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The Risk-Taking Channel of Monetary Policy: Exploring All Avenues

The literature on the risk-taking channel of monetary policy grew quickly, leading to scattered evidence. We examine this channel through different angles, exploring detailed information on loan origination and performance. *Ex ante* riskier borrowers receive more funding at the extensive margin when interest rates are lower. *Ex post* performance is independent of the level of interest rates at origination. Still, loans granted in periods of very low and stable interest rates show higher default rates once interest rates start to increase. Risk-taking is stronger among banks with lower capital ratios, suggesting that this channel may be linked to managerial incentives for risk-shifting.

JEL codes: E5, E44, G21

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

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, 2010b, Jiménez et al. 2014). The basic idea is that in an environment of low policy interest rates, the incentive for banks to take more risk

We are much indebted to Isabel Gameiro and João Sousa who were actively involved in earlier stages of this project, which would not have been possible without their support. The authors would also like to thank Rui Albuquerque, Nuno Alves, António Antunes, Francesco Carli, Dean Corbae, Isabel Horta Correia, Sandra Gomes, Oliver de Groot, Filippo Ippolito, Sudipto Karmakar, Ana Cristina Leal, Robert Marquez, Steven Ongena, Pedro Portugal, Nuno Ribeiro, participants of the 2013 meeting of the *Portuguese Economic Journal*, OFCE 2013 workshop on Empirical Monetary Economics, 2014 IFABS conference, 2014 PFN conference, 2014 EEA congress, 2014 CompNet meeting, 2014 European Winter Meeting of the Econometric Association, 2015 ASSA/IBEFa annual meeting and IX Lubrafin meeting, and seminar participants at the Bank of Portugal and of the Nova SBE Research Group. The views expressed in this paper are those of the authors and do not reflect the views of the Banco de Portugal or the Eurosystem.

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Received January 8, 2014; and accepted in revised form December 15, 2017.

into their balance sheets increases. In the last few years, the literature on this channel has flourished (Dell’Ariccia, Laeven, and Suarez 2017, Delis, Hasan, and Mylonidis 2017, Paligorova and Santos 2017, Morais, Peydró, and Ruiz 2015). 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 existence of a risk-taking channel is thus well documented. However, given the fast expansion of this literature during a very short period, the available evidence is scattered and anchored on many different methodologies, data sets and definitions. Our goal in this paper is to examine how this channel works through different angles. To do so, we explore detailed bank and borrower information to look at loan origination and performance over time. We use a loan-level Portuguese data set with universal coverage on loan, firm and bank information to provide a thorough and comprehensive assessment of the different ways through which the risk-taking channel of monetary policy may operate.

This allows us to obtain consistent answers to many of the questions previously addressed in the literature on this topic, while also addressing new ones. We first test whether the risk-taking channel exists when we consider the *ex ante* riskiness of borrowers. This allows us to understand if banks were making risky choices based on observable firm characteristics. We consider different risk measures and different lending choices. We also test the impact of the level of policy rates at the moment loans are granted on *ex post* risk. Further, we test whether loans granted when rates are low and stable are more sensitive to a tightening in monetary policy, thus assessing the role of banks’ expectations on risk-taking behaviors. Moreover, the richness of our data set allows us to explore the heterogeneity underlying the different ways in which the risk-taking channel operates, taking into account the role of firm and, more importantly, bank characteristics. This allows us to improve the link between theoretical and empirical evidence on the transmission of monetary policy through the risk-taking channel.

Testing all of these hypotheses 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 overcomes 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 European Central bank (ECB) should be negligible. This is the same argument used by Jiménez et al. (2012, 2014) and, to some extent, by Geršl et al. (2015) and Ioannidou, Ongena, and Peydró (2015).

Our empirical results partly support the existence of a risk-taking channel. When monetary policy interest rates are lower, banks are more likely to lend to *ex ante* riskier borrowers. However, the average exposure to existing risky borrowers does not increase. In other words, we find results for the extensive margin, but not for the intensive margin. When we track loan performance over time, we see that loans granted when monetary policy rates were low are not generally more likely to default *ex post*. However, one crucial exception occurs when interest rates increase after having been low for a long period. In this case, loans granted in low interest rate periods are significantly more likely to default when monetary policy tightens due to sudden changes in expectations. This result may be specially relevant for supervisors and other policymakers when interest rates increase after prolonged periods of loose monetary conditions.

Regarding bank heterogeneity, we find that risk-taking behaviors are stronger for banks with less capital. There is evidence that banks closer to minimum regulatory ratios take more risk because they do not fully internalize the potential consequences of the risks taken (Diamond and Rajan 2012, Jiménez et al. 2014). Though less consistently, we also find some evidence that banks with larger liquidity buffers are more prone to risk-taking behaviors. Taking the results for liquidity and capital together, we are able to conclude that risk-taking behaviors in a low interest rate environment may be associated with poor managerial incentives, which encourage risk-shifting strategies (Altunbas, Gambacorta, and Marquez-Ibanez 2010, Acharya and Naqvi 2012). Indeed, banks with more liquidity have more incentives to engage in risk-shifting when interest rates are lower, given that liquid assets usually offer null or very small remunerations. In a low interest rate environment, banks with many liquid assets may divert some of these resources to grant riskier loans in a search for yield strategy.

In sum, our paper contributes to the expanding empirical literature on the risk-taking channel of monetary policy by looking simultaneously at different dimensions of the transmission mechanism. By exploring a rich and detailed data set, 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 the effect of interest rates on banks' risk-taking behaviors through different angles. As such, the paper offers an encompassing analysis of the risk-taking channel, thereby helping to bring some consistency to this fast growing literature, while providing additional evidence supporting the existence of the channel.

The paper is organized as follows. In Section 1, we briefly summarize the theoretical and empirical discussions in the literature on the risk-taking channel. Section 2 describes the data set used and Section 3 details the identification strategy and methodologies followed. In Sections 4 and 5, we present our main results. The analysis is built around two blocks. First, in Section 4, we assess the risk-taking channel at the moment a lending decision is taken, both at the extensive and intensive margins. We focus on the effects of policy interest rates on lending by testing two hypotheses: (i) Do riskier firms get more credit when policy rates are lower? (Section 4.1) and (ii) Are riskier firms more likely than other firms to obtain a loan

when interest rates decrease? (Section 4.2). Second, in Section 5, we assess the risk-taking channel through *ex post* changes in loan portfolio quality. Again, two hypotheses are tested: (i) Does the level of the policy rate when loans are granted influence the (*ex post*) probability of default? (Section 5.1) and (ii) Are loans granted when policy rates are low and stable more likely to default when interest rates increase? (Section 5.2). Section 6 summarizes our main findings.

1. AN OVERVIEW OF THE LITERATURE

The theoretical research on the risk-taking channel has been expanding significantly during the last few years (Adrian and Shin 2008, 2010a, 2010b, De Nicolò et al. 2010, Dell’Ariccia, Laeven, and Marquez 2011, Borio and Zhu 2012, Morris and Shin 2014, Afanasyeva and Güntner 2015, González-Aguado and Suarez 2015, Cesa-Bianchi and Rebucci 2017). 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, Laeven, and Marquez 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. Given the evidence that banks target a leverage ratio (Adrian and Shin 2008, 2010a, 2010b, Bruno and Shin 2015), they get back to their target by increasing market funding, especially in shorter maturities, and by expanding credit to cover riskier projects. Both changes imply an increase in the risk banks assume (Dell’Ariccia, Laeven, and Marquez 2011, Valencia 2014). This mechanism reinforces itself, since banks increase demand for assets, increasing their price, and consequently further expanding their balance sheet and increasing their leverage. Moreover, a prolonged period of low interest rates can affect asset and collateral valuations, as it is associated with lower market volatility, thus reducing risk perception (Gambacorta 2009).

Other authors highlight a distortion of incentives in an environment of very low interest rates. In 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, when the central bank tends to loosen its monetary policy.

During the last few years, there were several relevant empirical contributions to the literature on the risk-taking channel, most of them finding evidence in favor of the existence of this channel. One important strand of the literature uses loan-level data sets on individual countries (Gaggl and Valderrama 2011, Jiménez et al. 2014, Ioannidou, Ongena, and Peydró 2015, Dell’Ariccia, Laeven and Suarez 2017, Morais, Peydró, and Ruiz 2015). Other authors use less granular data at the bank or country level (Altunbas, Gambacorta, and Marquez-Ibanez 2010, Maddaloni and Peydró

2011, Angeloni, Faia, and Lo Duca 2015, Bruno and Shin 2015, Paligorova and Santos 2017). Generally, these studies find a negative relationship between the level of policy rates and the risk of the loan portfolio of the banks. However, the evidence for the United States seems to be milder. For instance, Delis, Hasan, and Mylonidis (2017) find that low policy rates decrease the risk of banks' loan portfolios in the short term but significantly increase it in the medium run, while Buch, Eickmeier, and Prieto (2014) do not find favorable evidence for the overall banking system, finding however important differences between different types of banks.

Available empirical evidence suggests that there is some heterogeneity in bank risk-taking behaviors, in line with agency theories (Kashyap and Stein 2000, Freixas and Rochet 2008). Indeed, there seems to be some evidence that the risk-taking channel is stronger for poorly capitalized banks (Delis and Kouretas 2011, Jiménez et al. 2014, Ioannidou, Ongena, and Peydró 2015, Dell'Araccia, Laeven, and Suarez 2017), for banks with less liquidity (Brissimis and Delis 2010) and for smaller banks (Buch, Eickmeier, and Prieto 2014). Altunbas, Gambacorta, and Marquez-Ibanez (2010) also find that banks more involved in nontraditional banking activities take more risk. Finally, 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 United States, amplifying the effects coming from low policy rates (Delis and Kouretas 2011).

Our paper contributes to the expanding empirical literature on the risk-taking channel of monetary policy by looking at the risk-taking channel through different angles. By exploring a rich and detailed data set and by taking advantage of the exogeneity of 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 thorough analysis of this transmission channel. In line with most literature, our results support the existence of a risk-taking channel along some dimensions and especially for banks with less capital.

2. DATA

We collect data for the period between 1999 and 2007. As discussed next, the identification strategy relies on the exogeneity of monetary policy, thus we only use data for the period after Portugal joined the euro area. We chose to use data only up to 2007 since 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 exploiting the exogeneity of the interest rates set by the ECB Governing Council. The period under analysis allows us to cover a full business cycle.

The most important data source 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 report on a monthly basis all loans granted above 50 euros). The register includes outstanding loans to firms, as well as potential credit liabilities associated with irrevocable commitments. 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 semester. 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 monetary financial institutions with activity during at least 1 year between 1999 and 2007, we select institutions with a market share of at least 0.1% in the corporate loan market. After this selection, we have a sample of 52 credit institutions: 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 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 8% of total observations. On average, each firm has a relationship with three banks and has credit history for 24 quarters.² The average amount of each firm's loan per bank is around 234 thousand euros, 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 next, our analysis relies on different methodologies to look at different dimensions of the risk-taking channel. Depending on the methodology being used, we can use different measures of borrower's credit quality: having recent default history (for two consecutive quarters) (*bad_hist*), currently being in default with that specific bank (*D_default_bank*), or obtaining a loan for the first time ever (*new_bor*). For robustness, we considered different measures of credit quality (currently being in default in any loan, being in

1. Unlike Jiménez et al. (2012, 2014), we do not have individual loans data, that is, 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.

TABLE I
VARIABLES DESCRIPTION AND DESCRIPTIVE STATISTICS

	Description	Unit	Obs	Mean	Std. dev.	Min	Max
Dependent variables							
loan_growth	Change in the log of loan amount relative to the previous quarter (at firm-bank level)	%	8,667,766	-0.038	1.441	-46.010	46.212
loan_growth_cl	Change in the log of loan amount including unused credit lines relative to the previous quarter (at firm-bank level)	%	9,932,343	-0.031	0.985	-48.470	47.801
bad_hist	Dummy = 1 if the borrower has overdue credit in the current and in the previous quarter; = 0 otherwise	{0,1}	11,772,002	0.112	0.316	0	1
new_bor	Dummy = 1 if it is a first-time borrower; = 0 otherwise	{0,1}	11,772,002	0.018	0.133	0	1
D_default_bank	Dummy = 1 if the borrower has overdue credit in the current quarter with the bank; = 0 otherwise	{0,1}	11,772,002	0.080	0.271	0	1
new_loan	Dummy = 1 if there is an increase in loan amount or a new bank relationship is created; = 0 otherwise	{0,1}	11,772,002	0.305	0.461	0	1
new_loan_cl	Dummy = 1 if there is an increase in loan amount including unused credit lines or a new bank relationship is created; = 0 otherwise	{0,1}	11,772,002	0.286	0.452	0	1
Independent variables							
<i>Monetary Policy Rates</i>							
i ECB eqq	ECB main refinancing rate at the end of the quarter	%	11,772,002	2.978	0.885	2	4.75
Taylor residual	Residuals for Portugal of a panel-data Taylor rule with 10 euro area countries (AT, BE, DE, ES, FI, FR, IE, IT, NL, PT) against contemporaneous GDP growth and inflation	p.p.	11,552,445	-0.108	0.665	-1.553	1.203

(Continued)

TABLE 1
CONTINUED

	Description	Unit	Obs	Mean	Std. dev.	Min	Max
<i>Differences-in-differences</i>							
treatment	Dummy = 1 for firm-bank relationships with a new loan is granted between Jan-05 and Sep-05; = 0 for firm-bank relationships with a new loan granted between Oct-05 and Mar-06.	{0,1}	2,112,930	0.412	0.492	0	1
after t	Dummy = 1 after the low interest rate period (from 2006Q1 onwards)	{0,1}	11,772,002	0.263	0.440	0	1
<i>Bank characteristics</i>							
ln(assets)	Logarithm of the total assets of the bank.	ln(EUR)	11,536,811	23.419	1.662	16.70	25.19
liq ratio	The amount of liquid assets over total assets. Included in liquid 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.	%	11,536,811	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	%	11,536,811	-1.953	2.250	-3.79	22.55
capital_ratio	Equity capital over total assets	%	11,432,772	4.819	2.462	0.07	37.99
savings	Dummy = 1 if the bank is a saving bank; = 0 otherwise	{0,1}	11,772,002	0.033	0.179	0	1
CCAM	Dummy = 1 if the bank is a mutual agricultural credit bank; = 0 otherwise	{0,1}	11,772,002	0.023	0.150	0	1

(Continued)

TABLE 1
CONTINUED

	Description	Unit	Obs	Mean	Std. dev.	Min	Max
ICUE	Dummy = 1 if the bank is a branch of a credit institution with head office in the EU; = 0 otherwise	{0,1}	11,772,002	0.037	0.189	0	1
M&A	Dummy = 1 if the bank is involved in a merger in that quarter; = 0 otherwise	{0,1}	11,772,002	0.051	0.220	0	1
IAS	Dummy = 1 for the quarter when the bank switched from the old accounting standards to the IAS	{0,1}	11,772,002	0.032	0.175	0	1
<i>Borrower characteristics</i>							
#rel	Number of bank relationships of the firm	integer	11,772,002	3.057	2.424	1	38
credit	The total amount of credit of the firm	EUR	11,772,002	1,040,303	12,800,000	0	4,520,000,000
age	Number of quarters that the firm has credit	integer	11,772,002	23.785	13.510	0	51
loan	Total credit granted by the bank to the borrower	EUR	11,772,002	234,358	4,398,536	0	4,520,000,000
loan_cl	Total credit including unused credit lines granted by the bank to the borrower	EUR	11,772,002	313,461	5,086,170	0	4,520,000,000
Cred_LT_prop	Share of long term credit on the sum of short and long-term credit	%	10,222,954	48.769	39.713	0	100
<i>sectoral dummies</i>							
	Dummies for economic sectors based on 2 digit NACE codes (66 sectors)	{0,1}					
<i>Macrocontrols</i>							
GDP_PT	Portuguese real GDP y-o-y quarterly growth rate	%	11,772,002	1.612	1.592	-1.90	5.10
inflation_PT	Quarterly inflation rate (HICP)	%	11,772,002	2.926	0.702	1.90	4.40
trend	Time trend	integer	11,772,002	20.191	10.101	1.00	36.00

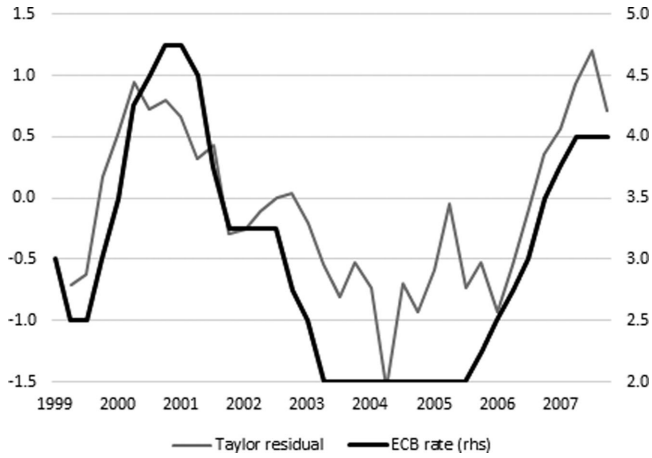


FIG. 1. ECB Main Refinancing Rate and Estimated Taylor Residual for Portugal.

default for four consecutive quarters or for four consecutive years or having a default in the future) and the results remain broadly robust.

We analyze lending at the intensive margin using two different quarterly firm–bank loan growth measures: the log change in loans (*loan_growth*) and the log change in loans including the unused amount of committed credit lines (*loan_growth_cl*). To study the extensive margin, we consider two dummy variables that take the value one if (i) there is an increase in loan exposure (*new_loan*) or (ii) if there is a new lending relationship (*new_bor*). In both cases we consider an alternative definition that takes into account unused committed credit lines (*new_loan_cl* and *new_bor_cl*, respectively).

The most relevant explanatory variable for our analysis is the monetary policy interest rate, defined as the ECB main refinancing rate at the end of each quarter. In addition to this, we also consider a Taylor rule residual to capture the stance of monetary policy. This is calculated as the residual for Portugal from a panel-data Taylor rule estimated for 10 euro area countries along the lines of Maddaloni and Peydró (2011). Figure 1 shows the evolution of the two main explanatory variables. We also considered the quarterly average of the ECB main refinancing rate and of the EONIA, and the results are robust.

We also control a broad set of bank and firm characteristics. Regarding bank characteristics, we control bank size ($\ln(\text{assets})$), liquidity (defined as liquid assets as a percentage of total assets—*liq_ratio*), credit quality (the nonperforming loans ratio of the bank relative to the ratio for the entire banking sector—*rel_npl/assets*), and solvency (*capital_ratio*). We also control 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*), number of quarters with credit history (*age*), loan size (*loan*), and share of long-term credit that the firm holds (*Credit_LT_prop*). We also control firms' business sector using two-digit NACE codes.³ Finally, we include macroeconomic controls (*GDP* and *inflation* for Portugal) and a time trend.

3. IDENTIFICATION STRATEGY AND METHODOLOGY

Our primary 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. Taken at face value, this would mean regressing variables that capture bank risk-taking on 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. Moreover, the correlation of the Portuguese economic cycle with that of the euro area was relatively low. For instance, the correlation for inflation, which is at the core of the primary objective of the ECB, was 0.3 during the sample period. Euro area monetary policy can thus be considered exogenous, 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 Geršl et al. (2015) and Ioannidou, Ongena, and Peydró (2015). Indeed, this paper follows to some extent part of their empirical strategy but includes additional layers of analysis, with the objective of testing from different perspectives whether there is a risk-taking channel.

Our methodological strategy is anchored in two blocks. In the first block, we assess the risk-taking channel at the intensive and extensive margins using *ex ante* information. In other words, we assess loan growth to risky borrowers and the probability of granting new loans to these borrowers, respectively. As such, we focus on the effects of policy interest rates on lending by testing two hypotheses: (i) Do riskier firms get more credit when policy rates are lower? (Section 4.1) and (ii) Are riskier firms more likely than other firms to obtain a loan when interest rates decrease? (Section 4.2). To answer the first question, we run the following panel regression:

$$\begin{aligned} \text{loan_growth}_{ijt} = & c_{ij} + \alpha i_{t-1}^{ECB} \times \text{bad_hist}_{it-1} + \beta i_{t-1}^{ECB} + \gamma \text{bad_hist}_{it-1} \\ & + \delta' X_{ijt-1} + \varepsilon_{ijt}, \end{aligned} \quad (1)$$

3. This information is compiled with information from a data set on firms (*Informação Empresarial Simplificada*).

where the index i stands for firm, the index j stands for bank and the index t for quarter. We include firm–bank fixed effects (c_{ij}) and α is the main coefficient of interest, capturing the (additional) effect of the policy rate (i^{ECB} or *Taylor*) on the loan growth of firms with recent bad credit history (*bad_hist*). A negative α would provide evidence in favor of the risk-taking channel. The vector of controls X_{ij} includes the bank and firm characteristics and macroconditions described in Section 2.

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.⁴ The following probit model is estimated:

$$\Pr(risky_{it} = 1 | new_loan_{ijt} = 1) = \Phi(\alpha i_{t-1}^{ECB} + \delta' X_{ijt-1} + \varepsilon_{ijt}). \quad (2)$$

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 1 when a new loan is granted to a borrower defined as risky (and 0 when a new loan is granted to any other borrower). A negative α would imply that when policy rates are lower (or when monetary policy stance is more accommodative than what is foreseen in a Taylor rule), it is more likely to grant a new loan to a riskier borrower. We consider two definitions of risky borrowers: when borrowers are in default with any bank in the last two quarters (*bad_hist*) or when borrowers obtain a loan for the first time (*new_bor*).

Positive answers to the above two questions would mean that there is more expansion of credit to riskier borrowers when interest rates are lower. 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, Dias, and Richmond 2012), we assess the *ex post* performance of the loans granted during periods of low interest rates. Again, two hypotheses are tested here: (i) Does the level of the policy rate when loans are granted influence the (*ex post*) probability of default? (Section 5.1) and (ii) Are loans granted when policy rates are low and stable more likely to default when interest rates increase? (Section 5.2).

In order to test the first hypothesis, we use duration analysis to assess the impact of monetary policy rates when loans are granted on the time until a firm defaults. We 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 . The time at risk is defined as the time elapsed between the moment a new loan is granted and the moment the firm (eventually) defaults with that bank. Taking into account the shape of the hazard function of the sample, we

4. 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.

estimate a parametric model with a Weibull distribution, which allows for a monotonic hazard function, that is, the hazard rate either increases or decreases over time according to the Weibull distribution parameter. In this estimation, p is the distribution parameter that indicates whether the Weibull hazard function is monotonically increasing ($p > 1$) or decreasing ($p < 1$). The following Weibull hazard function is estimated:

$$h_{ij}(t) = p \exp(\alpha i_{\tau-1}^{ECB} + \gamma bad_hist_{i\tau-1} + \delta' X_{ij\tau-1}) t^{p-1}, \tag{3}$$

where again we could interpret a negative α as an indication of a risk-taking channel at work. The explanatory variables are considered at the moment the loan was granted (τ).

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 ($treatment_{ijt} = 1$). We want to understand if these loans are relatively more likely to default once interest rates start to increase ($after_t_t = 1$), revealing themselves as riskier *ex post*. To be sure that the treatment and control groups are comparable, we focus our analysis on a very short window: we consider that treated loans are those granted immediately before interest rates began to increase in December 2005, when interest rate expectations were still anchored at low levels (2005Q1–2005Q3). The loans in the control group are those granted in the period when interest rates were still low, but interest rate expectations had increased markedly, as illustrated in Figure 2 (2005Q4–2006Q1).

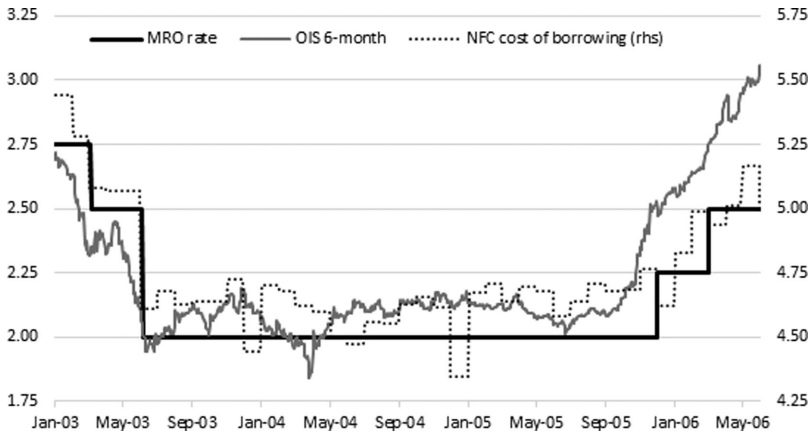


FIG. 2. Euro Area Short-Term Interest Rate Expectations and Non-Financial Firms’ Cost of Borrowing in Portugal.

NOTE: The black line is the main refinancing rate (MRO) of the ECB. The gray line is the 6-month OIS (overnight interest rate swap) rate and can be read as the average expected overnight rate 6-months forward. The dotted line is the composite cost of borrowing to non-financial corporations (NFC) in Portugal as calculated by the ECB.

SOURCE: Thomson Reuters and ECB MFI interest rate statistics.

The ECB had kept monetary policy interest rates stable at 2% since June 2003. In December 2005, the ECB increased rates for the first time since October 2000. This was a minor 25 basis points upward revision in the interest rate, which was not immediately reflected in firms' borrowing costs, as shown in Figure 2. The tightening trend of monetary policy only became clear during 2006, with interest rates reaching 4.25% in the summer of 2007. As such, the effective interest rates set by banks on loans granted to firms between January 2005 and March 2006 were very similar, as shown in Figure 2. The borrowing costs of Portuguese non-financial corporations oscillated in a narrow interval between 4.7% and 5% during this period.

The main difference between the loans granted in January–September 2005 and those granted in October 2005 to March 2006 relates to the level of interest rate *expectations*. The chart shows that market participants' expectations on future interest rates (proxied by the 6-month overnight interest rate swap) increased markedly in October 2005, decoupling from monetary policy rates and bank interest rates on loans to firms. This change in expectations was very sudden and was underpinned by a change in the communication of the ECB, signaling that monetary policy could be tightened in the near future.

This setting allows us to test the risk-taking channel in a unique scenario. With our DID approach, we are comparing loans granted with similar levels of prevailing interest rates, but with quite different expectations regarding future rates. We are thus able to test if banks adopted riskier behaviors when interest rates were low and were expected to remain so for the foreseeable future, compared to a situation in which rates were still low, but there was an emerging consensus that they would increase soon. Here we measure loan riskiness based on the likelihood of loan default in the period of monetary policy tightening, thus testing which borrowers were more sensitive to interest rate hikes. Our argument hinges on the idea that banks might have been less prudent in assessing borrowers' sensitivity to interest rate risk when interest rates are expected to remain low for some time.

We estimate the following equation:

$$\Pr(\text{bad_hist}_{it} = 1) = \Phi(\alpha \text{treatment}_{ijt} \times \text{after}_t + \gamma \text{treatment}_{ijt} + \beta \text{after}_t + \delta' X_{ijt-1} + \varepsilon_{ijt}). \quad (4)$$

In order to prove the existence of a risk-taking channel, we would need to find that loans granted when policy rates were low would have a higher probability of default when interest rates increase, which would imply a positive α .

One important dimension of our analysis is to understand which banks are more prone to risk-taking. To test this, we interact the risk-taking coefficient (α) with banks' liquidity, capital and total assets in all the approaches described above. Furthermore, for all identification strategies, we look separately at small and large firms and at small and large banks. This allows us to draw important insights about the role of bank and firm characteristics in the transmission of monetary policy through the risk-taking channel.

4. THE RISK-TAKING CHANNEL ASSESSED WITH *EX ANTE* INFORMATION

4.1 *Do Riskier Firms Get More Credit When Policy Rates Are Lower?*

To answer this question, Table 2 presents the results of a panel regression with fixed effects on firm loan growth against the monetary policy rate, the recent credit history of the firm (*bad_hist*) and an interaction term between these two, controlling for bank and firm characteristics and macroconditions (equation (1)). Given that 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, that is, not only on the bank offering the new loan.

The coefficient on the interaction term $i * bad_hist$ captures risk-taking. A negative coefficient would mean that when interest rates are lower, firms with a recent bad credit history show stronger loan growth than other firms. Looking across the several columns of Table 2, we find that this coefficient is generally nonsignificant, implying that, at the intensive margin, there seems to be no evidence of a risk-taking channel.

Let us analyze in more detail the different columns of Table 2. In the first column, we show the results of an estimation with relationship fixed effects, standard errors clustered at the quarter level, and bank, borrower and macroeconomic controls. Using this specification, we find statistically significant results to support the risk-taking channel. Nevertheless, the result is not strong enough to survive an estimation with standard errors clustered at the quarter and bank level (instead of only at the quarter level), as shown in column II.

The same is true when we consider unused credit lines as part of our dependent variable. As mentioned before, in our *ex ante* assessment of the risk-taking channel, we consider that there may be two ways to capture banks' increased exposure to a given firm. On one hand, we can consider, as in columns I and II, that the bank increases its exposure to the firm every time there is an increase in effective loan amounts. On the other hand, part of this effective loan amount increase may reflect the drawing down of credit lines by firms. As such, we consider that it might be important to also consider changes in the total exposure of a bank to a firm, including also the unused amount of committed credit lines. From column III onward we consider this latter definition of the dependent variable.

In column IV, we impose an even more demanding structure on the data, setting a three-way multiclustering of errors (quarter, bank, and firm) and, as it would be expected, the no-significance result also shows up.⁵ However, we consider that the most critical clustering level should be at the quarter and bank level and we adopt this throughout our analysis of the intensive margin.⁶ The reason for this is that (i) monetary policy interest rates, which play a key role in our analysis, vary simultaneously for every bank and firm at a quarterly frequency (Petersen 2009), and

5. We computed multiway clustering following Correia (2017).

6. The only exception are the results displayed in column V, where we have to go back to clustering only at the quarterly level when we add sectoral dummies, with the goal of better controlling for firm heterogeneity. The results remain nonsignificant when we do this.

TABLE 2
RISK-TAKING AT THE INTENSIVE MARGIN: LOAN GROWTH AND INTEREST RATES

	Dependent variable: loan-growth																							
	I		II		III		IV		V		VI		VII		VIII		Small firms IX		Large firms X		Small banks XI		Large banks XII	
	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.
$i^*_{bad_hist\ t-1}$	-0.018**	(0.009)	-0.018	(0.014)	0.001	(0.005)	0.001	(0.005)	-0.001	(0.005)	-0.001	(0.006)	0.001	(0.007)	-0.002	(0.016)	0.005	(0.007)	0.004	(0.006)	-0.003	(0.006)	0.002	(0.007)
$i^*_{bad_hist\ t-1}$ *																								
liq_ratio_t-1																								
$i^*_{bad_hist\ t-1}$ *																								
capital_ratio_t-1																								
$i^*_{bad_hist\ t-1}$ *																								
ln(assets)_t-1																								
i ECB eqo_t-1	0.016	(0.014)	0.016	(0.018)	-0.006	(0.030)	-0.006	(0.030)	-0.008	(0.025)	-0.006	(0.030)	-0.006	(0.031)	-0.006	(0.030)	0.015	(0.044)	-0.019	(0.019)	0.024	(0.045)	-0.037	(0.038)
bad_hist_t-1	0.112***	(0.026)	0.112**	(0.051)	-0.026	(0.016)	-0.026	(0.016)	-0.023	(0.014)	-0.025	(0.016)	-0.026	(0.015)	-0.026	(0.016)	0.002	(0.021)	-0.055***	(0.013)	-0.015	(0.018)	-0.032	(0.024)
liq_ratio_t-1	-0.002***	(0.001)	-0.002	(0.001)	-0.000	(0.001)	-0.000	(0.001)	-0.000	(0.001)	-0.000	(0.001)	-0.000	(0.001)	-0.000	(0.001)	-0.000	(0.001)	-0.000	(0.001)	-0.001	(0.001)	0.001	(0.002)
capital_ratio_t-1	0.003	(0.004)	0.003	(0.005)	-0.000	(0.003)	-0.000	(0.003)	-0.000	(0.002)	-0.000	(0.003)	-0.000	(0.003)	-0.000	(0.003)	-0.001	(0.003)	-0.000	(0.004)	-0.001	(0.001)	0.001	(0.002)

(Continued)

TABLE 2
CONTINUED

	Dependent variable: loan-growth																							
	I		II		III		IV		V		VI		VII		VIII		Small firms IX		Large firms X		Small banks XI		Large banks XII	
	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.
ln (assets) _{t-1}	0.139*** (0.043)		0.139** (0.060)		0.038 (0.042)		0.038 (0.042)		0.037 (0.037)		0.038 (0.042)		0.038 (0.042)		0.038 (0.042)		0.003 (0.039)		0.046 (0.048)		-0.038** (0.017)		0.147 (0.073)	
bank variables	yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes	
borrower variables	yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes	
inc. unused variables	no		no		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes	
credit lines	no		no		no		no		yes		no		no		no		no		no		no		no	
sectoral dummies	yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes	
macrovariables	relationship		relationship		relationship		relationship		relationship		relationship		relationship		relationship		relationship		relationship		relationship		relationship	
fixed effects	quarter		quarter & bank		quarter & bank		quarter & bank		quarter		quarter & bank		quarter & bank		quarter & bank		quarter & bank		quarter & bank		quarter & bank		quarter & bank	
Clustered s.e.	quarter		quarter & bank		quarter & bank		quarter & bank		quarter		quarter & bank		quarter & bank		quarter & bank		quarter & bank		quarter & bank		quarter & bank		quarter & bank	
N° obs.	6,427,685		6,427,685		6,927,838		6,927,838		5,919,775		6,927,838		6,927,838		6,927,838		2,690,267		904,414		2,568,837		4,359,001	

NOTE: All variables defined in Table 1. Results of panel data regressions on the dependent variable *loan-growth* (or *loan-growth_{it}*) defined as the quarterly growth (log difference) of the loan amount (or including unused credit lines) at the firm-bank level. Bank variables included and not reported: *rel-pp/assets*, *M&A* and *I&S*. Borrower variables included and not reported: *ln(1+age)*, *ln(credit)*, *ln(2+age)*, *ln(1+loan)* and *Cred.LI-prop*. Macrovariables included and not reported: *GDP-PT* (4 lags) and π *PT*. A constant and a quadratic trend are also included but their coefficients are not reported. Columns IX to XII report the results of the regression for sub-samples according to criteria defined in the top of the column. Small (large) firms proxied by the size of the total credit of the firm; Small firms are below the median, large firms are in the top-10 percentile. Large banks are the 5 largest banks in Portugal, representing around half of the total corporate loan market; small banks are the remaining ones. Multi-way clustering computed using *reghdfe* (Correia 2017). For each variable, we report the coefficient, the standard deviation (below in italics) and the significance level (* significance at 10 per cent, ** significance at 5 per cent, *** significance at 1 per cent).

(ii) banks' internal practices and the relatively low number of banks in the Portuguese economy justify grouping the errors by bank.

In columns VI–VIII we add another layer of analysis. The goal is to understand if the risk-taking channel works differently depending on bank characteristics. To answer this question, we add a triple interaction term to the regressions. More specifically, we consider the interaction between monetary policy interest rates, the dummy for bad-quality borrowers and banks' liquidity ratio (column VI), capital ratio (column VII), and log of total assets (column VIII), respectively. We cannot find any differential effect from these bank characteristics.

To better understand how the risk-taking channel works at the intensive margin, we estimate our regression separately for small and large firms (columns IX and X, respectively). Small firms are those below the median of the empirical distribution of total assets, while large firms are those in the 90th percentile. The results show no statistically significant interaction effects of the level of the interest rate and the credit history of the firm.

Finally, we run a similar exercise for bank size, estimating the regression separately for small and large banks (columns XI and XII, respectively), where the latter are the five largest banks (accounting for more than half of the corporate loan market). Again, no difference is to be mentioned and, contrary to some studies that find riskier behaviors by small banks (Kashyap and Stein 2000, Buch, Eickmeier, and Prieto 2014), we do not find evidence of risk-taking at the intensive margin for all types of banks.

Until now, we focused our analysis on the coefficients associated with the identification of the risk-taking channel. However, the results concerning some of the remaining control variables deserve a few words. The effect of interest rates on loan growth at the firm level is generally not statistically significant when we also control for banks' risk-taking.

The coefficient on the *bad_hist* variable in columns I and II is somehow puzzling. It seems to suggest that borrowers with recent poor credit history show stronger loan growth than other firms. Given that we are using relationship fixed effects, this is happening when firms get into distress. Using a similar data set, Bonfim, Dias, and Richmond (2012) showed that in Portugal, firms regain access to credit very easily after default. These two results taken together might be supportive of the existence of evergreening (Peek and Rosengren 2005). Banks may be extending loans to distressed borrowers to avoid recording losses on their loans. However, it is important to note that this result is only obtained when using effective loan growth as the dependent variable. When we include total loan exposure growth, that is, including unused credit lines (column III onward), the coefficient is no longer significant. Therefore, this result seems to be more in line with the argument that firms tend to increase their funds by withdrawing on preexisting commitments when they enter into default in a loan, in line with what Ivashina and Scharfstein (2010) find for the crisis period.

Using the residuals of a Taylor rule for the Portuguese economy as explanatory variable instead of the monetary policy interest rate does not change our conclusions. The results for our baseline regression with this alternative explanatory variable are

TABLE 3
RISK-TAKING AT THE INTENSIVE MARGIN: LOAN GROWTH AND TAYLOR RESIDUALS

	Dependent variable: loan_growth	
	I Coef. <i>S.e.</i>	II Coef. <i>S.e.</i>
Taylor*bad_hist _{t-1}	-0.017 (0.019)	0.012 (0.011)
Taylor residual _{t-1}	0.008 (0.010)	0.001 (0.014)
bad_hist _{t-1}	0.058*** (0.018)	-0.023*** (0.005)
liq_ratio _{t-1}	-0.002 (0.001)	-0.000 (0.001)
capital_ratio _{t-1}	0.003 (0.004)	-0.000 (0.003)
ln(assets) _{t-1}	0.141** (0.058)	0.035 (0.038)
bank variables	yes	yes
borrower variables	yes	yes
inc. unused credit lines	no	yes
sectoral dummies	no	no
macrovariables	yes	yes
fixed effects	relationship	relationship
Clustered s.e.	quarter & bank	quarter & bank
N° obs.	6,427,685	6,927,838

NOTE: All variables defined in Table 1. Results of panel data regressions on the dependent variable *loan_growth* (or *loan_growth_cl*) defined as the quarterly growth (log difference) of the loan amount (or including unused credit lines) at the firm-bank level. Bank variables included and not reported: *rel npl/assets*, *M&A* and *IAS*. Borrower variables included and not reported: *ln(1+#rel)*, *ln(credit)*, *ln(2+age)*, *ln(1+loan)* and *Cred_LT_prop*. Macrovariables included and not reported: *GDP PT* (4 lags) and π *PT*. A constant and a quadratic trend are also included but their coefficients are not reported. Multi-way clustering computed using *reghdfe* (Correia 2017). For each variable, we report the coefficient, the standard deviation (below in italics) and the significance level (* significance at 10 per cent, ** significance at 5 per cent, *** significance at 1 per cent).

presented in Table 3. In columns I and II we consider, respectively, loan growth without and with unused credit lines.

The interaction term between monetary policy and the credit history of the firm continues to be nonsignificant. The main difference relates to the *bad_hist* variable. We find that firms with a bad credit history indeed have a stronger effective loan growth, but a weaker potential loan growth. This reinforces the previous argument that firms make more use of preexisting commitments when they enter distress, though this does not correspond to an increase of the exposure of the bank to that firm.

In sum, we find no consistent evidence of a risk-taking channel of monetary policy working at the intensive margin: the level of interest rates or the monetary policy stance do not seem to be relevant for the expansion of credit by banks to riskier firms.

4.2 Are Riskier Firms More Likely than Other Firms to Obtain a Loan When Interest Rates Decrease?

In this section, we consider the extensive margin of loan dynamics: are riskier firms more likely than other firms to get new loans when interest rates are lower?

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 (equation (2)). 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.

Table 4 presents the results of the estimation for borrowers with recent default (*bad_hist*). Overall, we find that lower short-term interest rates increase the probability of banks granting a loan to a borrower with recent episodes of loan default vis-à-vis that of a healthy borrower, thus supporting the existence of a risk-taking channel at the extensive margin.⁷

This result holds in most specifications. The results are similar regardless of whether standard errors are clustered at the quarter level or multiclustered at the quarter and bank or at the quarter, bank, and firm level (columns I to IV). Moreover, adapting the dependent variable to include unused credit lines yields similar results (column III). However, the coefficient on the policy rate lacks statistical significance when we control for sectoral effects (column V).

As in the previous subsection, we try to determine whether bank characteristics play a role in the way the risk-taking channel operates. Again, there are interesting differences between the intensive and extensive margin. While at the intensive margin bank characteristics did not seem to play a role, at the extensive margin we find that risk-taking behaviors are more relevant for banks with more liquidity and, especially, less capital (columns VI–VIII).

On one hand, banks with more liquidity will possibly be more interested in doing some risk-shifting when interest rates are lower. Given that liquid assets usually offer null or very small remunerations, in a low interest rate environment banks with more liquid assets may divert some of these resources to grant riskier loans, in a search for yield strategy. Furthermore, banks with more liquidity may show a riskier behavior because managers' incentives to monitor risks decrease (Altunbas, Gambacorta, and Marquez-Ibanez 2010, Acharya and Naqvi 2012).

On the other hand, banks with less capital are usually more prone to risk-taking behaviors. There is evidence that banks closer to minimum regulatory ratios take more risk, as they do not fully internalize the potential consequences of the risks taken (Diamond and Rajan 2012, Jiménez et al. 2014). Our results do not support the hypothesis that banks with higher capital buffers take more risk (Dell'Ariccia, Laeven, and Marquez 2011).

Following again the same steps taken in the analysis of the intensive margin, we look separately at small and large firms (columns IX and X) and at small and large banks (columns XI and XII). We find evidence of risk-taking at the extensive margin

7. The absence of loan application data does not allow us to fully separate demand from supply effects, that is, we cannot clearly distinguish the effect coming from the possible higher number of loan applications from risky borrowers in periods of low interest rates from the effect of an increased probability of granting a loan to a risky borrower, for the same pool of loan applications. Nonetheless, the effect is favorable to risk-taking, since a higher proportion of new loans is granted to risky firms.

TABLE 4
RISK-TAKING AT THE EXTENSIVE MARGIN: PROBABILITY OF GRANTING A LOAN TO A RISKY FIRM AND INTEREST RATES

	I	II	III	IV	V	VI	VII	VIII	Small firms	Large firms	Small banks	Large banks	LPM
	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	Coef.	IX	X	XI	XII	XIII
	S.e.	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 eqo t-1	-0.043** (0.021)	-0.043** (0.019)	-0.048*** (0.017)	-0.048** (0.017)	-0.029 (0.022)	0.028 (0.050)	-0.152*** (0.044)	-0.157 (0.236)	-0.025 (0.022)	-0.094*** (0.016)	-0.062*** (0.024)	-0.091 (.)	-0.008*** (0.001)
i * liq_ratio t-1													
i * capital_ratio t-1							0.024*** (0.009)						
i * ln(assets) t-1								0.005 (0.010)					
liq_ratio t-1	-0.007*** (0.001)	-0.007** (0.003)	-0.007** (0.003)	-0.007** (0.003)	-0.007*** (0.001)	0.004 (0.009)	-0.007** (0.003)	-0.007** (0.003)	-0.012*** (0.005)	-0.003 (0.003)	-0.011*** (0.004)	0.001 (0.003)	0.001* (0.000)
capital_ratio t-1	0.021*** (0.004)	0.021 (0.014)	0.021 (0.016)	0.021 (0.016)	0.023*** (0.003)	0.021 (0.015)	-0.052 (0.037)	0.022 (0.016)	0.026* (0.014)	0.016 (0.019)	0.023* (0.014)	0.010 (0.022)	-0.004** (0.002)
ln(assets) t-1	-0.042*** (0.007)	-0.042 (0.026)	-0.040 (0.033)	-0.040 (0.033)	-0.042*** (0.006)	-0.040 (0.032)	-0.039 (0.032)	-0.055 (0.056)	-0.053 (0.042)	-0.017 (0.029)	-0.023 (0.060)	0.178* (0.091)	0.026* (0.013)
bank variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
borrower variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
inc. unused credit	no	no	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
lines													
sectoral dummies	no	no	no	no	yes	no	no	no	no	no	no	no	no
macrovariables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
fixed effects	no	no	no	no	no	no	no	no	no	no	no	no	relationship
Clustered s.e.	quarter	quarter & bank	quarter & bank	quarter & bank & firm	quarter	quarter & bank	quarter & bank	quarter & bank	quarter & bank	quarter & bank	quarter & bank	quarter & bank	quarter & bank
N° obs.	2,655,604	2,655,604	2,479,691	2,655,604	2,086,479	2,479,691	2,479,691	2,479,691	835,022	387,385	845,868	1,633,823	2,346,526

Note: All variables defined in Table 1. Results of probit regressions (except column XIII, which is a linear probability model) on the dependent variable *had_loan* conditional on a new loan (or a new loan including unused credit lines) being granted. Bank variables included and reported *ln(assets)*, *size*, *CCAM*, *ICUE*, *MEGA* and *IAS*. Borrower variables included and not reported: *ln(L+PE)*, *ln(credit)*, *ln(2+age)*, *ln(L+age)* and *Cred_LTE*. In *Mc* variables included and not reported: *GDP*, *PT* and *PI*. A constant and quadratic trend are also included but their coefficients are not reported. Columns IX to XII report the results of the regression for subsamples according to criteria defined in the top of the columns. Small (large) firms are below the median (large firms are in the top-10 percentile). Large banks are the 5 largest banks in Portugal, representing around half of the total corporate loan market; small banks are the remaining ones. Multi-way clustering computed following Cameron, Gelbach and Miller (2011) and Cameron and Miller (2015). For each variable, we report the coefficient, the standard deviation (below in italics) and the significance level (* significance at 10 per cent, ** significance at 5 per cent, *** significance at 1 per cent).

only for large firms, which are arguably less risky than smaller firms. In terms of bank size, risk-taking exists both for small and large banks.⁸

Finally, in column XIII we show the results of our estimations with a linear probability model. We do this because in the probit specifications, we are not able to use relationship fixed effects. When we add these fixed effects, we still find evidence that there is risk-taking on the extensive margin.⁹

In Table 5, we replicate all the estimations reported in Table 4. The only difference is the dependent variable: while in Table 4 the dependent variable was *bad_hist*, taking the value one if the firm was in default in this quarter and in the previous one, in this new table the dependent variable takes the value one if the firm is a first time borrower (*new_bor*). We consider that this is also a form of risk-taking, as information asymmetries are more acute when giving a loan to a firm without credit history (Diamond 1991, Thakor 2013). Note that at the intensive margin, we are only able to explore risk-taking within ongoing relationships. Adding this dimension of analysis at the extensive margin provides new insights on the workings of the risk-taking channel through different angles.

The results regarding the effect of monetary policy interest rates on risk-taking are entirely consistent: when interest rates are lower, banks become more likely to grant loans to new borrowers than to existing ones.

When we interact interest rates with bank characteristics, we do not find any statistically significant results in this case (columns VI–VIII). When we run sample splits by firm size we get an interesting difference: risk-taking through new borrowers occurs mainly through small firms (which are more likely to be first time borrowers), while we had found that for bad-quality borrowers the effect was coming mainly from large firms. The results of splitting the sample by bank size are consistent with what we found for borrowers in default, given that risk-taking through new borrowers exists for both small and large banks.

As in the previous section, we also conduct the same analysis but using the Taylor residuals as the main explanatory variable, instead of the monetary policy rate (Table 6). In this case, we find an increase in *ex ante* banks' risk-taking at the extensive margin for new borrowers (columns III and IV) but not for existing borrowers (columns I and II). This may signal that banks' risk-taking behaviors are associated mainly with environments of low monetary policy interest rates, rather than by periods in which monetary policy is too accommodative.

Summing up, our results consistently show that there is a risk-taking channel working at the extensive margin. Riskier borrowers are more likely to get new loans when interest rates are lower. These effects are stronger for banks with less capital.

8. In column XII, it is not possible to calculate the standard error for the interest rate coefficient, likely due to the high demanding multiclustering structure imposed. Indeed, when we cluster standard errors by quarter only (not reported, available at request), we get a strongly negative significant coefficient.

9. To be sure that the results are not being driven by the change in estimation methodology, we also estimate a linear probability model without relationship fixed effects. The results for the coefficient associated with risk-taking are entirely consistent.

TABLE 5
RISK-TAKING AT THE EXTENSIVE MARGIN: PROBABILITY OF GRANTING A LOAN TO A FIRST TIME BORROWER AND INTEREST RATES

	I		II		III		IV		V		VI		VII		VIII		Small firms		Large firms		Small banks		Large banks		LPM	
	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.
i ECB eq _{t-1}	-0.045** (0.022)		-0.045** (0.019)		-0.047** (0.018)		-0.047** (0.018)		-0.038 (0.034)		-0.010 (0.036)		-0.062* (0.034)		-0.088 (0.106)		-0.062*** (0.022)		0.054 (0.051)		-0.034** (0.014)		-0.086** (0.019)		-0.008** (0.004)	
i° liq_ratio _{t-1}																										
i° capital_ratio _{t-1}																										
i° ln(assets) _{t-1}																										
liq_ratio _{t-1}	-0.007*** (0.001)		-0.007*** (0.002)		-0.008*** (0.002)		-0.008*** (0.002)		-0.004*** (0.001)		-0.002 (0.006)		-0.008*** (0.002)		0.002 (0.005)		-0.007*** (0.002)		-0.001 (0.002)		-0.005* (0.003)		-0.008*** (0.002)		-0.001*** (0.000)	
capital_ratio _{t-1}	0.014***		0.014		0.015		0.015		0.010***		0.014		0.004		0.015		0.006		-0.002		0.020***		-0.027		0.002	
ln(assets) _{t-1}	-0.003 (0.008)		-0.003 (0.011)		0.003 (0.010)		0.003 (0.010)		-0.030*** (0.010)		0.002 (0.020)		0.003 (0.020)		-0.003 (0.030)		-0.040* (0.022)		0.074* (0.041)		-0.044 (0.035)		0.079** (0.039)		0.009 (0.007)	
bank variables	yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes	
borrower variables	yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes	
inc. unused credit lines	no		no		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes	
sectoral dummies	no		no		no		no		yes		no		no		no		no		no		no		no		no	
macrovariables	yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes	
fixed effects	no		no		no		no		no		no		no		no		no		no		no		no		no	
Clustered s.e.	quarter		quarter & bank		quarter & bank & firm		quarter & bank		quarter		quarter & bank		quarter & bank		quarter & bank		quarter & bank		quarter & bank		quarter & bank		quarter & bank		quarter & bank	
N° obs.	3,432,579		3,432,579		3,432,579		3,432,579		2,743,953		3,287,338		3,287,338		3,287,338		3,287,338		421,775		1,166,743		2,120,595		2,990,903	

NOTE: All variables defined in Table 1. Results of probit regressions (except column XIII, which is a linear probability model) on the dependent variable new_borrower conditional on a new loan (or a new loan including unused credit lines) being granted. Bank variables included and not reported: rel_np/assets, savings, CCA, ICUE, M&A and IAS. Macrovariables included and not reported: GDP PT and π PT. A constant and a quadratic trend are also included but their coefficients are not reported. Columns IX to XII report the results of the regression for sub-samples according to criteria defined in the top of the column. Small (large) firms proxied by the size of the total credit by the firm: Small firms are below the median, large firms are in the top-10 percentile. Large banks are the 5 largest banks in Portugal, representing around half of the total corporate loan market; small banks are the remaining ones. Multi-way clustering computed following Cameron and Miller (2011) and Cameron and Miller (2015). For each variable, we report the coefficient, the standard deviation (below in italics) and the significance level (* significance at 10 per cent, ** significance at 5 per cent, *** significance at 1 per cent).

TABLE 6

RISK-TAKING AT THE EXTENSIVE MARGIN: PROBABILITY OF GRANTING A LOAN TO A RISKY FIRM AND INTEREST RATES

	Bad history		New borrower	
	I Coef. <i>S.e.</i>	II Coef. <i>S.e.</i>	III Coef. <i>S.e.</i>	IV Coef. <i>S.e.</i>
Taylor residual $t-1$	-0.024 (0.026)	-0.030 (0.021)	-0.051* (0.029)	-0.043* (0.025)
liq_ratio $t-1$	-0.007** (0.003)	-0.007** (0.003)	-0.007*** (0.002)	-0.008*** (0.002)
capital_ratio $t-1$	0.022 (0.014)	0.022 (0.016)	0.014 (0.011)	0.015 (0.010)
ln(assets) $t-1$	-0.043* (0.026)	-0.041 (0.033)	-0.003 (0.018)	0.002 (0.020)
bank variables	yes	yes	yes	yes
borrower variables	yes	yes	yes	yes
inc. unused credit lines	no	yes	no	yes
sectoral dummies	no	no	no	no
macrovariables	yes	yes	yes	yes
fixed effects	no	no	no	no
Clustered s.e.	quarter & bank	quarter & bank	quarter & bank	quarter & bank
N° obs.	2,597,851	2,424,200	3,355,783	3,212,352

NOTE: All variables defined in Table 1. Results of probit regressions on the dependent variable *bad_list* (columns I and II) or on the dependent variable *new_borrower* (columns III and IV), conditional on a new loan (or a new loan including unused credit lines) being granted. Bank variables included and not reported: *rel_npl/assets*, *savings*, *CCAM*, *ICUE*, *M&A* and *IAS*. Borrower variables included and not reported: *ln(1+#rel)*, *ln(credit)*, *ln(2+age)*, *ln(1+loan)* and *Cred.LT_prop*. Macrovariables included and not reported: *GDP_PT* and π_{PT} . A constant and a quadratic trend are also included but their coefficients are not reported. Multi-way clustering computed following Cameron, Gelbach and Miller (2011) and Cameron and Miller (2015). For each variable, we report the coefficient, the standard deviation (below in italics) and the significance level (* significance at 10 per cent, ** significance at 5 per cent, *** significance at 1 per cent).

5. THE RISK-TAKING CHANNEL ASSESSED *EX POST*

In the previous section, we found evidence supporting the risk-taking channel at the extensive margin, based on banks' assessment when granting a loan. But what happens to the loans granted when interest rates are low? Even if bad-quality borrowers get more loans, 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 when loans are granted, 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 *ex post* 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 DID approach. Our goal is to understand if loans granted when rates are low and stable are riskier in the sense of showing heightened sensitivity to interest rate increases.

5.1 Does the Level of the Policy Rate When Loans Are Granted Influence the (Ex Post) Probability of Default?

Table 7 presents the results of the survival estimation (equation (3)). A brief inspection of the first line of the table shows that there is no evidence of an *ex post* risk-taking channel. The level of monetary policy interest rates in the moment loans are granted does not affect the *ex post* default performance of the loans. The only exception is reported in column X, where we show our baseline results estimated with time-varying covariates. In this case, we find evidence supporting the risk-taking channel *ex post*. However, in this specification, we are explicitly considering the role of changing firm, bank and macro characteristics over the life of the loan, while considering only the interest rate at the moment of concession. 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 this specification. As such, this latter result should be interpreted with caution. In sum, we cannot find consistent evidence to support the hypothesis that the level of interest rates when loans are granted matters for their *ex post* default probability.

It is important to note that these results are not in contradiction with the previous analysis. In the first part of our analysis, we wanted to assess how monetary conditions influence lending to *ex ante* riskier borrowers (i.e., their riskiness was to some extent verifiable). In this section, we are evaluating how monetary policy rates when loans are granted 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 in these two situations is quite different: in the former, banks were granting loans to borrowers who had verifiably poor quality, whereas in the latter case the results reflect more than just the decision of the bank. A possible interpretation is that even though when monetary policy rates are lower, banks grant credit to riskier borrowers, who are more likely to default in the future, 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. Moreover, we are assessing the entire interest rate cycle, while this channel may operate only in low interest rate periods, possibly undermining the results. To better capture this, in the next section we will focus specifically on these periods.

Besides the main results reported in the first line of Table 7, there are other results worth highlighting. We find that borrowers with recent defaults take less time to default again than other borrowers. This recidivist behavior is consistent with previous results found for Portuguese firms by Bonfim, Dias, and Richmond (2012). However, when we interact this variable with the interest rate in the moment loans were granted (column III), we do not find any statistically significant effect. Recidivism is independent of the level of interest rates when loans are granted.

Looking across the board at the role of bank characteristics shown at the bottom of the table, we find that *ex post* default probabilities are higher for loans granted

TABLE 7
CONTINUED

		Dependent variable: hazard rate (loan level)														
		Small firms			Large firms			Small banks			Large banks			Taylor residuals		
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV	XV
		Coef.	Coef.	Coef.	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.	S.e.	S.e.	S.e.
bank variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
borrower variables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
sectoral dummies	no	yes	no	no	no	no	no	no	no	no	no	no	no	no	no	no
macrovariables	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
time-variant	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
shared frailty	firm	no	no	no	no	no	no	no	no	no	no	no	no	no	no	no
Clustered s.e.	quarter	quarter	quarter	quarter	quarter	quarter	quarter	quarter	quarter	quarter	quarter	quarter	quarter	quarter	quarter	quarter
N° obs.		1,384,696	1,053,493	1,384,696	1,339,370	1,339,370	1,384,696	1,339,370	1,339,340	1,384,696	5,833,210	489,228	206,849	397,071	987,625	906,317

Note: All variables defined in Table 1. Results of the estimation of a Weibull hazard function at the loan level, i.e., of the probability of default of the firm relative to the bank at each moment, given that there was no default observed since a new loan was granted. τ refers to the moment when the loan is granted. $LECR_{it}$ is fixed to the moment prior to the loan accession. Bank variables included and not reported: $rd/np/ks$, scs , $CCAM$, $ICIE$, $M&A$ and MS . Borrower variables included and not reported: $ln(\#rel)$, $ln(Credit)$, $ln(2+age)$, $ln(1+loan)$ and $Credit/turnover$. Macrovariables included and not reported: GDP , PT , p (GDP growth fixed at the moment the loan is granted), GDP , PT , p (times-varying GDP growth) and π , PT . A constant and a quadratic trend are also included but their coefficients are not reported. Columns XI to XIV report the results of the regression for sub-samples according to criteria defined in the top of the column. Small (large) firms proxied by the size of the total credit by the firm; Small firms are below the median, large firms are in the top-10 percentile. Large banks are the 5 largest banks in Portugal, representing around half of the total corporate loan market; small banks are the remaining ones. Column XV reports the results using Taylor residuals instead of interest rates. For each variable, we report the coefficient, the standard deviation (below in italics) and the significance level (* significance at 10 per cent, ** significance at 5 per cent, *** significance at 1 per cent).

by larger banks, as well as for banks with more capital and less liquidity. When we interact these bank characteristics with the level of interest rates at loan origination (columns IV–VI), the only significant results refer to capital ratios. This means that the previous result stating that banks with more capital grant loans with a higher default probability is mitigated when interest rates are lower. Bank size and liquidity do not play a role. When we further interact these variables with the dummy proxying for loan quality, in order to get closer to the specifications implemented for the *ex ante* analysis, we do not obtain any additional result (columns VII–IX).

To be consistent with the analysis of *ex ante* risk-taking, we run sample splits by firm and bank size. Regarding firm size, the *ex post* risk-taking channel does not work independently of the size of the firm (columns XI and XII). In turn, regarding bank size we find some interesting differences (columns XIII and XIV). There is evidence supporting the existence of *ex post* effects of risk-taking when interest rates are low, especially for large banks. Finally, the lack of evidence of a risk-taking channel working *ex post* across all firms and banks does not depend on the way we measure monetary policy stance, given that the results are similar when we consider Taylor residuals instead of monetary policy rates (column XV).

We conclude that the results from the survival analysis show that the risk-taking channel does not have relevant *ex post* consequences in terms of financial stability. In the next subsection, we look at another possible way to identify the impact of the risk-taking channel on *ex post* loan performance.

5.2 Are Loans Granted When Policy Rates Are Lower More Likely to Default When Interest Rates Increase?

The results of the previous subsection suggest that loans granted during periods of lower interest rates do not contribute to a significant deterioration in the overall loan portfolio quality. In this section, we explore a related issue. Instead of analyzing how default probabilities evolve in general, taking the level of interest rates at loan approval as given, we focus our attention specifically on what happens to loans granted during low interest rate periods when 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 zoom in a particularly interesting period for analysis. Monetary policy interest rates in the euro area began to increase in December 2005, after a prolonged period of low and stable interest rates. The ECB maintained the main policy interest rate fixed at the historical minimum of 2% during a period of more than 2 years (between June 2003 and December 2005). Around October 2005, the ECB communication changed, signaling a possible increase in interest rates. This leads to a substantial revision of interest rate expectations, as illustrated in Figure 2. This revision was fast and sizeable. We believe that focusing on this period provides a great framework to address the interaction between risk-taking behaviors in low interest rate periods and the *ex post* performance of the loans.

We implement a DID. To grasp the effect of an increase in interest rates after a relatively long period of accommodative monetary policy, we compare two groups of loans: the treatment group includes the loans granted immediately before interest rates began to increase in December 2005, when interest rate expectations were still anchored at low levels (January–September 2005). The loans in the control group are those granted in the period when interest rates were still low, but interest rate expectations had increased markedly (October 2005 to March 2006). The main difference between the loans granted in the treatment and control groups is related to the level of interest rate *expectations*, as the level of interest rates in itself remained low in both periods. Furthermore, the effective interest rates charged by banks on loans granted to firms between January 2005 and March 2006 was very similar, as illustrated in Figure 2.

The performance of these two groups of loans is then compared in two different moments: we consider the probability of default before and after the monetary policy interest rate starts to increase (*after* = 0 and *after* = 1, respectively). This setting provides a unique opportunity to identify risk-taking behaviors. We are able to compare loans granted with similar levels of effective interest rates, but with underlying different expectations regarding the future path of monetary policy. We are thus able to test whether banks take more risk when they believe that interest rates will remain low for a long period. In this setting, risk is measured by borrowers' sensitivity to interest rate hikes.

Our analysis would support the existence of a risk-taking channel if loans granted during the period of low and stable interest rate expectations show a higher default probability when interest rates increase.

Table 8 presents the results of the DID estimation, where we estimate a probit model for the probability of default of the firm (equation (4)).¹⁰ We obtain a negative coefficient on the *treatment* variable. This means that loans granted when interest rate expectations are low are generally less likely to default. The coefficient on the *after* variable is also negative in most specifications, suggesting that when interest rates increase, default probabilities are actually lower. However, this result is slightly less consistent than the previous one.

The coefficient on the interaction term provides the main test to our hypothesis. The coefficient is positive and significant in most of the specifications considered, meaning that loans granted in the period of low and stable interest rates are more likely to default when interest rates increase relative to the loans granted when policy interest rate rises were already expected. This result provides new evidence on an important dimension of the risk-taking channel. Banks take more credit risk when policy rates are expected to remain low for a considerable horizon, though this risk only materializes when interest rates increase.

As already mentioned, this result holds across many specifications. We should thus briefly summarize the reasoning behind each specification presented in Table 8. In the

10. 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.

TABLE 8
EX-POST ASSESSMENT OF RISK-TAKING: DIFFERENCES-IN-DIFFERENCES APPROACH IN A SHORT SUB-PERIOD (2005-2007)

	I		II		III		IV		V		VI		VII		Small firms VIII		Large firms IX		Small banks X		Large banks XI		
	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	Coef.	S.e.	
treatment t	-0.273*** (0.051)		-0.273** (0.040)		-0.273		-0.261*** (0.050)		-0.273*** (0.051)		-0.273*** (0.051)		-0.273*** (0.051)		-0.413*** (0.060)		-0.107** (0.054)		-0.294*** (0.050)		-0.282*** (0.040)		
after t	-0.164*** (0.022)		-0.164 (-)		-0.164		-0.189*** (0.023)		-0.164*** (0.022)		-0.164*** (0.022)		-0.165*** (0.022)		-0.251*** (0.020)		-0.072*** (0.021)		-0.193*** (0.039)		-0.205*** (0.034)		
treatment* after t	0.242*** (0.058)		0.242*** (0.041)		0.242		0.225*** (0.056)		0.199*** (0.053)		0.253*** (0.068)		-0.062 (0.133)		0.337*** (0.066)		0.101* (0.061)		0.256*** (0.058)		0.267*** (0.046)		
treatment* after t* liq_ratio _{t-1}					0.041		0.003*** (0.001)		0.003*** (0.001)		-0.002 (0.002)		0.013* (0.007)										
treatment* after t* capital_ratio _{t-1}																							
treatment* after t* ln(assets) _{t-1}																							
liq_ratio _{t-1}	0.003*** (0.001)		0.003 (0.002)		0.003		0.003*** (0.001)		0.003*** (0.001)		0.003*** (0.001)		0.003*** (0.001)		0.002 (0.001)		0.003*** (0.001)		0.002** (0.001)		-0.001 (0.002)		
capital_ratio _{t-1}	-0.002 (0.002)		-0.002 (0.008)		-0.002		-0.003** (0.002)		-0.002 (0.002)		-0.002 (0.002)		-0.002 (0.002)		0.001 (0.002)		0.000 (0.004)		0.002 (0.002)		0.043*** (0.010)		
ln(assets) _{t-1}	-0.027*** (0.009)		-0.027 (0.022)		-0.027		-0.021** (0.009)		-0.027*** (0.009)		-0.027*** (0.009)		-0.027*** (0.009)		-0.028** (0.011)		-0.030*** (0.004)		0.062*** (0.023)		-0.044 (0.041)		
bank variables	yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		
borrower variables	yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		
sectoral dummies	no		no		no		no		no		no		no		no		no		no		no		
macrovariables	yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		yes		
fixed effects	no		no		no		no		no		no		no		no		no		no		no		
Clustered s.e.	quarter		quarter & bank		quarter & bank & firm		quarter		quarter		quarter		quarter		quarter		quarter		quarter		quarter		
N° obs.	1,640,137		1,640,137		1,640,137		1,509,658		1,640,137		1,640,137		1,640,137		692,727		189,480		605,002		1,035,135		

NOTE: All variables defined in Table 1. Results of a probit estimation on the dependent variable $\ln(\text{loan})$. Treatment equals 1 for firm-bank relationships with a new loan was granted between Jan-05 to Sep-05 and equals 0 for firm-bank relationships with a new loan granted between Oct-05 and Mar-06. After equals 1 for the period when interest rates began to rise (from Jan-06 onwards). Bank variables included and not reported: $\text{rel}/\text{np}/\text{assets}$, savings , CCAM , TCUE , M\&A and IAS . Borrower variables included and not reported: $\ln(1+\text{ret})$, $\ln(\text{credit})$, $\ln(2+\text{age})$, $\ln(1+\text{loan})$ and CredLT-prop . Macrovariables included and not reported: GDP PT and π PT . A constant and a quadratic trend are also included but their coefficients are not reported. Columns VIII to XI report the results of the regression for sub-samples according to criteria defined in the top of the column. Small (large) firms proxied by the size of the total credit by the firm. Small firms are below the median, large firms are in the top-10 percentile. Large banks are the 5 largest banks in Portugal, representing around half of the total corporate loan market; small banks are the remaining ones. Multi-way clustering computed following Cameron, Gelbach and Miller (2011) and Cameron and Miller (2015). For each variable, we report the coefficient, the standard deviation (below in italics) and the significance level (* significance at 10 per cent, ** significance at 5 per cent, *** significance at 1 per cent).

first column we show the results for the main variables of interest (*treatment*, *after* and the interaction term), controlling for bank, borrower, and macroeconomic variables. In columns II and III, we present the results using standard errors multiclustered at the quarter and bank and at the quarter, bank, and firm level, respectively, instead of only at the quarter level. In column IV, we go back to clustering at the quarter level and add sectoral controls. The interaction term that captures risk-taking remains almost unchanged across these specifications.

In columns V–VII we analyze the role of bank characteristics in the transmission of the risk-taking channel, as we did in the previous tables.¹¹ Again, we find evidence in favor of greater risk-taking by larger banks and especially by banks with higher liquidity ratios. This provides further support of the hypothesis of risk-shifting for banks with poor managerial incentives. In columns VIII and XI, we run again sample splits according to firm and bank size. We find that there is risk-taking across all firm size categories, though slightly stronger for smaller firms, and across all bank size categories.

All in all, the results presented in this section provide support to the existence of a risk-taking channel in prolonged periods of low interest rates, which materializes once interest rates start to increase.

6. CONCLUDING REMARKS

Banks play a key role in the transmission of monetary policy. Banks' lending decisions are shaped by the stance of monetary policy. While most of the classic literature on the transmission of monetary policy focused on volumes, more recently the quality of credit granted has also deserved a lot of attention. The more recent literature on the risk-taking channel thus asks whether loans granted when monetary policy is more accommodative are generally riskier.

Many recent papers offer evidence supporting the existence of this channel. However, the fast expansion of this literature led to scattered evidence, obtained under inconsistent analytical frameworks and methodologies. In this paper we analyze the risk-taking channel through different angles, using detailed bank and borrower information over time. We looked at the risk-taking channel from an *ex ante* and an *ex post* perspective and considered both intensive and extensive margins. We tracked loan performance over time and we analyzed what happens to loans granted when interest rates were low for a long time once rates increase.

We obtain evidence supporting the existence of the risk-taking channel along different dimensions. When we consider the information that banks have when granting a loan, we find that banks take more risk when interest rates are lower, but only at the extensive margin. When we track loan performance over time, we find that the level

11. Unlike what we did in previous tables, from these columns onward the results use only quarterly clustering, as the multiclustering procedure is excessively demanding for the narrow estimation window behind this identification strategy.

of policy interest rates does not have a significant impact on the overall loan portfolio quality, when looking at a full interest rate cycle. However, when we zoom in into the period of low policy rates, we find a higher sensitivity to interest rate hikes from loans granted in a period of low and stable interest rates. These loans are being compared with loans with very similar conditions, with the only relevant difference being the prevailing expectations about the future path of interest rates. Banks take more credit risk when policy rates are expected to remain low for a considerable horizon, though this risk only materializes when interest rates increase.

We also explore the role of firms' and banks' heterogeneity in the risk-taking channel. The results regarding firm size are mixed, depending on the way we look at the risk-taking channel. At the extensive margin, risk-taking is stronger for large firms when we consider being in default as the measure of riskiness. In contrast, when we proxy riskiness by lending to first time borrowers, we find that risk-taking is more concentrated in loans to the smallest firms. We also find that smaller firms are more sensitive to interest rate hikes.

Regarding bank size, our results suggest that risk-taking behaviors are common across all bank-size categories, despite some differences in intensity. The results seem to point to higher intensity of risk-taking by large banks.

These heterogeneous results on firm and bank size highlight the relevance of looking at the risk-taking channel through different angles. To further explore this heterogeneity, we also consider the role of banks' capital and liquidity. We find that risk-taking is stronger for less capitalized banks. This is consistent with previous empirical and theoretical evidence (Diamond and Rajan 2012, Jiménez et al. 2014). Banks closer to minimum capital requirements are less likely to fully internalize the potential consequences of the risks taken. Moreover, there is also some evidence that banks with more liquidity may also take more risk, in line with the literature of risk-shifting strategies for banks with poor managerial incentives (Acharya and Naqvi 2012).

These results have important policy implications. Interactions between monetary policy and financial stability should be especially taken into account during prolonged periods of accommodative monetary policy. While for monetary policy purposes, an expansion of credit would be desirable in times of high macroeconomic risk, this could have undesired effects on banks' soundness. Thus, this may call for an active role of macroprudential policy in taming possible undesirable effects of monetary policy.

This may be especially important after a decade during which central banks in advanced economies promoted a huge expansion of liquidity to fight the lasting consequences of the global financial crisis. This prolonged environment of very low interest rates and ample liquidity may have offered incentives for some banks to engage in risk-taking strategies, lending to riskier borrowers as a way to boost short term profitability. Our results show that this behavior was possibly more prevalent among banks with weaker capital ratios. Crucially, our analysis also suggests that the effects of these risky strategies will become apparent only when interest rates increase again.

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