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Abstract

We study the impact of higher capital requirements on banks' decisions to grant collateralized rather than uncollateralized loans. We exploit the 2011 EBA capital exercise, a quasi-natural experiment that required a number of banks to increase their regulatory capital but not others. This experiment makes secured lending more attractive vis-à-vis unsecured lending for the affected banks as secured loans require less regulatory capital. Using a loan-level data set covering all corporate loans in Portugal, we identify a novel channel of higher capital requirements: relative to the control group, treated banks require loans to be collateralized more often after the shock, but less so for relationship borrowers. This applies in particular for collateral that saves more on regulatory capital.

Key words: Capital requirements, collateral, relationship lending, lending technology.

JEL classification: G21, G28, G32.

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1 Introduction

A large literature in economics and finance has long recognized the importance of asymmetric information problems. Lending to small businesses, a core source of economic growth, is especially vulnerable to severe informational problems (e.g., Petersen and Rajan, 1994; 1995; Berger and Udell, 1995). At the same time, financing small businessees remains a key factor to economic recovery after a crisis.[1] In the aftermath of the global financial crisis, the issue regained a great deal of attention as young firms, having little access to alternative funding sources and limited collateral, were particularly hit by the volatile credit environment. Indeed, policy makers have recently addressed the issue at the highest level across the globe. OECD (2016) for example provides a review of the government measures undertaken to support access to finance for small businesses in the period 2007-14.

Because financing a small business is risky, most creditors choose to require collateral. Collateral is a key feature in most credit contracts, including in part commercial loans. Yet, the availability of collateral remains a key challenge especially at the initial stage of a business' life. [2] In this paper we empirically explore the role of relationship banking in providing firms with unsecured, as opposed to secured, funding. First, young and small businesses may simply lack the required collateral and hence face credit constraints, when otherwise unsecured funding opportunities are limited. Second, borrowers may

[1] http://www.oecd.org/cfe/smes/financing-small-business-key-to-economic-recovery.htm

[2] Use of collateral is pervasive in credit markets. Interbank repurchase agreements, commercial and residential mortgages, vehicle loans, loans for consumer durables are examples of mostly secured funding types. In the U.S., for instance, 84 percent of the value of loans under USD 100.000 is collateralized. See Small Business Lending in the United States, 2013, see https://www.sba.gov/advocacy/small-business-lending-united-states-2013.

face opportunity costs by binding up certain types of their assets as collateral. Finally, secured lending may constrain borrowers' access to funding at especially hard times, as borrowers' credit capacity can fluctuate due to volatile values of the underlying assets. Such pro-cyclical forces can further exacerbate downturns.[3]

Our focus is, first, on how relationship banking, in form of repeated lending by the same creditor, facilitates borrowers' access to unsecured (as opposed to secured) funding in normal times. To do so, we analyze firm-bank level lending relationship information from around nine years from the universe of new loans initiated in Portugal. The first important way in which we depart from the existing literature is that we study borrowers' access to secured and unsecured lending *at the beginning of the relationship*. Previous empirical research has focused on collateral use over time (Degryse and van Cayseele, 2000), a finding that we also confirm using a richer data and a new measure of relationship. While this is also in line with theoretical work on learning about borrowers over time, a new prediction that we test here refers to the cross-sectional implications on how a borrower's loyalty affects banks' choice of lending technology *at the initial stage of the relationship.*

Our main identification strategy relies on an exogenous shock to the costs and benefits of some banks' lending technologies but not others. In October 2011 the European Banking Authority (EBA) announced that major European banking groups would have to increase their core tier 1 capital ratios to 9 percent of their risk-weighted assets by June 2012. These groups were also required to hold a new temporary capital buffer to cover risks linked to sovereign bond holdings.[4] The EBA announcement affected a handful of

[3]For instance, loans that are secured by commercial or residential real estate, accounts receivable or inventory, will provide a lower credit capacity in downturns.

[4]At the time, the EBA had just conducted rigorous stress tests in July 2011, had already released

banks, while others stayed unaffected. An increased requirement of risk-weighted capital increase costs of unsecured lending as the latter requires more of costly (regulatory) capital, compared to secured, less risky lending. Such an unexpected increase in capital requirements imposed on some banks tilted those banks lending technology towards favouring collateral requirements.

The hypothesis we test is that a) affected banks will require more collateral; b) they will do so less for high-relationship borrowers, than for transactional borrowers. We find this is the case both at the beginning as well as over the course of the relationship. The observed effect is economically large: For high-relationship borrowers (borrowers in the top quartile of relationship length) the increase in required collateralization is lower by 4-9 percentage points, compared to their low-relationship (bottom quartile) counterparts at the start of the relationship. We show that such change increases the likelihood of collateralized lending by the same firm at treated banks relative to that firm taking a loan at control banks. We furthermore find that this shift towards collateralized lending does not take place for firms with strong relationships with treated banks.

Existing theoretical wpork suggests banks may choose one of two technologies to overcome asymmetric information(Manove and Padilla, 2001). First, *screening* with costly information collection about project type, or, second, use of *collateral*; in the latter case, borrowers with bad projects are not willing to pledge and lose large enough collateral. Banks generate incumbency informational rents on their borrowers over time. [5] How-

detailed information on the exposure of European banks to sovereign risk, and the announcement was largely perceived as a surprise (Mesonnier and Monks, 2015).

[5] While rent generation is quite standard in repeated banking interaction, the specific way in which it works in the setup could in more detail be described as follows; banks choose only one of the two technologies as both are costly. Collateral is costly due to liquidation losses in case of default, and this

ever, because of competition the prospective informational rents should be transferred to borrowers in form of lower interest rates at present, so that banks can attract them at the initial stage. If banks use the collateral technology, the lower interest rates must be combined with higher amounts of collateral, rendering this technology relatively more expensive for the bank (Karapetyan and Stacescu, 2016).[6] Therefore, provided the bank anticipates the borrower will return for a credit application later, the likelihood of unsecured credit is higher. The empirical prediction then is that borrowers with a high loyalty and longer relationship potential are more likely to obtain unsecured funding as opposed to secured funding.

In line with this theoretical prediction we find in the cross-section that borrowers' access to funding is more likely to be unsecured if the ensuing relationship is likely to be a long-term one. We show, that borrowers with a longer expected relationship potential and therefore stronger loyalty are indeed more likely to enjoy an unsecured credit. The economic magnitude is significant. Being a high-relationship potential borrower (i.e., having a relationship length in the top quartile of its distribution), the use of collateral in

cost is proportional to the amount of collateral a given borrower has pledged. Yet, that cost does not depend on the proportion of good (creditworthy) projects in the population. In contrast, screening costs depend on the proportion of good projects, and are a function of that proportion: since they cannot distinguish ex-ante between good and bad projects, banks have to screen all loan applicants, but will lend to only high-quality ones who have to incur the burden of *all* screening costs (Manove and Padilla, 2001). Due to learning over time, the set of borrowers that the incumbent bank focuses on in later stages has fewer bad risks and a higher proportion of good projects. The screening teechnology, therefore, becomes less expensive per borrower as the borrower pool improves over time, making it less expensive, but only for the incumbent bank.

[6]The negative relationship between interest rates and collateral is standard in an adverse selection model, see for instance Bester (1985). The idea is that for a given interest rate, collateral must be large enough so that it is not attractive for a borrower with a bad-quality project, who pays a combination of interest rate (when successful) collateral (in default). For recent evidence on such negative relationship, see Becker et al. (2016).

the earlier stage of the relationship is up to 10.4 percentage points less likely compared to being a short-term transactional borrower (i.e., being in the lowest quartile of the distribution). Thus, being a relationship borrower can decrease collateralization probability by about 20 percent (unconditional mean of collateralization is 48 percent in the data). Similarly, a borrower with a relationship length that is higher by a one standard deviation will have a 7.5 pp lower use of collateral (18 percent of the unconditional mean).

Our results are not driven by time-varying or time-invariant unobservables. We use firm, time, as well as firm-time (when appropriate) and bank-time fixed effects in our specifications. Moreover, in our difference-difference approaches we focus on various time spans, including short windows, and thus minimize the potential of any unobserved confounding effects.

In line with existing empirical banking literature, we further confirm the time series implication that borrowers' collateral requirements go down during the course of the relationship (see, for instance, Degryse and Van Cayseele, 2000: Berger et al., 2011).[7] In doing so, we make use of nine-year-long relationship information, as well as construct a new relationship length measure. The measure captures the frequency, rather than the simple length, of bank-firm borrowing interactions. Such relationship frequency measure more closely evaluates the active time between the bank and the firm compared to the more standard relationship length that measures the time elapsed from the first loan made by the bank to the borrower, and will treat frequent and infrequent borrowers equally.[8]

Our paper is closely related to a recent empirical debate about the way collateral

[7]Berger et al. (2011) in fact find several distinct effects underlying collateral requirements. We return to this later in the paper.

[8]We still confirm our results by the usual relationship length measure.

ameliorates information asymmetries. In testing ex-ante versus ex-post collateral in credit contracts, a particularly severe empirical challenge has until recently been the empiricist's inability to correctly disentangle the unobservable risk (underlying the ex-ante theory) from observable risk (ex-post collateral theory). Making use of a clean setting allowing such separation, this challenge has lately been overcome in Berger et al. (2011). In doing so, they in part find support for ex-ante theory, showing how unobservably safer borrowers start with collateral contracts (predicted by ex-ante collateral theories, starting from Bester, 1985), while enjoying more and more unsecured credit by proving their good-rating in later stages. While rationalizing certain particulars of their empirical findings, the model in KS has an important corollary: borrowers enjoy unsecured credit not only later (because they prove they are less risky, and it is unobservable at the beginning), but also today because they have a longer relationship potential. In this paper, we provide empirical evidence for the latter. This is a cross-sectional, rather than time-series, prediction that across the ensuing firm-bank relationships, the higher potential for loyalty is rewarded by unsecured credit at the start.

Our paper contributes to the literature on relationship banking.[9] Unlike early studies of relationship banking, we here focus on the role of banks in providing initial funding and funding at crisis times. More recent studies have focused on the global financial crisis and the bank's role in overcoming frictions (e.g., Chodorow-Reich, 2014, Iyer et al. (2014), Ongena et al. (2015), Bolton et al. (2016), Cingano et al. (2016)). Rather than focusing on access to funding and the role of banks' heterogeneity, we here focus on access

[9] For a review, see Boot (2000). See also Ioannidou and Ongena (2010), Degryse and Van Cayseele (2000), and Degryse and Ongena (2005) among others.

to unsecured funding, and on the role of borrowers' heterogeneity (i.e., its relationship aspect) in such access.

Closest to our work, several recent studies have focused on the role of relationship banking in crisis, and in particular in the global financial crisis of the last decade. Beck et al. (2015) analyze the role of lending technologies in overcoming firms' credit constraints over the business cycle. Among other findings, they show smaller and younger firms with less collateral to pledge face more credit constraints during a credit crunch, particularly if they have more limited access to a relationship lender. We instead focus on the role of the relationship between a given bank and a borrower over time as well as in the beginning of it, analyzing a universe of actual credit terms of one industrialized country. Becker et al. (2016) study the severity of asymmetric information problems over the business cycle and find that banks are in a better position to sort borrowers by credit quality in bad times, compared to good times. Bolton et al. (2016) develop and empirically test a model in which relationship banks gather costly information about their borrowers, which allows them to provide more informed loans for profitable firms during a crisis. Due to an interplay between costly information acquisition and competition, relationship loans are costlier in normal times, but cheaper during crises times. Thus, the study rationalizes a distinct role of relationship banks providing cheaper access at harder times. Instead we focus on collateral, rather than the interest cost of the loan, and provide evidence for easier access to unsecured funding at crisis times.

2 The data

Our data comes from three main sources. First, we use the central credit register (central de responsabilidades de credito or CRC) of the Bank of Portugal. The CRC contains information, reported by all credit granting institutions, on all loans granted to firms.[10] The minimum reporting threshold are loans above *Euro* 50 implying full coverage. Our sample covers the entire population of non-financial corporate loans from January 2009 to December 2013.

The database includes the following information: borrower and lender unique identifiers, amount of outstanding loans at end of each month, the credit standing (good, overdue etc.), if the credit is not in good standing - its exact situation, and the type of the loan (overdraft/demand deposits, working capital, credit card etc.). The CRC does not have an identifier for a new loan. Therefore, we formulate a methodology to identify new loans as follows. A loan is identified as new, when we see either a new bank-firm relationship or an increase in the number of loans in a bank-firm pair.

Because banks needed to report information on collateral starting January 2009, our analysis al newly generated loans starting January 2009 [11] However, we take advantage of the longer time span of the CRC to build bank-firm relationship variables based on borrowing history starting January 2005.

We employ two measures to capture a firm's relationship potential. The first is *relfreq*

[10]The CRC also comprises of household lending records but we only focus on corporate lending in this paper.

[11]We have information about the type of collateral and the amount pledged at issuance (if a single loan is backed up by several sources of collateral, their respective types and amounts are reported. It must however, be noted that the collateral value is not marked to market. Therefore, for our analysis, we will only use the information if a loan is collateralized or not and not the actual amount of collateral pledged.

- relationship length as proxied by *frequency of interactions.* Instead of using a simple relationship length that measures time elapsed from first loan made by the bank to the borrower until the current period, the frequency measure captures the *active* time between the parties until the current period. The measure is constructed by counting the number of effective interactions between a bank and the firm - the number of times there has been an increase in total outstanding loan and/or an increase in the number of loans. Thus, for any given point in time, the measure shows the cumulative number of interactions since the start and up to that point. This *active* length arguably better captures the depth of the information acquired by the bank.[12] We use CRC information from 2005, and thus the count starts from up to nine year back - a key advantage of the data.

Our second main independent variable is the expected loyalty as captured by the eventual relationship length - *relmax.* This bank-firm level relationship variable measures the maximum number of times a particular firm interacts with a particular bank. For a given bank-firm pair, it is thus time invaraint, unlike our relationship frequency measure. As in our relationship frequency measure, we take advantage of the longer time-span of the CRC and hence, this variable is also computed in the 2005-2013 range. To reduce right censoring, we exclude all the newly formed relationships at the end of the sample, i.e., we drop firm-bank pairs who have a relationship length less than 12 months as of December 2013.

We then combine the CRC database with bank and firm information. Firm characteristics such as size, age, and industry are taken from the Central Balance Sheet Database (CBSD). This database covers mandatory financial statements reported in fulfillment of

[12]Our results are robust to using the traditional relationship length measure.

firms' statutory obligations under the Informacao Empresarial Simplificada (Simplified Corporate Information, IES). Information on bank balance sheets is taken from the Bank of Portugal's Monetary and Financial Statistics (MFS), from where we take bank-level controls - total assets, capital and liquidity ratios. These statistics are reported monthly.

The summary statistics on new loans are provided in Table 1 and Table 2. Our purpose is to track collateralization of new only loans. However, a new loan is not directly observable: no loan can be tracked over time, since in each month it is recorded with a different identifier. Nevertheless, owing to the manner in which the data is collected, we are able to closely identify them. Specifically, we observe the total value of loans and the number of lending relationships within a bank-firm pair in two consecutive months. A new loan is said to have been made if (a) the number of lending relationships has increased, or, (b) if the number of lending relationships has diminished or remained the same but the total value of loans has risen from one month to the next. Our dependent variable - *Collateral dummy* - is then constructed as follows. If a new loan is generated as above, we count the number of collateralized loans in the current as well as the previous month. Whenever the number of collateralized loans has increased, we set the collateral dummy equal to 1 for that particular firm-bank pair in that month, and 0 otherwise. Table 1 shows that about 48 percent of all new loans is collateralized.

The table further shows that the median $relfreq$ and $relmax$ are 19 and 29 interactions, respectively. Maximum banking relationships is the maximum number of banks a firm has a relationship with. The median firm has 2 banking relationships whereas the maximum number of banking relationships is 14.

Next, we provide summary statistics of our firm and bank specific variables. The firm-level variables are annual. Firm profits are recorded at the end of a year. Firm leverage is defined as total debt over total assets, and the median firm has leverage of 0.77. Firms employ on average about 33 employees while half of the firms employ less than 8 employees. This shows that Portuguese non-financial firms are mainly small firms which are typically bank dependent. In our empirical specifications we employ the natural logarithm of the number of employees as proxy for firm size. The last three variables are the banks' assets, liquidity ratio and capital. The bank liquidity ratio is the sum of cash and short term securities normalized by total assets. The median bank liquidity ratio is only 1 percent, possibly reflecting the difficult liquidity position of banks during our sample period. The bank capital ratio is the tier 1 core capital over risk weighted assets. Its median is 8 percent.

2.1 Hypotheses

The first two testable hypotheses are based on Karapetyan and Stacescu (2016) (KS, hereafter)that is extended on an ex-ante theory of collateral (e.g., Bester, 1985). KS develop a two-period extension similar to the model in Manove et al. (2001). The theoretical prediction is that over time collateral requirements will go down. A second result is that borrowers may enjoy unsecured credit at the start of relationship (not only because of their risk characteristics - as in a collateral-based theory, but also) because they have a longer relationship potential .

Accordingly, the first hypothesis we test is that borrowers who initially post collateral to signal their high-quality project, are more likely to be screened (and less likely to post

Table 1: Summary Statistics

	Mean	Median	SD	Min	Max
Dependent variable					
Collateral dummy	0.49	0.00	0.49	0.00	1.00
Main explanatory variables					
Relationship frequency	21.50	20.00	13.37	1.00	92.00
Relmax	30.20	29.00	15.81	1.00	92.00
Bank level variables					
Bank total assets	2.2e+09	1.0e+08	9.6e+09	3.0e+05	7.2e+10
Bank liquidity ratio	0.03	0.01	0.05	0.00	0.22
Bank capital ratio	0.19	0.08	0.22	0.02	0.73
Firm level variables					
Age	14.69	11.00	12.44	0.00	196.00
Total assets	3.09e+06	3.66e+05	8.06e+07	0.01	2.08e+10
Profits	3.97e+05	8.41e+04	1.13e+06	-9.75e+04	8.66e+06
Number of employees	14.88	6.00	33.57	1.00	318
Max. banking relationships	1.82	2.00	1.07	1.00	14.00

Note: The dependent variable and the main explanatory variables are computed using the central credit registry database. The banking variables are taken from the monetary and financial statistics database while the firm level variables are obtained from the central balance sheet database.

Table 2: Summary Statistics

	Collateral	Relfreq	Relmax	Loan amount
Non Collateralized				
Mean	0.00	20.32	29.06	1.83e+05
Median	0.00	19.00	28.00	15000
SD	0.00	13.02	15.58	2.16e+06
Min	0.00	1.00	1.00	50.00
Max	0.00	90.00	92.00	8.08e+08
Collateralized				
Mean	1.00	22.69	31.36	2.38e+05
Median	1.00	22.00	31.00	37000
SD	0.00	13.63	15.96	2.47e+06
Min	1.00	1.00	1.00	50.00
Max	1.00	92.00	92.00	8.08e+08

collateral) by their bank for subsequent loans (these later stages of interacting with the bank is captured by the variable *relfreq*). The intuition of the theory behind is described in footnote 5.

Thus, our first hypothesis (H1) is:

H1: ***Repeated interaction over time reduces the incidence of pledging collateral over the course of a relationship.***

The second theoretical prediction is that when the potential length of the banking relationship increases (*relmax*), the preference for screening in the *initial* stages of the relationship is more pronounced. The explanation behind this finding is linked to the classical hold-up problem in lending. In long-term relationships borrowers anticipate that banks will extract information rents in the later stages, and competition between banks will push them to offer discounts in the initial period. A lower interest rate offered in initial lending will however increase collateral requirements to prevent low-quality borrowers from getting a loan (the standard negative relationship between collateral and interest rate in an adverse selection model). This will raise the expected liquidation costs. In contrast, screening does not involve such an increase in cost. As a result, a higher probability of repeated lending decreases the incidence of collateral in initial lending.

Our second hypothesis (H2) is:

H2: ***The potential for long interaction reduces the incidence of pledging collateral at the beginning of the relationship.***

To the best of our knowledge, this is not tested previosuly in the literature. To test this, we need to instrument the length of the future relationship (i.e., the potential for repeated interaction - *relmax*); indeed, while in most of our specifications we use firm fixed effects to control for demand, a key endogeneity concern due to the *future* nature of the variable remains. The firm may want to stay longer with those banks who do not require collateral. We thus instrument it by the average of the length of relationships of the firm with the rest of the banks. The correlation of this measure with the eventual length of interaction with the firm's bank is 0.26.

2.2 Empirical analysis of H1 and H2

In Table 3 we test H1. We use a dummy based on the relationship frequency (*relfreq*) variable. *Hrel* is equal to 1 if *relfreq* is above the 75th percentile, and is equal to 0 if it is less than the 25th percentile. The observations in between are thus omitted.[13] The result means that moving from an average firm in the lowest quartile to one in the highest quartile (having a short versus a long relationship with a bank) decreases collateral requirements by 2.7 pp, or around 6 percent of the unconditional mean. Column 2 instead uses the continuous variable ln(*relfreq*) and shows similar results. Columns 3-5 saturate the model with bank*time and firm*time fixed effects. Column 3 shows a more pronounced decrease in collateral usage (3.7 pp or 8 percent). Columns 4 & 5 report results from sub-samples of small and big banks respectively. We observe that the collateral requirements decrease by more than double (5 pp vs. 2.2 pp) if a firm is a relationship borrower with a small bank as opposed to a large bank. This finding lends credence to the fact that smaller banks tend to be more relationship lenders while the larger ones are more transactional.

Table 4 tests H2, where we focus on the cross-section of firms at the beginning of a bank-firm relationship. We employ our measure of relationship potential *relmax*, i.e., eventual length of relationship. In column 1 we use a dummy *Hrelmax* equal to one 1 if *relmax* is above the 75th percentile, 0 if it is below the 25th percentile, and undefined for the rest. To focus on the beginning of the relationship, we analyze the sample up to the first half of the duration of the relationship, by restricting observations to those for which the cumulative relfreq measure is less than the median (20). *Hrelmax* has a statistically significant negative impact on the use of collateral in the earlier stages of the relationship.[14] In column 2 we use the continuous relmax measure. We instrument the

[13]Note that results are qualitatively the same when we instead use a dummy to categorize borrowers above and below the median relfreq.

[14]Importantly, we confirm our results by restricting the observations to only the first interaction, i.e., relfreq less than 2.

Table 3: **Determinants of Collateral (Over the relationship)**. We use a dummy based on the relationship frequency variable in Column 1: *Hrel* is equal to 1 if log of relfreq is above the 75th percentile, is equal to 0 if it is less than the 25th percentile, and is undefined for the rest. Column 2 instead uses the continuous log of relationship frequency. Columns 3-5 saturate the model with bank-time and firm-time fixed effects. Columns 4 & 5 report results from sub-samples of small and big banks, respectively.

	[1]	[2]	[3]	[4]	[5]
hrel	-0.035***		-0.038***	-0.051***	-0.028***
	[0.001]		[0.001]	[0.002]	[0.002]
lrelfreq		-0.021***			
		[0.000]			
lvalore	0.135***	0.134***	0.138***	0.127***	0.143***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
tot assets	0.000***	0.000***			
	[0.000]	[0.000]			
cap ratio	-0.066**	-0.123***			
	[0.026]	[0.020]			
liq ratio	-0.297	-1.400***			
	[0.701]	[0.476]			
Bank FE	Y	Y			
Bank-time FE			Y	Y	Y
Firm FE	Y	Y			
Firm-time FE			Y	Y	Y
R-squared	0.53	0.51	0.72	0.62	0.69
Number of obs.	1504322	3233201	1482552	636115	826437

bank-firm *relmax* by the firm's maximum relmax with all other banks (i.e., excluding the bank-firm pair in question). The regressions in columns 1-2 use firm fixed effects, as well as bank and time dummies.

Columns 3-5 saturate the model further with bank*time and firm*time fixed effects. We observe that the magnitude of *Hrelmax* falls three times in column 3. The economic magnitudes are not small: column 1 (3) shows that for a firm in the top quartile of relmax the use of collateral in the earlier stage of the relationship is 10 (3) percentage point less likely compared to the same firm being in the lowest quartile of relmax. Thus, being a long-term borrower can decrease collateralization probability by 10.4 pp, which is above 20 percent (unconditional mean of collateralization is 48 percent in the data). Similarly, using the continuous measure of relmax in column 2, we find that a one standard deviation ($\sigma_{relmax} = 15$) increase in the variable would bring about a 7.5 pp decrease in the usage of collateral (18 percent of the unconditional mean).

Columns 4 and 5 show, respectively, the results from subsamples of small and large banks. The columns show that smaller banks are more effective in building relationship value for their borrowers.

3 Testing in diff-in-diff

3.1 Lead up to the sovereign debt crisis

3.1.1 The macroeconomic environment

Until late 2009 or early 2010 the sustainability of the Portuguese sovereign debt was not perceived as a concern for the markets. For over ten years since the introduction of the Euro, the yields of bonds issued by European countries were low and stable. However, in April 2010 when the Greek government requested an EU/IMF bailout package, markets started to doubt the sustainability of the sovereign debt. Shortly afterwards, investors began to be concerned about the solvency and liquidity of the public debt issued by countries like Ireland and Portugal. Specifically, in May 2010, the Portuguese banks

Table 4: **Determinants of Collateral (Beginning of the relation)**. *Hrelmax* is an indicator and is 1 if relmax is above the 75th percentile, 0 if it is below the 25th percentile, and undefined for the rest (column 1). In column 2 we use the continuous relmax measure, instrumented by the borrower's average length of relationship with other banks. Column 3-5 saturate the model with bank-time and firm-time fixed effects. Columns 4 and 5 report results from sub-samples of small and large banks respectively. All columns use observations from the first half of the relationship duration.

	[1]	[2]	[3]	[4]	[5]
hrelmax	-0.104***		-0.034***	-0.093***	-0.009
	[0.003]		[0.006]	[0.010]	[0.010]
relmax		-0.005***			
		[0.000]			
lvalore	0.129***	0.136***	0.132***	0.129***	0.136***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
tot assets	0.000***	0.000***			
	[0.000]	[0.000]			
cap ratio	0.298***	0.281***			
	[0.032]	[0.028]			
liq ratio	1.781*	9.441***			
	[0.904]	[0.690]			
Bank FE	Y	Y			
Bank-time FE			Y	Y	Y
Firm FE	Y	Y			
Firm-time FE			Y	Y	Y
R-squared	0.56	0.53	0.65	0.64	0.75
Number of obs.	776939	1496643	753383	437055	301494

suddenly lost access to international capital markets. They could not obtain funding in medium and long term wholesale debt markets and this had been an important source of their funding. This sudden stop scenario can be attributed mainly to investors concerns on contagion from the sovereign crisis in Greece.

Reis (2013) documents the events as they happened during the crisis. The yields on

10 year Portuguese bonds rose from 3.9 to 6.5 percent during 2010. Public spending also rose markedly, partly because of the automatic stabilizers, and partly because the government implemented a campaign promise of raising public sector wages after years of stagnation. The sudden stop in capital inflows affected, especially, the non-tradables sector and brought about a sharp decline in output, a phenomenon that has also been observed in some Latin American countries. The entire economic environment in Portugal was adverse at this point and all the agents of the economy were under stress. The banks were hit particularly hard as they were at the center of the capital flows and in 2010 and accounted for approximately half of the net foreign debt of Portugal. The Portuguese banks also hold a substantial amount of public debt. In European Banking Authority's stress tests of December 2010, the exposure of Portuguese banks to Portuguese government debt was estimated at 23 percent of their assets.[15] As a result the banks and the sovereign are quite closely linked. The correlation between the CDS spreads of the sovereign and the banks is extremely strong. Brunnermeier et al. (2011) argue that the sudden panics and the spike in sovereign bond yields in Portugal and elsewhere were the consequence of the close inter-linkages between banks and sovereigns. Fears about the solvency of a sovereign can put the solvency of banks in that country at risk, since banks typically hold so much of their assets in the sovereign debt of the respective country. The situation was no different in Portugal. On the side of the non-financial corporations, uncertain economic conditions led them to cut back on investment as well. In fact, Buera and Karmakar (2016) document that highly leveraged firms and firms with a shorter maturity

[15] The pattern is similar in many other European countries where banks hold a significant amount of their domestic public debt.

structure of debt, found it difficult to obtain financing and contracted more during 2010.

To sum up, 2010 was an extremely eventful year for Portugal and for the peripheral European countries in general. The aggregate macroeconomic scenario worsened rapidly during this year and that could be attributed to a number of factors like elevated budget deficits, sovereign-bank inter-linkages, political instability in some countries and uncertainty overall. Finally, in March 2011, 10-year interest rates were at 7.8 percent, and Portuguese banks found it nearly impossible to obtain international funding. The prime minister asked for external assistance and a rescue loan, from the IMF, the European Commission, and the ECB, was obtained.

3.1.2 Bank liquidity vs. corporate risk channel

As discussed above, higher sovereign risk since early 2010 in Euro area has dramatically increased the cost of some euro area banks' funding. The size of the impact is generally proportional to the deterioration in the creditworthiness of the domestic sovereign. Banks in Greece, Ireland, Spain, and Portugal have found it difficult to raise wholesale debt and deposits, and have become reliant on central bank liquidity. How does this really affect banks' funding costs and their lending technologies?

When sovereign risk is increased, it can adversely affect banks' funding costs through several *bank liquidity channels*. These channels are due to the pervasive role of government debt in the financial system. For instance, losses on holdings of government debt weaken banks' balance sheets, increasing their riskiness and making funding more costly and difficult to obtain. At the same time, higher sovereign risk can reduce the value of the collateral banks can use to raise wholesale funding and central bank liquidity. Due to the increases in bank funding costs, banks may eventually increase their lending rates and or simply deleverage by borrowing/lending less.

However, apart from these bank liquidity channels, the *firm risk channels* may become more important due to a rise in sovereign risk. When an economy approaches a sovereign default, banks may start perceiving firms as more risky. Therefore, banks may demand higher returns when lending to them as a compensation for holding this additional risk. This mechanism has been shown to be quite important quantitatively (e.g., Bocola, 2016, using Italian Credit Registry data).

Indeed, while eventually both channels may be at work when it comes to the determination of credit volume and loan interest rates, the firm risk channel may be empirically more dominant with respect to banks' decision to extend *collateralized* lending, as opposed to uncollateralized lending. After all, bank liquidity channels impact banks' ability to generate a loan (ex-ante), whereas the firm risk channel is related to the bank's estimate of the firm's repayment probability. A decline in the repayment probability can then increase banks' required compensation, in terms of not only higher interest rates, but also higher collateral requirements.[16] Along these lines, we show that the sovereign debt crisis increases banks' collateral requirements from business lending. However, we do not find any convincing heterogeneity of increased use of collateral based on banks' differential exposure to sovereign bond holdings.

Nevertheless, the above argument is true as long as collateralized lending does not carry an advantage in terms of a decreased funding costs for banks. When it does, the

[16] Using comprehensive micro-data from Spain, Jiménez et al. (2006) demonstrate precisely such a negative relationship between collateral requirements and the business cycle.

banks' ability and willingness to extend a collateralized loan may be greater than for extending an unsecured loan. In the second part of our analysis we elaborate precisely on an experiment of this type: a certain number of banks holding more sovereign bonds had to accumulate more capital to meet the new regulatory minima.[17]

3.2 The EBA capital exercise

In October 2011 the European Banking Authority (EBA) announced that major European banking groups would have to increase capital. First, the requirement referred to banks with sovereign bond holdings: banks were required to hold a new exceptional and temporary capital buffer to cover risks linked to sovereign bonds.

Second, banks were also required to hold an additional temporary capital buffer, increasing their core tier 1 (CT1) capital ratios to at least 9 percent of their risk-weighted assets (RWA) by June 2012.

[17] For exposures secured by covered bonds, there exists a preferential treatment (i.e. these exposures receive a lower risk weight). This is indicated in Article 129(5) of the CRR (http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:176:FULL:EN:PDF). When computing own fund requirements for credit risk according to the standardized approach, banks may apply a preferential risk weight to exposures in the form of covered bonds when collateralized by any of the assets referred in article 129(1) of CRR. How the risk weight is determined will depend if those covered bonds are rated or not by a recognized rating agency (e.g. Fitch, S&Ps, Moodys, DBRS). If the covered bonds are rated, the risk weight applied to exposures on those bonds will vary from 10% to 100%, in line with the table envisaged in article 129(4) of the CRR. For example, if a specific covered bond has received a rating of "A" from S&Ps, the risk weight will be 20%. If the covered bonds are not rated, the risk weights applied to the exposures on those bonds will depend on the weights applied to the institution which issues them, in accordance with article 129(5) of CRR. For exposures secured by immovable property, the safest and most collateralized part of the exposure is eligible for a preferential risk weight. The terminology is however a bit difficult. There is a difference between:

- Exposures fully and completely secured by immovable property (for residential real estate, it is the part of the exposure with a loan-to-value ratio of up to 80%), and for commercial immovable property it is the part of the exposure with an LTV up to 50% (in case of a market value) or 60% in case of a mortgage lending value. This secured part of the exposure gets a 35% risk weight (residential real estate) or 50% (commercial real estate) in accordance with article 125 and 126 of the CRR respectively.
- Exposures fully secured by immovable property: this is the part of the exposure secured by immovable property, but not fully and completely secured. This part of the exposure gets a 100% risk weight, (article 124 of the CRR).

In other words, exposures fully and completely secured by immovable property for residential estate and exposures fully and completely secured by commercial immovable property may benefit from a preferential risk weight when certain conditions are verified. For example, in the case of an exposure of 90 M fully and completely secured by immovable property for residential estate with a LTV of 90% (i.e the value of the property is 100 M), a risk weight of 35% is applied to 80 M and a risk weight of 75% or 100% (depending if the debtor is qualified as retail or not) is applied to the remaining 10 M.

Both of the above cases correspond to the Standardized Approach. Under the IRB approach, the institutions estimate their PD and sometimes also their LGD (advanced IRB approach). For the latter approach, there is no specific regulation which explains that the risk weight is lower in case of collateralized exposures. It will however be the case, because institutions will recover more from collateralized exposures, and this will affect their LGD estimates. The existence of collateral (assuming that the guarantee fulfills all the conditions required in CRR to be accepted as an eligible form of credit risk mitigation) will imply a reduction of the LGD.

These buffers were not designed to cover losses in sovereigns. The exercise was rather undertaken with the aim of building confidence in the ability of euro-area banks to withstand adverse shocks (and still have enough capital), including in part those arising from the exposure to sovereigns. The buffer against the sovereign exposure would be based on sovereign bonds' market prices as of the end of September.

The announcement came at a time when the euro area was still perceived as extremely fragile. The timing of the EBA's capital exercise therefore soon came under criticism for having contributed to a credit crunch in the euro area,[18] and the risk-weighted capital requirements were met, at least to a significant extent, by shrinking the asset side (Acharya et al., 2016).

The announcement in October 2011 came largely as a surprise, as the EBA had just conducted rigorous stress tests in July 2011 and had already released detailed information on the exposure of European banks to sovereign risk (Mesonnier and Monks, 2015). It must be noted that none of the eight banking groups which failed the stress tests, conducted in July, were included in the forthcoming capital exercise of October. Furthermore, only nine out of the sixteen groups which narrowly passed the test were finally included in the capital exercise. Lastly, the level of the new required CT1 capital ratio was substantially higher than the one planned under the transition to Basel III, and explicitly not related to the level of risks of any particular banking group. As a result, it is fair to assume that the increased capital requirements came as a surprise for most of the banking groups involved in the capital exercise. In December, 2011, the EBA published a recommendation with reference to the bank balance sheets as of September 2011. Twenty

[18] For details, see Mesonnier and Monks (2015).

seven banks were identified as having an aggregate capital shortfall of 76 billion euros. They were required to submit capital plans to the EBA through their national supervisory authorities by January 2012 and an evaluation of the plans was done by February 2012.

In the Portuguese context, four out of the seven biggest and most important banks in Portugal were recommended to raise capital in this exercise. The total capital shortfall (after including the sovereign capital buffer) for all banks operating in Portugal stood at 6,950 million euros which is roughly 6.06 percent of the aggregate shortfall in the euro-area. This amount of shortfall was roughly equal to 22 percent of total capital or 30 percent of core tier1 capital (as of 2011:Q2) of affected banks.[19]

3.3 Hypotheses

We formulate our hypotheses based on the impact the law has on banks' decisions regarding collateral. Banks' decision involves extending collateralized versus uncollateralized loans (as in KS, the latter will still require screening). Note, importantly, that collateralized loans have lower risk weights: this observation is key, since it then makes extending collateralized-based loans cheaper relative to screening- based loans. It is is in line with the actual implementation of regulation. Indeed, bank-firm exposures secured by collateral require less regulatory capital than unsecured exposures. Secured exposures receive a preferential risk weight in the standardized approach[20], or a lower probabil-

[19] Refer: `http://www.eba.europa.eu/risk-analysis-and-data/eu-capital-exercise` and related documents listed therein for further details.

[20] For example, exposures secured by immovable property for residential estate and by commercial immovable property may benefit from preferential risk-weights when certain conditions are verified (see articles 124-126 of the CRR).

ity of default and loss-given default in the internal ratings-based approach.[21] Affected banks may meet these increased capital requirements by modifying their portfolio of firm exposures. In the empirical analysis, this would be reflected in the issuance of more collateralized loans for those banks, who do not meet capital requirements - the *treated banks*, (denoted by *dummy*). This leads to our third hypothesis (H3) focusing on the EBA capital exercise:

H3: ***Affected banks will require more collateral than unaffected banks***

Support for H3 would be reflected in a positive *post*dummy* coefficient.

Our next hypothesis looks at the differential effect of the EBA rule for the use of collateral for relationship versus transactional borrowers (i) over time, and (ii) at the beginning of relationship for borrowers with high relationship potential. Because use of screening is less costly for relationship borrowers (as described earlier), we hypothesize that any substitution by collateral after the experiment will take place with only muted extent for relationship borrowers.

H4: ***While affected banks will require more collateral, they will do so less for high-relationship borrowers than for transactional borrowers.***

4 Empirical analysis of H3 and H4

Based on our discussion in the previous sections, we compartmentalize our analysis into two time-periods: in the first part of the analysis we focus on the 2011 to 2012

[21]While there is no specific regulation explaining the lower risk weights for collateralized exposures, the required capital from banks' internal models will be lower as banks will recover more from collateralised exposures, and this will affect their loss-given default estimate.

period, where we use a difference-in-difference (as well as triple difference) approach to quantify the effect of the EBA capital exercise on the treated banks and their borrowers. Afterwards, we discuss the lead-up to 2011, studying how the European sovereign debt crisis affected the lending activity of the Portuguese banks.

In Table 5, we use pre- and post-EBA windows to quantify the diff-in-diff effect, testing H3 and H4. The pre-EBA period includes 6 months preceding the EBA announcement (November 2011): June to November 2011, while the post-EBA period includes July to December 2012. According to the EBA announcement the new requirements were to be met by end of June 2012. Thus, the period closely precedes and follows the event. The results show qualitatively and quantitatively significant results for the *hrel* (column 1) and *hrelmax* (column 3) variables (this is H4). First, the high-relationship dummy (*hrel*) is statistically significantly different from zero (at 1 percent) as before. It shows that a borrower is 8.1 pp less likely to have a collateralized loan with a bank in the control group. Note, that this constitutes around 16 percent of the unconditional average. At the same time, a high-relationship borrower with a treated bank (dummy) does not enjoy a decreased rate of collateralization, as can be seen by the interaction of *hrel*dummy*. [22]

Most importantly, for high-relationship borrowers the increase in required collateralization is much lower for the treated banks as evidenced from the negative coefficient of the triple interaction *hrel*post*dummy*. Specifically, those in the upper quartile of the relfreq have a combined effect of 0.012+0.018-0.04 by the treated banks, as compared to their low-relationship counterparts (those in the lowest quartile of the relfreq index have a combined effect of 0.012+0.018). Column 2 shows similar findings when using the

[22] The total is 0.017 (i.e., 0.098-0.081).

continuous variable *lrelfreg*. Second, borrowers with a high relationship potential (i.e., *hrelmax)=1*) similarly do not suffer an increase in collateralization by treated banks, as opposed to their low-relmax counterparts, as is seen in column 3 (0.009+0.014-0.032 versus 0.009+0.014). Column 4 reveals qualitatively similar results when using the continuous *relmax* variable. Turning to H3, we observe that after the EBA capital exercise borrowers of treated banks require collateral more often than when borrowing from non-treated banks. The post*dummy is significant and positive in columns (1) to (3).

A potential concern is that treated banks over time may have increased their capital requirements, but less so for high-relationship borrowers. Our results above would then simply reflect a trend already observed in the pre-event period. Table 6 analyzes rate of collateralization in the 2010-2011 period, i.e., the period before and during the sovereign crisis. As the table confirms, banks overall increased collateral requirements over that period. In Column 1, 3 and 4 post10 (a dummy variable that takes value 1 for year 2011 and 0 for year 2010) shows a statistically significant increase of collateralization (in column 1and 4 the p-values are 0.56 and 0.52, respectively). At the same time, the interaction of *post10*dummy* does not indicate any differential increase of collateralization by the banks for high-relationship borrowers.

In table 7, we study the effect throughout the whole 2010-2012 period. Column 1 shows, first, that high-relfreq borrowers (those in the upper quartile of the relfreq index) on average enjoy a 9 pp less likelihood of having the loan collateralized during the whole period, both before and after. After the event, banks require 5 pp more collateral (positive coefficient on the *post* dummy) but the effect is more pronounced for the treated banks, as shown by the statistically significant *post*dummy* interaction in column 1. In other

Table 5: **EBA Experiment:** The dependent variable is *collateral dummy*. *Hrel* and *Hrelmax* are equal to 1 if the log of relfreq or relmax are above the 75th percentile, and are equal to 0 if they are less than the 25th percentile (and undefined for the rest). Post is an indicator variable and is 1 for two quarters post the shock (Q3-Q4:2012) as opposed to two quarters prior to the shock (Q3-Q4:2011). Column 2 is similar to column one but uses the continues measure of relfreq instead of the dummy. Column 3 uses the dummy *Hrelmax* while column 4 uses the continuous measure (relmax). All specifications have bank and firm fixed effects.

	[1]	[2]	[3]	[4]
hrel	-0.081***			
	[0.005]			
hrel*dummy	0.098***			
	[0.006]			
hrel*post	0.012**			
	[0.005]			
hrel*pos*dum	-0.040***			
	[0.007]			
post	0.012***	-0.008	0.009	-0.001
	[0.003]	[0.006]	[0.006]	[0.005]
post*dummy	0.018***	0.038***	0.014***	0.004
	[0.005]	[0.009]	[0.005]	[0.005]
lvalore	0.142***	0.144***	0.141***	0.144***
	[0.000]	[0.000]	[0.000]	[0.000]
lrelfreq		-0.036***		
		[0.002]		
dummy*lrelfreq		0.038***		
		[0.002]		
post*lrelfreq		0.012***		
		[0.002]		
post*dummy*lrelfreq		-0.019***		
		[0.003]		
hrelmax			-0.103***	
			[0.005]	
hrelmax*dummy			0.115***	
			[0.005]	
hrelmax*post			0.007	
			[0.005]	
hrelmax*pos*dum			-0.032***	
			[0.006]	
relmax				-0.003***
				[0.000]
relmax*dummy				0.003***
				[0.000]
relmax*post				0.000**
				[0.000]
relmax*pos*dum				-0.001***
				[0.000]
Firm FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
R-squared	0.64	0.60	0.63	0.60
Number of obs.	350079	659373	363672	659373

Table 6: **Sovereign:** The dependent variable is *collateral dummy*. *Hrel* and *Hrelmax* are equal to 1 if the log of relfreq or relmax are above the 75th percentile, and are equal to 0 if they are less than the 25th percentile (and undefined for the rest). Post10 is an indicator variable: it is zero for 2010, and 1 for 2011 Q1 onwards (post sovereign debt shock). Column 2 is similar to column one but uses the continues measure of relfreq instead of the dummy. Column 3 uses the dummy *Hrelmax* while column 4 uses the continuous measure (relmax). All specifications have bank and firm fixed effects.

	[1]	[2]	[3]	[4]
hrel	-0.112***			
	[0.030]			
hrel*dummy	0.105***			
	[0.031]			
hrelpost10	0.043			
	[0.026]			
hrel*pos10*dummy	-0.036			
	[0.033]			
post10	0.023*	0.027	0.033***	0.020*
	[0.012]	[0.020]	[0.011]	[0.010]
post10*dummy	-0.011	-0.017	-0.015	0.004
	[0.018]	[0.034]	[0.017]	[0.018]
lvalore	0.143***	0.145***	0.143***	0.145***
	[0.010]	[0.009]	[0.009]	[0.009]
lrelfreq		-0.048**		
		[0.020]		
dummy*lrelfreq		0.031		
		[0.020]		
post10*lrelfreq		0.005		
		[0.010]		
post10*dummy*lrelfreq		0.000		
		[0.012]		
hrelmax			-0.130***	
			[0.037]	
hrelmax*dummy			0.097***	
			[0.035]	
hrelmax*post10			0.010	
			[0.023]	
hrelmax*pos10*dum			-0.009	
			[0.026]	
relmax				-0.003***
				[0.001]
relmax*dummy				0.003***
				[0.001]
relmax*post10				0.000
				[0.000]
relmax*pos10*dum				-0.000
				[0.001]
Firm FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
R-squared	0.70	0.65	0.69	0.65
Number of obs.	166764	389057	199425	389057

words, after the EBA capital exercise, the affected banks require even higher collateral. They would be 18 pp more likely to extend a new collateralized loan than their unaffected counterparts. This is above 35 percent of the unconditional mean of 48 percent collateralization. Column 2 repeats the analysis using the original continuous variable relfreq.

Similarly, columns 3-4 repeat the analysis for relmax. The triple interaction of -0.09 in column 3 points to the fact that for high-relmax borrowers the increase in required collateralization is much lower. That is, the increase of collateralization rate by treated banks is around half for high relationship borrowers (specifically, those in the upper quartile of the relmax have a combined effects of 0.053+0.123-0.089) compared to their low-relationship counterparts (those in the lowest quartile of the relmax index have a combined effect of 0.053+0.123).

5 Robustness

To ensure our results are robust we consider a number of various specifications with respect to firm and bank cohorts, and type of collateral. We first observe that the results are similar, in terms of both statistical power and economic magnitude, for small and large firms, as well as for young and old firms. In unreported regressions we run separate models for various groups of firms. We see no significant quantitative or qualitative difference for firms below versus above the median age or size. The little difference between the two may speak to the fact that in Portuguese market even large firms hardly have access to alternative funding sources (such as bond markets). Therefore, in this market a potentially

Table 7: **The entire period (2010-2012):** The dependent variable is *collateral dummy*. *Hrel* and *Hrelmax* are equal to 1 if the log of relfreq or relmax are above the 75th percentile, and are equal to 0 if they are less than the 25th percentile (and undefined for the rest). Column 2 is similar to column one but uses the continuous measure of relfreq instead of the dummy. Column 3 uses the dummy *Hrelmax* while column 4 uses the continuous measure (relmax). All specifications have bank and firm fixed effects.

	[1]	[2]	[3]	[4]
hrel	-0.089***			
	[0.004]			
hrel*dummy	0.124***			
	[0.004]			
hrel*post	0.016***			
	[0.005]			
hrel*pos*dum	-0.112***			
	[0.005]			
post	0.050***	0.041***	0.051***	0.037***
	[0.004]	[0.005]	[0.004]	[0.003]
post*dummy	0.129***	0.215***	0.123***	0.134***
	[0.003]	[0.006]	[0.003]	[0.003]
lvalore	0.138***	0.138***	0.136***	0.137***
	[0.000]	[0.000]	[0.000]	[0.000]
lrelfreq		-0.037***		
		[0.001]		
dummy*lrelfreq		0.038***		
		[0.001]		
post*lrelfreq		0.007***		
		[0.002]		
post*dummy*lrelfreq		-0.051***		
		[0.002]		
hrelmax			-0.105***	
			[0.003]	
hrelmax*dummy			0.123***	
			[0.004]	
hrelmax*post			-0.006*	
			[0.004]	
hrelmax*pos*dum			-0.089***	
			[0.004]	
relmax				-0.003***
				[0.000]
dummy*relmax				0.003***
				[0.000]
post*relmax				0.000
				[0.000]
post*dummy*relmax				-0.002***
				[0.000]
Firm FE	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y
R-squared	0.59	0.55	0.58	0.55
Number of obs.	687455	1446882	808759	1536798

muted impact of relationship banking for large firms does not seem to be at work.

In the diff-in-diff analysis, we try to expand windows in several dimensions. First, we implement different window spans for the EBA capital exercise. We change the length of the pre- and post- periods, using a quarter, 4 or 5 month-long of observations for both before and after-event periods. Windows spanning between 2010 and 2012 yield qualitatively similar results. In table 8, for instance, we use 2011 Q2 to 2012 Q4 as the pre- and post-event periods, thus stretching the window by one quarter both before and after the event. In the first two specifications for hrel and hrelmax, respectively, we confirm that treated banks did not increase collateral requirements for their relationship borrowers, while they did so for relatively new borrowers. In the last two columns we saturate the model by firm-time fixed effects, and confirm the qualitative robustness of the results. At the same time, quantitatively the magnitudes are to some extent more pronounced, as compared to table 5. For instance, as before, an average borrower from the lowest quartile of the relationship depth (relfreq) as compared to the one from the highest quartile, is 8 pp point more likely to pledge collateral with banks in the control group. However, most probably due to a larger window, the triple interaction coefficient has increased (from 4 pp to 6.6 pp in absolute terms), and so have post and post*dummy.

Furthermore, our results are also robust when we run separate regressions for before and after the EBA capital exercise. We also saturate the models in Tables 3 and 4 with firm-time-product-type fixed effects and confirm our results: these fixed effects account for any unobserved heterogeneity present within a given firm and a given month across various product types.

As a final step, we exploit variation in various collateral types. If collateral is not costly,

Table 8: **Altering the window for the EBA exercise:** Post is an indicator variable for post-event window Q4:2012, while the pre-event window is Q2:2011. Column 3 and 4 add firm-month fixed effects.

	[1]	[2]	[3]	[4]
hrel	-0.082***		-0.116***	
	[0.007]		[0.010]	
hrel*dummy	0.115***		0.152***	
	[0.008]		[0.012]	
hrel*post	0.021***		0.077***	
	[0.008]		[0.013]	
hrel*pos*dum	-0.066***		-0.148***	
	[0.010]		[0.017]	
post	0.021***	0.035***		
	[0.005]	[0.005]		
post*dummy	0.029***	0.031***	0.078***	0.045***
	[0.008]	[0.007]	[0.013]	[0.012]
lvalore	0.145***	0.144***	0.148***	0.146***
	[0.000]	[0.000]	[0.001]	[0.001]
hrelmax		-0.085***		-0.118***
		[0.007]		[0.009]
hrelmax*dummy		0.118***		0.135***
		[0.008]		[0.012]
hrelmax*post		-0.002		0.055***
		[0.007]		[0.013]
hrelmax*pos*dum		-0.052***		-0.093***
		[0.009]		[0.016]
Firm FE	Y	Y		
Firm-time			Y	Y
Bank FE	Y	Y	Y	Y
R-squared	0.68	0.68	0.81	0.81
Number of obs.	176755	184004	176755	184004

it will not generate a decreasing preference for secured loan over relationship lending. The decrease in the use of collateral should be more pronounced when the pledged collateral has higher liquidation value, compared to the one that has no or little liquidation value, such as financial guarantees. For this purpose, we redefine collateral, to consider only costly collateral: Thus, our dummy for costly collateral takes into consideration only real collateral and personal collateral, and excludes financial collateral. Thus if a loan is collateralized with financial collateral only, we treat it uncollateralized. We repeat our baseline specifications and confirm that results hold qualitatively, and observe a small increase in the magnitude of the coefficients.

6 Conclusion

Banks possess several technologies to reduce asymmetric information problems that are prominent in credit markets. Collateral is one of them. It is a pervasive feature in debt contracts but it is costly for banks and borrowers. We empirically study the trade-off between using information-based screening versus pledging collateral in loan contracts, using a comprehensive database on loan contracts. In line with the literature, we find that borrower' collateral requirements go down over the course of lending relationship. Novel to the literature, we show that banks may stay away from costly collateral and turn more to unsecured loans (i.e., screening) *at the start of a bank-firm relationship* when the borrower has a high potential relationship length. A borrower with high relationship potential enjoys a 10 percentage points lower use of collateral in the initial stages of its relationship.

We further exploit an exogenous variation caused by unexpected regulatory requirements on bank capital to study lending contracts in "crisis" times. In particular, in October 2011 the European Banking Authority imposed increased capital requirements on some major European banking groups as a result of risks linked to their sovereign bond holdings.[23] This exogenous variation favours collateralized lending by the treated banks relative to unsecured lending as collateralized loans require less regulatory capital. We find that treated banks in general require more collateral. However, for high-relationship borrowers the treated banks' increase in required collateralization is much lower, by 4-9 percentage points, as compared to the treated banks' low-relationship counterparts. In sum, we show that relationship banking is an empirically important driver of collateral decisions.

[23] At the time, the EBA had just conducted rigorous stress tests in July 2011, had already released detailed information on the exposure of European banks to sovereign risk, and the announcement was largely perceived as a surprise (Mesonnier and Monks, 2015).

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Table 9: Variables Description

Variable	**Source**	**Description**
Collateral Dummy	Constructed using CRC 2009-2013	A dummy that takes a value of 1 if collateral is pledged within a firm-bank pair in a given month & 0 otherwise.
Relationship frequency	Constructed using CRC 2005-2013	Measure of active length of a relationship. Number of times a new loan is transacted (time-variant).
Hrel	Constructed using CRC 2005-2013	is equal to 1 if log of relfreq is above the 75th percentile (3.52), and is equal to 0 if it is less than the 25th percentile .
Relmax	Constructed using CRC 2005-2013	Maximum number of times a particular firm has interacted with a particular bank (time-invariant).
Hrelmax	CRC 2005-2013	An indicator that is 1 if relmax is above the 75th percentile which is 41, and 0 if it is below the 25th percentile (17).
Max. banking relationships	Constructed using CRC 2005-2013	Maximum number of banks a firm has had a relationship with.
Firm profits	IES	Total profits from operations during the given year.
Firm leverage	Constructed using IES	All interest bearing liabilities normalized by total assets.
Firm num. of employees	IES	Number of employees on a firms' payroll during the given year.
Bank total assets	MFS	Total assets of the bank reported at monthly requency
Bank liquidity ratio	Constructed using MFS	Cash and short-term securities (less than 1Y) normalized by total assets.
Bank capital ratio	Constructed using MFS	Tier-1 core capital divided by risk-weighted assets.