effect is more pronounced when only macro controls are included (column I) than when we include bank, borrower and loan characteristics (columns II, III and IV). The regressions with the variables fixed for the moment of loan concession and including bank, borrower and loan characteristics do not show a significant effect of the policy interest rate, either taking into account borrower heterogeneity or not (columns III and IV). When we include inflation varying through the life of the loan, the coefficient on the interest rate turns statistically significant (column VII). In sum, the survival analysis results do not support the hypothesis of a risk-taking channel in Portugal, as loans granted during periods of lower interest rates do not show higher default probabilities over time. As mentioned above, the only exception to these results comes from the specifications with time-varying covariates (columns V and VI). However, in this specification 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 two 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 necessarily in contradiction with the results from the probit models. In the first part of our analysis, 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 affects borrowers *ex-post* probability of defaulting, increasing the credit risk implicit in banks' balance sheet. As banks do not have

¹¹ The size of the sample decreases substantially when we include bank, loan and borrower characteristics fixed at the moment prior to the loan concession (e.g., columns I and II compared to columns III and IV) 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' capital.

Table 4 (continue)

SURVIVAL ANALYSIS RESULTS								
	Non-time varying			Time-va	arying	Time-va GDP a	arying nd π	
	T	П	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 (loan) _{t-1}	0.126***	0.071***	0.016	0.019	-0.013***	-0.055***	0.062***	0.056***
	0.005	0.005	0.017	0.022	0.005	0.005	0.018	0.018
In(assets) _{t-1}		-0.034***	0.024**	0.080***	-0.057***	-0.032***	0.084***	0.092***
		0.003	0.011	0.016	0.004	0.003	0.015	0.015
liq ratio _{t-1}		-0.011***	-0.007***	-0.004***	-0.011***	-0.014***	-0.004***	-0.004***
		0.000	0.001	0.001	0.001	0.001	0.001	0.001
rel npl/assets _{t-1}		0.041***	0.095***	0.235***	0.038***	0.036***	0.222***	0.213***
		0.001	0.010	0.016	0.002	0.002	0.016	0.015
capital/assets		0.035***	0.067***	0.106***	0.034***	0.045***	0.112***	0.117***
		0.001	0.007	0.009	0.001	0.001	0.009	0.008
savings _{t-1}		0.175***	0.332***	0.231***	0.001*	-0.019	0.267***	0.289***
		0.017	0.052	0.074	0.023	0.023	0.074	0.072
CCAM		-0.357***	-0.108	0.098	-0.304***	-0.199***	0.140	0.157
		0.025	0.105	0.118	0.032	0.032	0.117	0.114
ICUE t-1		-0.048**	0.247***	0.678***	0.203***	0.306***	0.636***	0.653***
		0.021	0.093	0.128	0.025	0.024	0.127	0.124
M&A t		0.054***	0.003	-0.048	0.013	-0.056***	-0.116*	-0.088
		0.015	0.061	0.079	0.018	0.018	0.078	0.076
IAS t		0.043**	0.451**	0.446*	0.038*	-0.006	0.370	0.559**
		0.020	0.208	0.250	0.021	0.020	0.250	0.244
In(credit) _{t-1}			-0.002***	0.004***	-0.082***	-0.082***	0.006***	0.004***
			0.005	0.009	0.002	0.002	0.009	0.009
In(1+#rel) _{t-1}			0.271***	0.464***	0.667***	0.641***	0.458***	0.445***
			0.025	0.039	0.013	0.013	0.039	0.038
bad_hist _{t-1}			1.821***	2.350***	1.483***	1.515***	2.344***	2.368***
			0.036	0.059	0.013	0.013	0.058	0.057
In(2+age) _{t-1}			-0.471***	-0.735***	-0.350***	-0.329***	-0.731***	-0.666***
			0.025	0.038	0.007	0.007	0.038	0.036
In(1+loan) _t			0.023	0.063***	0.175***	0.175***	0.064***	0.061***
			0.005	0.007	0.002	0.002	0.007	0.007
share LT credit _t			0.002***	0.002***	0.006***	0.006***	0.002***	0.002***
			0.000	0.000	0.000	0.000	0.000	0.000
GDP PT (loan) _{t-1}	-0.075***	-0.058***	-0.051***	-0.033***			-0.056***	-0.073***
	0.003	0.003	0.010	0.012			0.011	0.010
GDP PT t	0.004	-0.002	-0.039***	-0.049***	-0.003	0.013***	-0.035***	0.011***
	0.003	0.003	0.008	0.008	0.004	0.003	0.008	0.006
π PT _t	-0.070***	-0.036***	0.095***	0.130***	0.171***	0.101***	0.149***	0.046***
	0.006	0.006	0.020	0.027	0.007	0.006	0.014	0.013
trend	-0.012***	-0.015***	-0.063***	-0.059***	-0.023***		-0.072***	
	0.003	0.003	0.007	0.007	0.003		0.007	
trend ²	0.000***	0.000***	0.001***	0.002***	0.001***		0.002***	
	0.000	0.000	0.000	0.000	0.000		0.000	
constant	-4.166***	-3.395***	-4.489***	-6.199***	-5.333***	-5.721***	-6.456***	-7.004***
	0.103	0.069	0.291	0.395	0.096	0.089	0.394	0.381
р	1.037***	1.042***	1.173***	1.350***	1.334***	1.375***	1.325***	1.370***
	0.003	0.003	0.013	0.012	0.005	0.005	0.012	0.120
θ	0.435***			3.956***	2.126***	2.035***	3.905***	3.430***
	0.094			0.142	0.031	0.030	0.140	0.108

Table 4 (continuation)

SURVIVAL ANALYSIS RESULTS									
	Non-time varying				Time-	/arying	Time-varying GDP and π		
	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.	
shared frailty bank	yes	no	no	no	no	no	no	no	
shared frailty NFC	no	no	no	yes	yes	yes	yes	yes	
N° obs.	7 193 128	7 087 951	1 384 696	1 384 696	5 833 210	5 833 210	1 384 696	1 384 696	
Log pseudolikel.	-363 163	-358 391	-46 713	-44 823	-224 247	-224 696	-44 780	-44 937	
Prob> chi 2	0	0	0	0	0	0	0	0	

Sources: Banco de Portugal and authors' calculations.

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.

perfect foresight on borrower quality, the risk-taking behaviour 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 entirely contradictory. A possible interpretation is that even though Portuguese banks grant credit to riskier borrowers when monetary policy rates are lower, they are not necessarily increasing the overall risk of their loan portfolio, but instead they consider that these *ex-ante* riskier borrowers become more attractive as their net worth increases, for instance (balance sheet channel). Furthermore, it is important to note that there is a volume effect associated with the bank lending channel: as banks grant more loans, there is necessarily more heterogeneity in borrower quality. Given these arguments, we could have evidence more in favour of a bank lending and balance sheet channel (already documented in Farinha and Marques, 2003) than of a risk-taking channel operating in Portugal.

Higher GDP growth in Portugal, both at the moment of the loan concession and during the life of the loan, decreases the hazard rate, in the generality of the specifications. This is broadly in line with the literature and previous evidence found for Portugal (Bonfim, 2009). When we only include macro and/or bank characteristics, GDP growth over the life of the loan is not found to be statistically significant (column I).

The expected coefficient on inflation is not clear. One could consider that higher inflation could reduce the probability of default because it reduces the real value of debt. Alternatively, higher inflation is usually associated with higher nominal interest rates, increasing the nominal cost of debt and thus may increase the probability of default. We find that, when taking into account firm and loan characteristics, inflation both at the moment of the loan concession and during the life of the loan has a positive coefficient, *i.e.*, higher inflation increases the hazard rate. Regarding bank characteristics, it is worth referring to the coefficients on capital and on non-performing loans ratio, which are significant and consistent across specifications. In line with the probit analysis, more capitalized banks tend to grant loans with a higher hazard rate. However, in contrast with the probit results, banks with more non-performing loans relative to the whole sector also tend to take more risk when granting loans. In turn, banks with a higher liquidity ratio tend to be more prudent as they seem to be exposed to loans with lower hazard rates. The results on bank size are not very stable across specifications.

Turning to firm and loan characteristics, we find that recent bad credit history is a highly relevant borrower characteristic for the loan hazard rate. The coefficient turns out high and highly significant regardless the specification. Thus, firms that have defaulted on loans in the recent past are also much more likely to default in the future, as shown by Bonfim *et al.* (2012). We observe that borrowers with more bank

relationships (usually larger firms) tend to be riskier, what may be somewhat counterintuitive. Instead, in line with previous evidence firms with a longer credit history tend to be less risky. Finally, it is worth mentioning that, in line with the probit analysis, firms with a higher share of long-term credit tend also to present loans with a higher hazard rate.

The Weibull distribution parameter p is greater than one and, therefore, the hazard function is monotonically increasing in all specifications. This means that, after controlling for bank, borrower and loan characteristics, macro variables and policy interest rate level, the probability of the firm defaulting on the loan increases over time.

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 (bad history, age as borrower, banks' assets, liquidity rate, relative NPL and type) the conclusions are broadly the same. The effect of the policy rate is no longer relevant in any of these specifications. Only the interaction term with the liquidity ratio shows up as relevant. 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. 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. The coefficient on the interest rate turns out even higher. The results of the Cox regression do not provide any relevant addition to our results.

6. CONCLUDING REMARKS

In this paper, we tested whether Portuguese banks take more risk in their balance sheets when monetary policy interest rates are lower. The analysis was based on three major blocks: (i) discrete choice models to assess the probability of borrowers with bad credit history or no credit history being granted loans, (ii) a regression to test whether smaller banks are more prone to risk-taking when policy interest rates are lower and (iii) a survival analysis to assess the impact of monetary policy rates on the time until a firm defaults.

The results of the discrete choice models show that lower short-term interest rates increase the probability of banks granting a loan to a borrower with recent bad credit history and this result is quite robust to different specifications. Smaller banks tend to grant more loans to *ex-ante* riskier borrowers than larger banks when monetary policy is looser. When we look only at new firm-bank relationships, we also conclude that it is mostly the smaller banks that take more risk on granting loans to new borrowers when monetary policy rates are lower. These results support the hypothesis of the existence of a risk-taking channel in Portugal. However, they are not entirely conclusive, since under low interest rate environments banks may increase credit to riskier firms because both of a volume effect and of an increase in firms' net worth. Thus, these results may simply support the existence of a credit channel.

We find some evidence of a more aggressive behaviour of small banks on loan granting activity, which tends to amplify slightly in periods of lower policy rates. There seems to be a slight increase in loan supply by small banks to all borrowers following an expansion in monetary policy, which is consistent with evidence obtained by Jiménez *et al.* (2008) or Buch *et al.* (2011).

While the discrete choice models suggest an increase in the *ex-ante* risk taken by banks in their loan activity when policy rates are lower, the survival models do not confirm this increase in risk-taking *ex-post*, *i.e.*, over the life of the loan. When bank, borrower and loan characteristics are fixed at the moment of the loan concession, lower policy interest rates decrease the hazard rate of the loans. The only exception to this result occurs when we consider time-varying covariates. However, these latter results are not sufficient to support the existence of a risk-taking channel, as the banks' decisions when granting loans could not perfectly foresee the future evolution of firm, bank and macro conditions.

In sum, 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 (namely borrowers with recent defaults or without credit history). However, despite this increased risk-taking, the entire portfolio of loans granted during such periods does not show higher default probabilities through time. As such, our results do not support the existence of a fully-fledged risk-taking channel in Portugal. Instead, they seem to be generally more supportive of a credit channel.

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