To Ask or Not To Ask? Collateral versus Screening in Lending Relationships[*]

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Abstract

Using a comprehensive loan-level dataset, we study the impact of bank-firm relationships on collateral requirements both at the beginning of the relationship and over time. First, we document that when a borrower is loyal and has a long relationship potential, the bank is more likely to offer unsecured credit *at the beginning* of the relationship, complementing existing evidence that collateral requirements decline *over the course* of the relationship. Second, we study the impact of the EBA capital exercise, a quasi-natural shock that required increased capital requirements for a number of banking groups in the European Union. This experiment ceteris paribus makes secured lending cheaper vis-à-vis unsecured lending for the affected banks, since secured loans require less regulatory capital. We find that relative to the control group, the affected banks engaged in more collateralized lending, but *less so both for borrowers with long relationship potential at the beginning of relationship, and for relationship borrowers over the course of their relationship*. The results suggest that relationship banks are important for alleviating credit access, especially for young, collateral-constraint businesses, and during times of economic distress.

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1 Introduction

A large literature in economics and finance has long recognized that overcoming asymmetric information is important, since it is an impediment to economic performance. Lending to small businesses, a core source of economic growth, is especially susceptible to severe informational problems (e.g., Petersen and Rajan, 1994; 1995; Berger and Udell, 1995). In the aftermath of the global financial crisis, the issue regained considerable attention as small firms, facing tougher credit conditions, were particularly hit in the volatile environment. In particular, to overcome growing asymmetric information creditors increased collateral requirements for these firms which have limited collateral available. This can be quite detrimental for lending and business activity overall, which is particularly alarming given that small business growth is considered to be a key factor to economic recovery after a financial crisis.[1] [2]

Collateral requirement is a crucial measure used by banks to overcome adverse selection. Indeed, collateral is pervasive in credit markets, especially in situations with severe asymmetric information. It is a key feature in, for instance, commercial loans and credit lines.[3] Yet, the availability of collateral remains a key challenge, especially at the initial stage of a companys life.

Building relationships with borrowers is another important channel used by banks to overcome asymmetric information. Learning about borrowers allows banks to weed out bad projects over time and overcome adverse selection.[4] Therefore, one may well expect that banks may require *less collateral from relationship borrowers*. How do collateral requirements differ for borrowers with long relationship potential? What happens to the required collateral in loans to relationship borrowers (compared with transactional ones) when there is a (plausibly exogenous) shock to collateral requirements at the bank level?

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

[2]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 2007-2014.

[3]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: https://www.sba.gov/advocacy/small-business-lending-united-states-2013.

[4]See, Boot (2000) for a review on the role of relationship banking in resolving problems of asymmetric information.

In this paper, we empirically explore the role of relationship banking in providing firms with uncollateralized, rather than collateralized, funding. The question is important for at least three reasons. First, young and small businesses may simply lack the required collateral, and hence face credit constraints, when otherwise unsecured funding opportunities are limited. Indeed, analyzing the role of lending technologies in overcoming firms' credit constraints Beck et al. (2017) show that young firms with less collateral to pledge face more credit constraints during times of distress, particularly if they have limited access to a relationship lender. Second, borrowers may face opportunity costs by binding up certain types of their assets as collateral. Finally, secured lending may constrain borrowers' access to funding especially at hard times, as borrowers' credit capacity can fluctuate due to volatile values of the underlying assets. Such pro-cyclical forces can further exacerbate downturns.[5] Our focus is on how relationship banking, in the form of repeated lending by the same creditor, facilitates borrowers' access to unsecured (as opposed to secured) funding.

To answer the question, we analyze firm-bank level lending relationship information from the universe of loans in Portugal spanning over a nine-year period. We study borrowers' access to secured and unsecured lending *at the beginning of the relationship* as well as over time. In the first case, we analyze in the cross-section the impact of the borrowers' loyalty with each of their (multiple) banks. We find that borrowers' access to funding is more likely to be uncollateralized if the ensuing relationship is likely to be a long-term one. This result holds true both when we exploit variation in the whole cross-section, as well as variation within a borrower's relationships with her banks (using borrower fixed effects). The economic magnitude is significant. Being a loyal relationship borrower (as defined by a dummy taking value 1 above the median) reduces the use of collateral at the beginning of the relationship by up to 10.4 p.p., compared to being a *transactional* borrower. Thus, being a relationship borrower can decrease the probability of collateralization by about 20% (the unconditional mean of collateralization is 51% in our sample). Similarly, a borrower with an actual relationship length that is higher by a one standard deviation at the time of loan origination will have a 7.5 p.p. lower likelihood of collateralization (15% of the unconditional mean).

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

Existing theoretical work suggests banks should require less collateral from their relationship borrowers, compared to their transactional borrowers. In Manove and Padilla (2001), Karapetyan and Stacescu (2016), banks may choose one of two technologies to overcome asymmetric information; *screening* with costly information collection about project type (unsecured credit), or, use of *collateral* (secured credit). In the latter case, borrowers with bad projects are not willing to pledge and lose collateral, if it is large enough, i.e., collateral plays the ex-ante role of filtering out non-creditworthy projects. Banks generate incumbency informational rents on their borrowers over time. However, because of competition the prospective informational rents should be transferred to borrowers in form of lower interest rates at present (Boot and Thakor, 1994; Sharpe, 1990; von Thadden, 2004; Karapetyan and Stacescu 2016). Yet, due to the negative relationship between interest rate and *ex-ante collateral*, the lower interest rates must be combined with higher amounts of collateral in any secured loan, 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* (i.e., *relationship* borrowers) are more likely to obtain uncollateralized funding at the beginning of their relationship.

Second, in line with the existing empirical banking literature, we further confirm the time series implications of a bank-borrower relationship; a borrower's collateral requirements go down during the course of the relationship. Previous empirical research has focused on the use of collateral over the length of relationship, but either lacked comprehensive panel data (Berger and Udell, 1995; Degryse and Van Cayseele, 2000), lacked information covering the whole industry (Kirschenmann, 2016), or lacked detailed information on the firms themselves (Berger et al., 2011).[7] In doing so, we make use of nine-year-long relationship information to construct a new relationship length measure. The measure captures the frequency, rather than the simple length, of bank-firm borrowing interactions. Such a relationship frequency

[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 collateral. For recent evidence on such negative relationship, see Becker et al. (2016).

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

measure more closely evaluates the active time between the bank and the firm compared to the more standard relationship length. The latter measures the time elapsed from the first loan made by the bank to the borrower, and treats frequent and infrequent borrowers equally.[8]

Our main identification strategy relies on two approaches. First, given a rich dataset, we exploit firms with multiple bank relationships and saturate the models with firm fixed effects to account for any unobserved time-invariant firm-level factors that may affect demand for loans by the firms. In most specifications, we add time fixed-effects to further make sure our results are not driven by time-varying unobservable factors. Also, in our regression analysis studying the time series impact of bank relationships, we saturate the models further by firm-time effects to further rule out results that are driven by time-varying firm level unobservables. Second, we use an exogenous shock to the lending technology of the creditors. In October 2011, the European Banking Authority (EBA) announced that major European banking groups would have to enhance their capital positions: first, core tier 1 capital ratios must reach 9 percent of their risk-weighted assets by June 2012. Second, they were required to hold a new temporary capital buffer to cover risks linked to sovereign bond holdings.[9] At the same time, granting an uncollateralized loan requires more (regulatory) capital, compared to a collateralized loan. Therefore, such an unexpected increase in capital requirements, imposed on some banks, changed the relative cost of collateralized versus uncollateralized lending. So long as equity is costlier than debt, the new capital requirement should increase the costs of uncollateralized lending more.

The EBA announcement affected a handful of banks, while others stayed unaffected, allowing us to study the question in a difference-in-differences setting. The hypotheses we test in this setting are a) affected banks will require more often collateral; b) they will do so less for relationship borrowers, compared to transactional borrowers. We find support for our hypotheses both at the beginning as well as over the course of the relationship. The observed effect is economically large: For relationship borrowers, the increase in required collateralization is lower by 4-9 percentage points, compared to transactional borrowers (i.e., borrowers

[8]We, however, confirm our results using the conventional relationship length measure to ensure robustness.

[9]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).

below the median of loyalty) at the start of the relationship. We show that such a change increased the likelihood of collateralized lending to the same firm at treated banks relative to the same firm at control banks. Most importantly, in the triple difference specifications, we find that this shift towards collateralized lending happens at an extent 30 percent lower for loyal firms with treated banks. Finally, our results are robust to using several windows around the EBA shock, including short ones, and thus minimize the potential of any unobserved confounding effects.

At the end of the empirical analysis, we document that collateral requirements can have real consequences. We show that when borrowers pledge collateral at the time of obtaining a new loan, they grow less (both in terms of employees hired as well as capital expenditure) compared to the (same) borrowers when they do not pledge collateral. The effects are economically important: pledging collateral will reduce growth in employment (capital expenditure) by about 1.5% (4%).

Our paper contributes to the literature on relationship banking.[10] 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; Beck et al. 2017). Rather than focusing on access to funding and the role of banks' heterogeneity, we here focus on access to unsecured funding, and on the role of borrowers' heterogeneity (i.e., its relationship aspect) in such access.

Our paper is closely related to the recent empirical debate about the way collateral 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 collateral theory, showing that unobservably safer borrowers start with collateral contracts, while enjoying more and more unsecured credit by proving their good

[10] For a review, see Boot, 2000; Degryse, Kim and Ongena, 2009; Kysucki and Norden, 2016 among others.

quality in later stages. Instead, in this paper we document borrowers enjoy unsecured credit not only later in the relationship (because they prove they are less risky, which is unobservable at the beginning), but also at the beginning (because they have a longer relationship potential). This cross-sectional, rather than time-series, prediction is confirmed across the ensuing firm-bank relationships, and using borrower fixed effects from the multiple-bank borrower population.

Several recent studies have focused on the role of relationship banking in distress times or in the global financial crisis of the last decade. 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 distress times for relationship borrowers. Closest to our work, Gropp et al. (2017) study the impact of higher capital requirements in the EBA capital exercise and show that banks reach higher capital ratio by reducing their credit supply (rather than raising new equity).[11] Instead, we focus on the collateral requirements of the credit, *conditional on a new loan being granted.* There are at least three ways to reach a higher risk-weighted capital ratio: increasing equity, reducing supply of credit, or reducing the required risk-weights assets as a whole by providing safer, collateralized credit. To the best of our knowledge, we are the first to examine the latter channel.

2 The data

Our data come from three 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.[12] Any loan above

[11] A number of other studies have studied the credit supply implications of increased capital requirements or increased cost of equity. See Fraisse et al. (2015), Aiyar et al.(2014), Cèlèrier et al. (2016) among others.

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

50 euros is recorded in the CRC data, implying full coverage. Our sample covers the entire population of non-financial corporate lines of credit from January 2005 to December 2013. The database includes information on 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, we observe days overdue for that loan. We focus on borrowers who have at least two banking relationships.

Because banks needed to report information on collateral starting January 2009, our analysis is based on all newly generated loans after that date.[13] 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. The CRC does not have an identifier for a new loan. Therefore, we formulate a methodology to identify whether a new loan is granted; we define a new loan being granted (*New loan =1*) by a given bank to a given firm in any month if we see either a new bank-firm relationship, or an increase in the number of loans in a bank-firm pair.

We employ two measures to capture a firm's relationship potential. Our first main independent variable is the expected loyalty as captured by the eventual relationship length - *maximum relationship* (or *max. relationship*). This bank-firm level relationship variable measures the maximum number of times a particular firm interacts with a particular bank. We will instrument this variable by setting up a prediction model whereby a bank predicts the expected maximum relationship length based on some observable borrower and lender (i.e. its own) characteristics. We thus assume that banks use those observable characteristics (e.g., industry, size of the firm, its location, external finance dependence, ...) to predict the firm's relationship length. For a given bank-firm pair, it is thus time invariant. We use CRC information from 2005, and thus the count starts from up to nine years back. To reduce right censoring issues, 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.

The second measure is *cumulative relationship* (or *cum. relationship*) - the relationship length as proxied by *frequency of interactions* up to the point of origination of the loan under consider-

[13] 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.

ation. 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 times a new loan has been granted, since the start of a new bank-firm relationship. 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.[14] As in the *max. relationship* measure, this variable is also computed starting 2005.

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), and are available at an annual basis. This database covers mandatory financial statements reported in fulfillment of 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. Our purpose is to track collateralization of new loans only. Accordingly, our dependent variable - $Collateral\ dummy$ - is 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.[15] Table 1 shows that about 51 percent of all new loans is collateralized. The table further shows that the median *cum. relationship* and *max. relationship* are 12.81 and 17.47 interactions, respectively.

Next, we provide information about banks' characteristics, such as total assets, their liquidity and capital ratios. The bank liquidity ratio is the sum of cash and short term securities

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

[15]One concern is that lenders can use existing collateral on an old loan (which has been nearly repaid) to cross-collateralize a new loan, even when the latter was recorded unsecured. It should be noted that reporting of the collateral is rather detailed at the Credit Registry and is broken down into detailed sources. A bank would not have any incentive to report a new loan unsecured when in fact it has collateral from another loan and if anything, the opposite incentive would be present for regulatory purposes. Furthermore, in Portugal it is not possible to create a floating charge or floating lien.

normalized by total assets. The median bank liquidity ratio is only 1%, reflecting the difficult liquidity position of banks during our sample period. The reported bank capital ratio is the core tier 1 capital over risk weighted assets, with a median of 8%.

In the final part of the table we provide summary statistics of our firm specific variables. The firm-level variables are annual. Firms employ on average about 27 employees, while half of the firms employ less than 8 employees. This shows that Portuguese non-financial firms are mainly small firms which tend to be more bank dependent. In our empirical specifications we employ the natural logarithm of the number of employees as proxy for firm size. Number of banking relationships gives the 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.

In what follows, we first develop our hypotheses with respect to the impact of the intensity of banking relationships on collateral requirements. We then quantify the impact of collateralization on firm level asset growth and employment activity, to motivate how important collateral requirements are for the real sector.

2.1 Hypotheses

Our first hypothesis is related to the impact of a borrower's (predicted) maximum relationship (borrower's loyalty) with banks on the use of collateral at the beginning of the relationship with that bank. When the borrower is expected to be more loyal (the expected length of the banking relationship is higher), banks may prefer to screen such borrowers investing in information, rather than using collateral in the *initial* stages of the relationship.

More formally, we estimate the following model:

$$y_{i,k,t} = \alpha_i + \beta Max.relationship_{i,j} + \theta x_{i,k,t} + \gamma f_{i,t} + \delta b_{j,t} + \lambda_j + \epsilon_{i,k,t} \tag{1}$$

where $y_{i,j,t}$ is the collateral dummy in loan k by firm i in year t. $x_{i,k,t}$ denotes log of the loan volume, $f_{i,t}$ and $b_{j,t}$ denote time-varying firm and bank characteristics, while α_i and λ_j denote, respectively, firm and bank fixed effects.

H1. $\beta < 0$: *The expected length of the borrower's relationship reduces the incidence of pledging*

Table 1: Summary Statistics

	Mean	Median	SD	Min	Max
Dependent variable					
Collateral dummy	0.51	1.00	0.51	0.00	1.00
Firm-bank level variables					
Cumulative relationship	14.42	12.81	9.98	1	92
Maximum relationship	19.50	17.47	13.37	1	92
Bank level variables					
Total assets (thousand euros)	2152951	103695.70	9554217	303.82	7.23e+07
Liquidity ratio	0.03	0.01	0.05	0.00	0.22
Capital ratio	0.19	0.08	0.22	0.02	0.73
Firm level variables					
Age	16.18	13.00	12.98	1.00	177.00
Total assets (thousand euros)	2413.32	630.48	5433.83	18.88	32919.75
Number of employees	27.22	8.00	206.09	1.00	22734
Number of banking relationships	2.58	2.00	1.02	2.00	14.00
%Δ Employment	0.01	0.00	0.26	-0.69	0.85
%Δ Fixed Assets	0.04	-0.04	0.57	-1.35	2.11

collateral at the beginning of the relationship.

A key endogeneity concern arises due to the forward-looking nature of our main variable: The firms may want to stay longer with those banks who do not require collateral. To tackle this concern, we construct the *predicted length* of the future relationship, using a number of observables (observable to the bank at the time of granting credit) from the dataset. This approach is justified since banks can use firm-level and bank-level characteristics to predict what the expected loyalty of the firm is (in terms of the number of expected future loan interactions with the firm). As an alternative way to address endogeneity, we instrument the variable by the average of the maximum relationship the firm has with all other banks.[16]

The second 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 collateral) by their bank for subsequent loans. These later stages of a firm's interaction with the bank is captured by the variable *cum. relationship*.

More specifically, the second hypothesis (H2) can be tested by running the following model:

$$y_{i,k,t} = \alpha_i + \beta Cum.relationship_{i,j,t} + \theta x_{i,k,t} + \gamma f_{i,t} + \delta b_{j,t} + \lambda_j + \epsilon_{i,k,t} \tag{2}$$

H2.$\beta < 0$: *In repeated interaction, the incidence of pledging collateral decreases over the course of the relationship.*

2.2 Empirical analysis of H1 and H2

Table 2 tests H1, where we focus on the cross-section of firm-bank relationships at the beginning. To focus on the beginning of the relationship, we analyze the sample up to the 10th percentile of the duration of the relationship, i.e., by restricting observations to those for which the cumulative relationship measure is less than the 10th percentile.[17]

In columns 1 - 3, we use the predicted maximum relationship length as our main independent variable. Column 2 saturates the model further with bank fixed effects, while column

[16] The correlation of this measure with the actual maximum relationship between the firm and the bank is 0.26.

[17] Importantly, we confirm our results by restricting the observations to only the first interaction, i.e. strictly the formation of the new relationship where cumulative relationship is less than 2.

3 adds a large-bank interaction dummy. The models include firm fixed effects, so identification comes from variation in a firm's predicted maximum relationship measures with each of its banks. The economic magnitudes are large: column 1 for instance shows that for a one-standard deviation increase in the predicted relationship (the standard deviation of the predicted maximum relationship is 1.2), collateral requirements go down by about 3.5 percentage points (or by about 7 percent of the unconditional mean). Magnitudes are also comparable in columns 2 and 3. In column 3, the positive interaction with the large bank dummy (a statistically significant 0.018) lends credence to the fact that smaller banks tend to be more relationship lenders while the larger ones are more transactional. Similarly, we confirm our results using an instrumental variables estimator in column 4. Here *maximum relationship* is instrumented by the average of the maximum relationship length a given firm has with all other lenders. it must be noted that while the coefficient is much smaller the interepretation in terms of magnitus is comparable given that the maximum relationship is more volatile compared to the predicted maximum relationship: $\sigma_{Max.Relationship} \approx 13$).

In column 5, we use an IV estimator, too, but focus on an indicator variable. We first define an indication variable: *High max. relationship* equals to one 1 if the max. relationship is above its median value. Our instrument for the indicator variable for high relationship is an indicator variable that is based on the original instrument: the indicator-instrument is equal to 1, if the average max. relationship with other banks (i.e., the original instrument) is above its median value and 0 otherwise. The (instrumented) dummy has a statistically significant negative impact on the use of collateral in the earlier stages of the relationship. The economic magnitude remains significant here, too: for a high-relationship borrower, collateral requirements are lower by about 5 percentage point, or by around 10 percent of the unconditional mean.

In Table 3 we test H2 which focuses on the impact of relationship building on collateral use, but over the course of a bank-firm relationship. In columns 1-3, we use the cumulative relationship length as the main independent variable. In column 1, our results show that for a one-standard deviation increase in the cumulative relationship, borrowers are 20 percentage point less likely to be asked for collateral. Column 2 further saturates the model with bank-

Table 2: **Determinants of Collateral (Beginning of the relation)**. $\widehat{Max.relationship}$ is the predicted maximum relationship length using observable firm and bank characteristics like size, profitability, leverage, number of banking relationships, sector of operation, location, capital ratio, liquidity ratio, and bank size. Column 1 reports the regression with firm FE, while column 2 augments it with bank FE. Columns 3 documents heterogeneity based on bank size. *Max. relationship* in column 4 is *instrumented* by a given firms maximum relationship length with all other lenders. *High max. relationship* in column 5 is an indicator and is 1 if the average *max. relationship* is above its median value, and 0 otherwise.

	[1]	[2]	[3]	[4]	[5]
$\widehat{Max.relationship}$	-0.030***	-0.021***	-0.029***		
	[0.004]	[0.004]	[0.004]		
$\widehat{Max.relationship} * Dummy_{bigbank}$			0.018***		
			[0.003]		
Max. relationship				-0.003***	
				[0.000]	
High max. relationship					-0.051***
					[0.010]
Loan amount	0.123***	0.124***	0.124***	0.125***	0.124***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Firm FE	Y	Y	Y	Y	Y
Bank FE	N	Y	Y	Y	Y
Bank Controls	Y	Y	Y	Y	Y
Firm Controls	Y	Y	Y	Y	Y
R-squared	0.56	0.59	0.59	0.59	0.59
Number of obs.	216024	216024	216024	311519	311519

time and firm-time characteristics. Identification on our firm-time level relationship variable comes from variation of a firm's elapsed relationship with (the number of times it has asked loans from) each of its banks as of a given point in time. The firm-time fixed effects thus rule out possible confounding effects from any firm-specific and time-varying unobservables.

Column 3 documents heterogeneity based on bank size. The coefficients on the standalone independent variable (-0.41) and its interaction with the large bank dummy (+0.31) emphasize the fact that the importance of relationships is more pronounced for small banks, for whom the use of soft information is more effective, compared to big, hierarchical banks, focusing more on the acquisition and processing of hard information.

In columns 4 and 5, we use a dummy to denote high relationship borrowers (High cum.relationship) which is based on the cumulative relationship length variable, and is equal to 1 if the cumulative length is above the median and zero otherwise.[18] The results in column 5 suggest that for a high relationship borrower (having a long versus a short relationship with a bank) decreases collateral requirements by about 12 percentage points, or around 20 percent of the unconditional mean. Columns 2 and 5 present alternative specifications, saturating the model with bank-time and firm-time fixed effects. Results are qualitatively unaffected.

This result can be seen as a validation of earlier reminiscent results established in the banking literature, such as Berger et al. (2011), Degryse and can Cayseele (2000).[19] Using detailed registry data with a long time span, our contribution in this part is the introduction of the *active* relationship length. it must be noted that our results hold and comparable to those established when we instead use the usual relationship length measure.

3 Empirical Analysis around the EBA capital exercise

3.1 The EBA capital exercise

On October 26, 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. 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

[18]Note that results are qualitatively the same when we instead use a dummy to categorize borrowers above 75th percentile.

[19]Rents are generated as follows: Collateral is costly due to liquidation losses in case of default, and this 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 technology, therefore, becomes less expensive per borrower as the borrower pool improves over time, making it less expensive, but only for the incumbent bank.

Table 3: **Determinants of Collateral (Over the relationship)**. We use the cumulative relationship length as the main dependent variable in columns 1-3. Column 2 documents heterogeneity based on bank size. Column 4 and 5 use *high cum. relationship*, a dummy that is equal to 1 if the cumulative length is above the median and zero otherwise. Columns 3 and 5 present alternative specifications with bank-time and firm-time fixed effects.

	[1]	[2]	[3]	[4]	[5]
$Cum.relationship$	-0.022***	-0.020***	-0.041***		
	[0.000]	[0.000]	[0.001]		
$Cum.relationship * Dummy_{bigbank}$			0.031***		
			[0.001]		
High cum. relationship				-0.121***	-0.123***
				[0.001]	[0.001]
Loan amount	0.134***	0.134***	0.135***	0.134***	0.135***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Firm FE	Y	Y	N	Y	N
Bank FE	Y	Y	N	Y	N
Time FE	Y	Y	N	Y	N
Firm- Year FE	N	N	Y	N	Y
Bank- Year FE	N	Y	Y	N	Y
Bank Controls	Y	Y	Y	Y	Y
R-squared	0.50	0.50	0.58	0.50	0.58
Number of obs.	3087858	3087858	3082197	3087858	3082197

buffer against the sovereign exposure would be based on sovereign bonds' market prices as of the end of September.

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; Gropp et al, 2017). As Gropp et al. (2017) argue, the credibility of the June stress tests were doubtful. For instance, the stress tests identified the Belgian bank Dexia as one of the safest banks in Europe, but in fact it failed less than three months later.[20] 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.

The announcement came at a time when the euro area was still perceived to be extremely

[20]See Greenlaw et al. (2017) for further details.

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,[21] and the risk-weighted capital requirements were met, at least to a significant extent, by shrinking the asset side (Acharya et al., 2016).

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 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 to be done by February 2012.

In the Portuguese context, owing to the presence of many small firms, the banking system is one of the most important sources of credit. The domestic credit to the private sector as a percentage of GDP peaked at about 160 percent in 2009.[22] There are about 180 credit granting granting institutions in Portugal which can be grouped into approximately 33 banking groups. The largest 8 banking groups account for about 82 percent of the total banking assets and around 82 percent of loans varying marginally from year to year. Four out of the eight biggest banks 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.[23]

3.2 Hypotheses

We formulate our hypotheses based on the impact the exercise has on banks' relative cost (and thus, their decision) of extending collateralized versus unsecured loans. Collateralized loans have lower risk weights in line with the actual implementation of regulation. In our context this means that bank-firm exposures secured by collateral require less regulatory

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

[22]Source: World bank data.

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

capital than unsecured exposures. This observation is key, since it then makes extending collateralized-based loans cheaper relative to screening-based loans, to the extent that, for the banks, equity is costlier than debt.

First, in the standardized approach (the system used by the majority of Portuguese banks) secured exposures receive a preferential risk weight. For instance, exposures secured by immovable property, such as residential real estate and by commercial immovable property, benefit from preferential risk-weights when certain conditions are verified (see articles 124-126 of the CRR). Furthermore, a lower probability of default and loss-given default can be assigned in the internal ratings-based approach.[24] Further details of the impact of collateralization on risk-weights are described in Appendix C.

Will the affected banks then (at least partially) meet the increased capital requirements by modifying their lending technology and giving preference to secured lending after the implementation of the exercise? If so, this would be reflected in the granting of more collateralized loans for those banks who were identified to have shortfall and must increase capital ratios - 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, following the capital exercise.*

Support for H3 would be reflected in a positive *post*dummy* interaction coefficient, where, *post* would be a dummy equal to 1 for the period after the EBA announcement.

Our final hypothesis looks at the differential effect of the EBA exercise 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. As the use of screening is less costly for relationship borrowers (described earlier), we hypothesize that any substitution by collateral after the experiment will take place, only to a subdued/muted extent, for the relationship borrowers.

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

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

3.3 Around the EBA window

In this part of the analysis we focus on the 2011 to 2012 period, where we use a difference-in-difference estimator to quantify the effect of the EBA capital exercise on the treated banks and their borrowers.

3.3.1 Testing H3 and H4

We now test the main hypothesis; treated banks increased collateral requirements for firms, but less so for the relationship borrowers. In Table 4, we use pre- and post-EBA windows to quantify the diff-in-diff and triple-difference effects, testing H3 and H4. The pre-EBA period includes 6 months preceding the EBA announcement, i.e., June to November 2011, while the post-EBA period includes 2 periods after the implementation (except for column 4, where both pre- and post-EBA periods include one period of observations). In column 1 (2), we use two quarters immediately following the *start of* the implementation, 12/2011 (beginning three months after the start of the implementation). According to the EBA announcement, the new requirements were to be met by the end of June 2012, which is the deadline of the implementation. Thus, a further relevant window is the period that closely follows the deadline, July to December 2012, which we use in column 3. Our main focus is on the double and triple interactions. In all the cases, the double interaction coefficient (*post*dummy*) is statistically significant and positive, consistent with H3. The triple interaction instead shows a statistically significant and negative coefficient. More interestingly, the magnitude of the triple interaction increases as we move away from the most adjacent period (column 1), towards wider windows acknowledging the adjustment period; this can be seen in columns 1 through 4. The results show qualitatively and quantitatively significant effects. In column 2, while affected banks increase collateral requirements by 4.9 percentage points ($Dummy_{ebabank} * Post = 0.049$), which is about 10 percent of unconditional mean, they do so less for relationship borrowers. In particular, a borrower with a one-standard-deviation higher predicted maximum relationship (standard deviation of which is 1.2), would see a significantly lower collateralization increase from treated banks, namely by approximately 4.2 percentage points ($\approx$ 0.049-0.006*1.2). This means relationship borrowers are about 15 percent less likely to face an increase in collateralized loans compared with their transactional peers with lower relationship. In column (3), the comparable magnitude is a 10 percent increase in collateralization for transactional, versus a 9 percent (0.10-0.007*12) for relationship borrowers, which means the latter group is 10 percent less likely to have the new loan collateralized after treatment by treated banks compared to the transactional borrowers of the same bank. When we move to the cumulative relationship variable, the corresponding triple-difference "discount" increases further: a borrower with a long relationship history would be 40 percent less likely to face increased collateral requirements compared to a new borrower.

3.4 Validity of parallel trends assumption

In this section we test the validity of the underlying assumption of the parallel trends in our diff-in-diff analysis. For this purpose, we study the lead-up to 2011 and examine how the lending activity of the treated and control banks differed for relationship versus transactional borrowers.

A potential concern in the diff-in-diff estimator is that the underlying assumption of parallel trends does not hold: absent our capital exercise, under the parallel trends assumption the affected banks would have treated their relationship borrowers in the same way (in terms of collateral requirements), as the non-affected banks. This assumption is hard to test. To corroborate its validity, we must reject the possibility that treated banks over time may have increased their collateral requirements, but less so for high-relationship borrowers. Our results above would otherwise simply reflect a trend already observed in the pre-event period.

Yet, this exercise is challenging due to the volatile markets before 2011. Until late 2009 or early 2010 the sustainability of the Portuguese sovereign debt was not perceived as a concern for the markets.[25] 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. The higher sovereign risk since early 2010 in the Euro area has an effect, on the one hand, on financial institutions. In particular, it has

[25] For over ten years since the introduction of the Euro, the yields of bonds issued by European countries were low and stable.

Table 4: **EBA Experiment: relationship versus transactional borrowers.** The dependent variable is the *collateral dummy*. $Max.\widehat{relationship}$ is the predicted value of maximum potential relationship length based on observable firm and bank characteristics. Post is an indicator variable which is equal to 1 for quarters post the implementation date of December 2011. $Dummy_{ebabank}$ is a dummy which takes a value of 1 for the EBA affected banks. Columns 1-4 report our main regression where we vary the post shock period. Column 1 considers the immediate impact of the shock (Q1, Q2 of 2012), column 2 allows for a quarter of adjustment (Q2, Q3 of 2012) and so on. The pre-shock period is a 2-quarter period (6 months) preceding December 2011, except in column 4 where it is 1 quarter (months 9, 10, 11). Columns 5 and 6 use the cumulative relationship length as the main independent variable and the post shock quarters to be Q2,Q3 and Q3,Q4 respectively.

	(1) Q1,Q2	(2) Q2,Q3	(3) Q3,Q4	(4) Q4	(5) Q2,Q3	(6) Q3,Q4
$Max.\widehat{relationship}$	-0.039***	-0.041***	-0.048***	-0.055***		
	[0.012]	[0.012]	[0.015]	[0.017]		
$Max.\widehat{relationship} * Dummy_{ebabank}$	0.029**	0.031***	0.033***	0.028**		
	[0.011]	[0.008]	[0.011]	[0.012]		
$Max.\widehat{relationship} * Post$	0.001	0.006	0.003	-0.003		
	[0.006]	[0.007]	[0.008]	[0.009]		
$Max.\widehat{relationship} * Dummy_{ebabank} * Post$	-0.003**	-0.006***	-0.007***	-0.006***		
	[0.001]	[0.001]	[0.001]	[0.002]		
$Dummy_{ebabank} * Post$	0.011	0.049***	0.101**	0.138**	0.023**	0.065***
	[0.013]	[0.017]	[0.044]	[0.059]	[0.011]	[0.011]
Cum. relationship					-0.040***	-0.040***
					[0.002]	[0.002]
$Cum.relationship * Dummy_{ebabank}$					0.013***	0.016***
					[0.003]	[0.003]
Cum. relationship * Post					0.005**	0.018***
					[0.002]	[0.002]
$Cum.relationship * Dummy_{ebabank} * Post$					-0.013***	-0.027***
					[0.003]	[0.003]
$Cum.relationship * Dummy_{bigbank}$					0.045***	0.041***
					[0.002]	[0.002]
Loan amount	0.130***	0.130***	0.131***	0.131***	0.133***	0.133***
	[0.011]	[0.010]	[0.010]	[0.010]	[0.000]	[0.000]
Bank FE	Y	Y	Y	Y	Y	Y
Time (month) FE	Y	Y	Y	Y	Y	Y
Firm Controls	Y	Y	Y	Y	Y	Y
R-squared	0.43	0.43	0.42	0.42	0.41	0.41
Number of obs.	30575	29029	28866	15463	459187	459828

dramatically increased the cost of some euro area, including Portuguese, 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 had more difficulty raising wholesale debt and deposits, and have become reliant on central bank liquidity. In the 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. As a result the banks and the sovereign are quite closely linked.[26] On the other hand, uncertain economic conditions also affected non-financial corporations indirectly, since those are perceived as more risky by banks. So how can and how did these developments affect lending technologies?

With respect to non-financial corporations, the effect works via banks, too. 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 - the *firm risk channel* - has been shown to be quite important quantitatively (Bocola, 2016).[27] A decline in the repayment probability can then increase banks' required compensation, in form of higher collateral requirements and higher interest rates.[28] Along these lines, we show that the sovereign debt crisis increases banks' collateral requirements from business lending.

However, we do not find any *heterogeneity* of the increased use of collateral, with respect to the sovereign-bank direct link. As we show below, there had been no difference in pre-EBA period based on banks' treatment status in the EBA exercise.[29]

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

[27]In fact, Buera and Karmakar (2017) document that especially highly leveraged firms found it difficult to obtain financing and contracted more in the aftermath of the sovereign debt crisis.

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

[29]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. 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

The presumption that there should be no heterogeneity in the increased use of collateral for treatment versus control banks holds as long as collateralized lending does not carry an advantage in terms of a decreased funding costs for banks. As soon as it does, the banks' ability and willingness to extend a collateralized loan will be greater than for extending an unsecured loan. The EBA capital exercise had precisely this effect: a certain number of banks had to increase their capital ratios to meet the new regulatory minima and also hold additional capital against their sovereign holdings (sovereign buffers) by June 2012. After this period, collateralized lending ceases to have any advantage.

In table 5, we analyze the rate of collateralization by all banks in *non-EBA* periods during 2009-2012, i.e., covering windows both before and after the EBA capital exercise. As column 1 confirms, after 2012 treated banks did not change collateral requirements for relationship borrowers differently compared to the control banks (*post12* is a dummy variable taking value 1 for 2013 and 0 for 2012). In Column 2-4, pre-EBA periods are analyzed. For instance, column 2 and 3 show the same pattern as in column 1 for the window around mid 2009 (*postmid9* is a dummy variable that takes value 1 for year July 2009 onwards and 0 for earlier) and the end of 2009 (*post9* is a dummy variable that takes value 1 for year 2010 and 0 for year 2009) respectively. Column 4 uses *postmid10* as the indicator variable which takes a value of 1 from July 2010 and 0 earlier. The last column uses the cumulative relationship length as the relationship variable instead of the predicted maximum length. As can be seen from the table, our conclusions remain robust and consistent across all specifications covering various time spans.

4 Robustness

To ensure our results are robust, we consider a number of various specifications with respect to firm and bank cohorts, the definition of the main right-hand side variables, and collateral types.

In Table 6, as before, we move from the immediate aftermath to post-June 2012 windows in columns 1-3. However, our *max. relationship* variable is predicted using the entire sample:

firm's repayment probability.

Table 5: **Falsification** The dependent variable is *collateral dummy*. $\widehat{Max.relationship}$ is the predicted value of maximum relationship based on observable firm and bank characteristics. Post12, post9, postmid9, and postmid10 are indicator variables altering our post-crisis windows. All columns have bank fixed effects. Column 6 reports results using the cumulative relationship length as the main independent variable.

	[1]	[2]	[3]	[4]	[5]
$\widehat{Max.relationship}$	-0.024***	-0.024***	-0.024***	-0.033***	
	[0.007]	[0.006]	[0.005]	[0.004]	
$\widehat{Max.relationship}$*$Dummy_{ebabank}$	0.000	0.005	0.018**	0.013*	
	[0.006]	[0.006]	[0.008]	[0.006]	
$\widehat{Max.relationship}$*post12	0.018***				
	[0.004]				
$\widehat{Max.relationship}*post12 * Dummy_{ebabank}$	0.003				
	[0.002]				
post12*$Dummy_{ebabank}$	-0.047				
	[0.033]				
$\widehat{Max.relationship}$*postmid9		-0.002			
		[0.004]			
$\widehat{Max.relationship}$*postmid9*$Dummy_{ebabank}$		0.010			
		[0.006]			
postmid9*$Dummy_{ebabank}$		-0.127			
		[0.088]			
$\widehat{Max.relationship}$*post9			-0.013***		
			[0.004]		
$\widehat{Max.relationship}$*post9*$Dummy_{ebabank}$			-0.002		
			[0.006]		
post9*$Dummy_{ebabank}$			0.020		
			[0.068]		
$\widehat{Max.relationship}$*postmid10				0.000	
				[0.004]	
$\widehat{Max.relationship}$*postmid10*$Dummy_{ebabank}$				0.003	
				[0.006]	
postmid10*$Dummy_{ebabank}$				-0.066	-0.041
				[0.060]	[0.038]
Cum. Relationship					-0.047**
					[0.021]
Cum. Relationship*$Dummy_{ebabank}$					0.027
					[0.021]
Cum. Relationship*postmid10					-0.001
					[0.010]
Cum. Relationship*$Dummy_{ebabank}$*postmid10					0.007
					[0.015]
Firm FE	N	N	N	N	Y
Firm Controls	Y	Y	Y	Y	N
Bank FE	Y	Y	Y	Y	Y
Cluster	Bank	Bank	Bank	Bank	Bank
R-squared	0.41	0.39	0.39	0.41	0.63
Number of obs.	30500	66215	58049	50324	298948

we assume that at any given point in time the bank uses information from the bureau, that is not only information available up to that point in time, but also later. Our results remain unchanged, both qualitatively as well as quantitatively. In column 4, *dummy* is a dummy variable taking value 1 for both domestic and foreign affected banks, operating in Portugal. Our results and conclusions remain unchanged.

The EBA capital exercise was conducted for the largest banks in different European countries. Thus, on average the EBA capital exercise affected larger and significant financial institutions in each jurisdiction. A potential concern could be that this exercise only affects large banks and hence the results could be influenced by bank size or unobservable factors that change differently for large and small banks. This concern is partly resolved in the diff-in-diff setting to the extent that any unobservable *changes* affecting the EBA (larger) banks are not different from those affecting the control group. To rule out that our results are driven by bank size (or unobservable factors that change differently for large and small banks), we match EBA banks to Non-EBA banks in the *Overlap Sample* of banks: banks that are larger than the smallest EBA bank, and smaller than the largest Non-EBA bank (Gropp et al., 2017). This is possible because there are foreign banks operating in Portugal and there is a non-trivial overlap due to the various size thresholds applied in each of the (host) countries. In columns 5 and 6, the matched control group confirms the validity of our results, and we verify the results using the predicted maximum relationship length as well as the cumulative relationship length measures.

In unreported regressions we run separate models for various groups of firms. We observe that the results are similar, both in terms of statistical power and economic magnitude, for small and large firms, as well as for young and old 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 muted impact of relationship banking for large firms does not seem to be at work.

In the tripe difference 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

Table 6: **Robustness** The dependent variable is *collateral dummy*. In columns 1-3 $\widehat{Max.relationship}$ is the predicted (out of sample) value of maximum relationship based on observable firm and bank characteristics. In column 4 Dummy is a dummy variable for all domestic and foreign affected banks. In columns 5 and 6, the control group is matched based on the size of the banks.

	(1) Q1,Q2	(2) Q2,Q3	(3) Q3,Q4	(4) DUMMY	(5) MATCHING	(6) RELFREQ
$\widehat{Max.relationship}$	-0.035***	-0.036***	-0.041***	-0.054***	-0.027***	
	[0.009]	[0.009]	[0.012]	[0.012]	[0.004]	
$\widehat{Max.relationship}$*$Dummy_{ebabank}$	0.028***	0.029***	0.032***			
	[0.010]	[0.008]	[0.009]			
$\widehat{Max.relationship}$*Post	-0.002	0.004	0.001			
	[0.005]	[0.005]	[0.006]			
$\widehat{Max.relationship}$*post*$Dummy_{ebabank}$	-0.003**	-0.006***	-0.007***			
	[0.001]	[0.001]	[0.001]			
$\widehat{Max.relationship}$*$Dummy_{ebabank}$	0.012	0.050***	0.103**			
	[0.013]	[0.017]	[0.046]			
$\widehat{Max.relationship}$*Dummy				0.032**		
				[0.012]		
$\widehat{Max.relationship}$*Post				0.012	0.019**	
				[0.011]	[0.008]	
$\widehat{Max.relationship}$*Post*Dummy				-0.029*		
				[0.014]		
$\widehat{Max.relationship}$*Dummynew					0.026***	
					[0.008]	
$\widehat{Max.relationship}$*Post*Dummynew					-0.021*	
					[0.012]	
Cum. Relationship						-0.042***
						[0.002]
Cum. Relationship*Dummy						0.016***
						[0.003]
Cum. Relationship*Post						0.018***
						[0.002]
Cum. Relationship*Post*Dummy						-0.027***
						[0.003]
R-squared	0.43	0.43	0.42	0.42	0.41	0.41
Number of obs.	30575	29029	28866	28866	19572	459828

pre- and post- periods, using a quarter, 4 or 5 month-long window of observations for both before and after-event periods. Windows spanning between 2010 and 2012 yield qualitatively similar results, too. For instance, when we use 2010 Q1 and 2012 Q4 for the pre- and post-event periods as the widest window, we still confirm that treated banks did not increase collateral requirements for their relationship borrowers, while they did so for transactional borrowers. Specifically, we find that high relationship borrowers on average enjoy a 9 percentage point less likelihood of having the loan collateralized during this entire period. After the capital exercise, banks as a whole required 5 pp more collateral (positive coefficient on the *post*) but the effect was found to be more pronounced for the treated banks (i.e., we again find a statistically significant *post*dummy* interaction).

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 Table 3 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. Karapetyan and Stacescu (2016) show that with costly collateral, banks over time prefer to screen borrowers and acquire more information than use collateral. This is because over time banks learn about the borrower population and informational screening becomes less costly for the incumbent bank. This preference is especially important if the alternative technology, that is collateral, is particularly costly. Instead, if in the extreme collateral has no liquidation cost at all, there will be no increased preference for costly (even if the costs are decreasing) information acquisition. Therefore, 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. To test this, we assume that immovable collateral, such as corporate real estate is more costly, than movable collateral, such as financial guarantees. We thus restrict our attention to consider only costly collateral: the dummy for costly collateral takes a value of one for real collateral and personal collateral, and excludes financial collateral. We repeat our baseline specifications and confirm that the results hold qualitatively, and observe a small increase in the magnitude of the coefficients.

4.1 Real Effects of collateral

Thus far we have analyzed how relationship borrowers are shielded from increased collateral requirements in the face of adverse economic conditions. But the question that remains to be answered is why is this lower collateral requirement important? Does pledging collateral have real consequences? Do firms who pledge more collateral perform poorly when compared to their counterparts? These are the issues we address in this section. To motivate the importance of collateral requirements, we quantify the impact of collateral requirements on firm growth. To do so, we regress firm's employment growth and growth in fixed assets (capital expenditure) on the (average) collateralization rate of the firm's loans, the (average) loan sizes as well as on firm and bank fixed effects. We use the following model:

$$z_{i,t} = \alpha_i + \beta x_{i,t} + \gamma y_{i,t} + \delta_j + \epsilon_{i,t} \tag{3}$$

where $z_{i,t}$ is the growth rate of employment or fixed assets for firm 'i' in year 't'. $x_{i,t}$ denotes the average collateralization or the *weighted collateral* that is calculated at a firm-month level. The weights are the share of each of the firm's loans in the total borrowing of the firm in a given month (if the firm has just one loan, the variable takes value 1 or zero for secured and unsecured credit, respectively). Similarly, $y_{i,t}$ denotes the average loan size. α_i and δ_j denote firm and bank fixed effects respectively. The results are shown in Table 7. Collateral requirements appear to have real consequences, with a significant magnitude, both statistically and economically. At the time of obtaining a new loan, employment grows by about 1.2 to 1.6 percent less if the loan is collateralized (about 5 percent of its standard deviation). At the same time, pledging collateral reduces growth in capital expenditure by about 3.9 to 4.4 percent (about 5 percent of its standard deviation). The results have important economic implications: for a one-standard deviation increase in (weighted) collateralization (i.e., an increase by 0.47), employment will decrease by about 1 percentage point. At the same time, for the same increase in weighted collateral, the growth in fixed assets will decrease by about 2.5 percentage point.

Table 7: **Real effects**. The dependent variable in columns 1-3 is the growth of employment and in columns 4-6 it is the growth rate of fixed assets which is our measure of investment. In columns 3 and 6, the model is restricted to the sub sample of year-month-firm observations for which there was a new loan approved. Wtd_Coll is the weighted collateral that is calculated at a firm-month level. The weights are the share of a particular loan in the total borrowing of the firm in a given month. Log(avg. loan) is the natural logarithm of the mean of all outstanding loans of a given firm in a given month. The lead bank of a firm (defined on a monthly basis) is the bank that provides the largest share of loans to the firm in a given month.

	(1) Gr_emp	(2) Gr_emp	(3) Gr_emp	(4) Gr_ast	(5) Gr_ast	(6) Gr_ast
Wtd_Coll	-0.018***	-0.020***	-0.022***	-0.047***	-0.053***	-0.055***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.002]	[0.002]
Log(avg. loan)	0.004***	0.004***	0.004***	0.010***	0.012***	0.012***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]
Const.	-0.027***	-0.031	-0.038	-0.040***	-0.065	-0.065
	[0.001]	[0.029]	[0.037]	[0.003]	[0.074]	[0.091]
Firm FE	Y	Y	Y	Y	Y	Y
Lead-Bank FE	N	Y	Y	N	Y	Y
R-squared	0.34	0.35	0.37	0.32	0.32	0.35
Number of obs.	1303531	1303531	675043	1281662	1281662	665322

5 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 borrowers' 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 3 to 5 percentage points lower use of collateral in the initial stages of its relationship.

We further exploit an exogenous variation, caused by an unexpected change in regulatory requirements of bank capital, to study lending contracts in "distress" times. In particular, in December 2011 the European Banking Authority imposed stricter capital requirements on some major European banking groups as a result of risks linked to their sovereign bond holdings. This exogenous variation favors collateralized lending by the treated banks relative to unsecured lending as collateralized loans carry lower risk weights and therefore require less regulatory capital to be held, against them. We find that treated banks in general are 5 percentage points more likely to require collateral. However, for high-relationship borrowers the treated banks' increase in required collateralization is dampened by about 4 percentage points. In sum, we show that relationship banking is an empirically important driver of collateral decisions.

A Variable Definition

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.
Cumulative Relationship Length	Constructed using CRC 2005-2013	Measure of active length of a relationship. Number of times a new loan is transacted (time-variant).
Predicted Max. Relationship Length	Estimated using CRC, IES, MFS, 2005-2013	Maximum relationship potential/loyalty at the start of a relationship.
Max. banking relationships	Constructed using CRC 2005-2013	Maximum number of banks a firm has had a relationship with.
Firm profitability	IES	Total profits from operations during the given year normalized by total assets.
Firm leverage	Constructed using IES	All interest bearing liabilities normalized by total assets.
Firm num. of employees	IES	Number of employees on a firm's payroll during the given year.
Bank total assets	MFS	Total assets of the bank reported at monthly frequency
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.

B Prediction Model

In this appendix we describe the methodology adopted to estimate the potential loyalty of a borrower at the time of the first interaction with the lender. The maximum relationship length is predicted using the following empirical specification:

$$Max.Relationship_{i,j} = \alpha_0 + \alpha_1 F_{i,t} + \alpha_2 B_{j,t} + \beta\Gamma_{FE} + \nu_t, \tag{4}$$

where $Max.Relationship_{i,j}$ is the maximum active relationship length between firm 'i' and bank 'j'. $F_{i,t}$ consists of a number of firm specific characteristics namely size, leverage, profitability, number of banking relationships etc., $B_{j,t}$ consists of a suite of bank characteristics namely bank size, capital ratio, and the liquidity ratio. We also include fixed effects for the firm's sector of operation and the location (Γ_{FE}) as these factors are also likely to influence the length of the relationship. The regression above is conditioned to include observations from the first five interactions between a particular firm and a bank, which corresponds to the 10th percentile of the distribution of cumulative active relationship length. The idea is to focus at the very initial stages of a relationship when information is relatively scarce. We have conducted robustness checks by including the first ten interactions, which corresponds to the 25th percentile of the distribution, as well as the extreme case of the very first interaction. In all of these cases, our results remain robust. We report the results in the following table.

C Risk-weights

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.[30] 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

[30] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2013:176:FULL:EN:PDF

Table 8: **Prediction of maximum relationship length**

	1st interaction	5 interactions	10 interactions
Firm_size	-0.353***	-0.367***	-0.314***
	[0.056]	[0.022]	[0.016]
Leverage	0.006	-0.026***	-0.003**
	[0.038]	[0.008]	[0.001]
No. of banks	-0.210***	-0.207***	-0.219***
	[0.045]	[0.018]	[0.013]
Profitability	0.190***	0.369***	0.503***
	[0.037]	[0.015]	[0.011]
Bank_size	-0.154***	-0.045***	0.079***
	[0.036]	[0.014]	[0.010]
Capital ratio	-0.207***	-0.167***	-0.144***
	[0.034]	[0.012]	[0.009]
Liquidity ratio	-5.703***	-3.304***	-2.924***
	[0.696]	[0.247]	[0.161]
Sector FE	Y	Y	Y
Location FE	Y	Y	Y
R-squared	0.02	0.02	0.02
Number of obs.	32812	220082	484895

(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.