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To Ask or Not To Ask? Collateral versus Screening in Lending Relationships

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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 dataset covering all corporate loans in Portugal, we identify a novel channel of tighter capital requirements: relative to the control group and after the shock, treated banks require loans more often to be collateralized but *less so for relationship borrowers.* We further find this impact is stronger for collateral that saves more on regulatory capital.

JEL: G21, G28, G32

1. Introduction

Lending to small businesses, a core source of economic growth, is especially susceptible to informational problems (e.g., Petersen and Rajan, 1994; 1995; Berger and Udell, 1995; Degryse and Van Cayseele, 2000; Beck et al. 2018). In the aftermath of the global financial crisis, small-business lending has regained considerable attention as small firms, facing tougher credit conditions, were particularly hit in the volatile environment.[1] An element of this changing environment is tighter bank regulation and supervision. Following the global financial crisis, banks are subject to increased capital requirements (Basel III) and supervisory banks' stress tests. Banks can fulfill these stricter requirements in several ways. Next to increasing regulatory capital, banks can shrink their risk-weighted assets by cutting lending, possibly inducing negative real effects (e.g., Hanson, Kashyap, and Stein, 2011; Gropp et al., 2018). Banks may also save on required regulatory capital by requiring loans to be collateralized as such loans carry lower risk weights. In this paper, we document a novel channel through which banks adjust in the face of tighter capital requirements: banks modify their lending technology and turn more to collateralized lending, in particular for their transactional borrowers.

Requiring collateral is common in credit markets, especially in situations with severe asymmetric information.[2] However, collateral is costly to use, and the availability of collateral remains a key challenge. Building relationships and screening borrowers is another way to mitigate asymmetric information. Learning about borrowers allows banks to weed out bad projects over time and overcome adverse selection.[3] Therefore, it is plausible that banks may

1. Policy makers have recently addressed this issue at the highest level around 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. See: http://www.oecd.org/cfe/smes/financing-small-business-key-to-economic-recovery.htm.

2. For theories on the usage of collateral in asymmetric information environments, see, e.g., Bester (1985), Boot and Thakor (1994), Besanko and Thakor (1987), Manove, Padilla and Pagano (2001), Inderst and Muller (2007), and Karapetyan and Stacescu (2018).

3. See, Boot (2000) for a review on the role of relationship banking in resolving problems of asymmetric information, and Liberti and Petersen (2017) on soft information in lending.

require less collateral from relationship borrowers, and shield these borrowers from the consequences of tighter capital requirements. In this paper we address this question: do building relationships aid in overcoming collateral constraints stemming from stricter capital requirements?

To answer this question, we use a loan-level data set covering all loans granted by banks to firms in Portugal and containing firm-bank relationship information. We exploit a regulatory increase in bank capital requirements and study the outcome of that increase on banks' granting of collateralized and uncollateralized loans towards relationship and transactional borrowers. Capital requirements represent a shock to the banks' choice of lending technology. This is so, because granting an uncollateralized loan requires more (regulatory) capital compared to a collateralized loan. Appendix B, on risk weights, provides the institutional details lending credence to this claim.

Empirically, it is challenging to identify the effect of increased capital requirements on banks' lending behavior. Changes in capital requirements may be rare, endogenous to overall economic conditions, and applied to all banks at the same time. To overcome these concerns, we use the European Banking Authority's (EBA) capital exercise as our key identification strategy (see also Gropp et al., 2018 and Blattner et al., 2018 who exploit the same quasi-natural experiment to study other questions). In October 2011, the EBA unexpectedly announced that a subset of European banks (including Portuguese ones) had to meet substantially higher capital ratios by June 2012. There were two main components of the capital exercise. First, banks were required to hold a new, exceptional and temporary capital buffer against their holdings of sovereign bonds. Second, banks were instructed to increase their core tier 1 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. When faced with a sudden rise in capital requirements, banks have a stronger incentive to decrease the ratio between the risk-weighted assets and total total assets i.e. reduce the critical average risk weight of assets on the balance sheet. One possible way to achieve this is to require more collateral from borrowers. In the *Standardized* method, such exposures would receive preferential risk weights while in the *Internal Ratings Based* method this would imply a reduction of LGDs. In particular, the exercise increased the relative cost of uncollateralized lending for treated banks (those that had binding capital constraints) but not for control banks (those that did not have binding capital constraints), allowing us to answer our research question in a difference-in-differences(-in-differences) setting. The hypothesis we test is: *affected banks will increase collateral requirements after the shock compared to control banks, but they will do so less for relationship borrowers.*

Our main findings are as follows. First, treated banks are more likely to ask for collateral (relative to control banks) from the same firm in the aftermath of the EBA Capital Exercise, but less so for relationship borrowers. The observed effect is economically large: while treated banks increase collateral requirements by about 6 to 10 percent, they do so less for relationship borrowers. In particular, in our triple-difference specifications we show that a borrower with a one-standard-deviation higher relationship length with her lender, would be 40 to 50 percent less likely to have the new loan collateralized from the same (treated) bank compared to transactional borrowers. Second, using a quadruple difference setup, we further identify a collateral composition effect. In particular, after the EBA capital exercise, treated banks are more likely to ask for *collateral with lower risk-weights* from the same firm (relative to the control banks) but again less so for relationship borrowers. Third, the EBA exercise included the largest banks in terms of their market shares by total assets in each member state. Therefore, affected and unaffected banks differ in size in any given country. To overcome this size difference, we make a matched control group of similar sized banks and note that Portugal is home to some important foreign banks. If anything, we find that our main results are slightly stronger. Fourth, we exploit the *intensity of treatment* as not all banks were required to increase their capital requirements to the same degree. We find that more intensively treated banks are more likely to ask for collateral, but less so for relationship borrowers. Finally, a potential concern is that Portugal has been subject to other events such as the sovereign crisis and banks solvency support under the Economic and Financial Assistance Program. We mitigate these possible confounding factors by employing short windows around the EBA capital exercise where confounding factors did not take place, and providing falsification tests.

Our paper contributes to the literature on relationship banking and collateral pledging in normal and stress periods.[4] There is an extant empirical literature on how *ex ante* information asymmetries and observed risk impact the incidence of pledging collateral (e.g., Berger et al., 2011 and references therein). Berger, Frame and Ioannidou (2011) employ a nice institutional setting to disentangle *ex ante* and *ex post* frictions and show that unobservably safer borrowers start with collateralized loan contracts (which provides support for *ex ante* collateral theory), while enjoying more and more unsecured credit by proving their good quality in later stages. More recent studies have focused on the global financial crisis and the bank's role in overcoming frictions (e.g., Banerjee et al., 2017, Chodorow-Reich, 2014, Iyer et al., 2014; Ongena et al., 2015; Bolton et al., 2016; Cingano et al., 2016; Beck et al., 2018). Rather than focusing on access to funding and the role of banks' heterogeneity, we here focus on access to *unsecured* funding, and how relationships affect such access after a shock to their banks' capital requirements. 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 to 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. (2018) study the impact of higher capital requirements in the EBA capital exercise and show that banks reach a higher capital ratio by reducing their credit supply (rather than raising new equity). Analyzing increased capital requirements in Norway, Juelsrud and Wold (2018) use banks' financial statements to show that low capitalized banks decrease credit growth to firms but not to households, eventually reducing credit growth

4. For a review, see Boot, 2000; Degryse, Kim and Ongena, 2009; Kysucky and Norden, 2016, among others.

at the firm-level.[5] Instead, we focus on the collateral requirements of a new credit at the loan level *conditional on a new loan being granted*. Thus, our study shows, that apart from increasing equity or decreasing credit, banks can use a third channel to meet increased regulatory capital requirements: exploiting variation in risk weights. To the best of our knowledge this channel has previously not been documented.

The rest of the paper is organized as follows: Section 2 provides details on the EBA capital exercise and formulates our hypotheses. Section 3 describes the data and the methodology used to construct some of our key variables for the analysis. Section 4 presents the empirical analysis of the impact of the EBA capital exercise. Section 5 presents several robustness checks. Section 6 concludes.

2. The EBA Capital Exercise

2.1. *The Event*

On October 26, 2011 the European Banking Authority (EBA) announced that major European banks would have to strengthen their regulatory capital positions. First, banks were required to hold a new, exceptional and temporary capital buffer to cover risks linked to their holdings of 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 buffer against the sovereign exposure would be based on the market prices of repective sovereign bonds, as of the 30th of September.

5. A number of other studies have analyzed the credit supply implications of increased capital requirements or increased cost of equity. See Fraisse et al. (2015), Aiyar et al.(2014), Célérier et al. (2016) among others.

The announcement in October 2011 came largely as a surprise. The EBA had just conducted stress tests in July 2011, and had already released detailed information on the exposure of European banks to sovereign risk (Mésonnier and Monks, 2015; Gropp et al., 2018). Gropp et al. (2018) argue that the credibility of the June stress tests were doubtful. Only nine out of the sixteen groups which narrowly passed the test were finally included in the capital exercise. In addition, the level of the new required core tier 1 capital ratio was substantially higher than the one planned under the transition to Basel III, and was not explicitly 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 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, and the risk-weighted capital requirements were met, at least to a significant extent, by shrinking the asset side (Acharya et al., 2018).[6]

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 issued a press release identifying twenty seven banks as having an aggregate capital shortfall of 76 billion euros. These banks 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.

The EBA exercise was applied in each EU member state, using a country-specific selection rule. It included the largest banks in terms of their market shares by total assets in each country. In descending order of size, the marginal affected bank would be such that at least 50 percent of the national banking sector in the respective country would be covered. Therefore affected and unaffected banks will eventually differ in size.[7]

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6. For details, see Mésonnier and Monks (2015).

7. We address this issue later in the empirical section. However, we find little difference across the two groups, with respect to other observable bank characteristics, like liquidity and solvency ratios, sovereign exposures, profitability, and loans and deposits as a fraction of total assets.

In the Portuguese context, owing to the presence of many small firms, the banking system is one of the most important sources of credit. There are about 180 credit granting institutions in Portugal which can be grouped into 33 banking groups. The largest 8 banking groups account for about 82 percent of loans, to non-financial corporations, varying marginally from year to year. Four out of the eight biggest banking groups were required to increase their capital ratios in the EBA capital 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. Gropp et al. (2018) argue that exposed banks aimed to comply with the higher capital ratios without raising costly new capital.[8]

2.2. Hypotheses

We formulate two hypotheses related to the quasi-natural experiment induced by the EBA capital exercise. Our first hypothesis relates the impact of the EBA capital exercise on the granting of collateralized loans for relationship versus transactional borrowers at treated and control banks. We formulate our hypothesis based on the impact the quasi-natural experiment has on banks' relative cost of extending collateralized versus unsecured loans. In general, 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 capital than unsecured exposures. This observation is key, since it then makes extending collateral-based loans cheaper relative to screening-based loans, to the extent that equity is costlier for the banks than debt. It will therefore increase banks' incentive to require collateral on a new loan.

To see why this is so, note first that in the standardized approach (the system used by the majority of Portuguese banks) secured exposures receive a

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

preferential risk weight. For instance, exposures secured by immovable property, such as residential real estate and commercial immovable property, benefit from preferential risk-weights (see Directive 2006/48/EC (the original CRD)). Furthermore, in the internal ratings-based approach a lower probability of default and loss-given default can be assigned to collateralized loans.[9]

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 collateralized loans rather than uncollateralized ones for those banks who were identified to have a shortfall and must increase capital ratios - the *treated banks*, (denoted by $dummy_{ebabank}$). Furthermore, as the use of screening is less costly for relationship borrowers, we hypothesize that the increase in collateral requirements, after the capital exercise, will take place by treated banks, but only to a muted extent for the relationship borrowers. This leads us to our first hypothesis (H1):

H1: *Following the capital exercise, the loans granted by treated banks are more likely to be collateralized than those by the control banks, but less so for relationship borrowers.*

In our empirical work, we employ two measures of relationship strength; elapsed *relationship length* from first interaction (in natural logarithm of months) and the number of loan interactions with a bank up to the point of the new loan origination (*Cum. Relationship* (in natural logs)). In the specifications, our focus is on the differential effect of the EBA exercise for the use of collateral for *relationship versus transactional* borrowers:

Formally, we test:

$$\begin{gathered}
y_{i,j,k,t} = \alpha + \beta * relationship\ length_{i,j} + \delta * relationship\ length_{i,j} * Dummy_{ebabank} * Post + \\
\delta_1 * relationship\ length_{i,j} * Dummy_{ebabank} + \delta_2 * Dummy_{ebabank} * Post + \\
\delta_3 * relationship\ length_{i,j} * Post + \theta * x_{i,k,t} + \gamma * f_{i,t} + \eta * b_{j,t} + \lambda_j + \varepsilon_{i,j,k,t}
\end{gathered} \tag{1}$$

9. Further details of the impact of collateralization on risk-weights are described in Appendix B.

and:

$$y_{i,j,k,t} = \alpha + \beta * Cum.\ relationship_{i,j} + \delta * Cum.\ relationship_{i,j} * Dummy_{ebabank} * Post+$$
$$\delta_1 * Cum.\ relationship_{i,j} * Dummy_{ebabank} + \delta_2 * Dummy_{ebabank} * Post+$$
$$\delta_3 * Cum.relationship_{i,j} * Post + \theta * x_{i,k,t} + \gamma f_{i,t} + \eta * b_{j,t} + \lambda_j + \varepsilon_{i,j,k,t} \tag{2}$$

where $y_{i,j,k,t}$ is the collateral dummy in loan k granted by bank j to firm i in month 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 λ_j denotes bank fixed effects. Depending upon the specification, we further include firm or firm*time fixed effects.

Support for H1 would be reflected in a positive coefficient for $dummy_{ebabank} * Post$ interaction in both equations, and a negative coefficient for $relationship\ length_{i,j} * Dummy_{ebabank} * Post$ and $Cum.relationship_{i,j} * Dummy_{ebabank} * Post$ triple interactions, in equation 1 and 2 respectively.

Our second hypothesis focuses on the set of collateralized loans and investigates heterogeneity within the collateral pledged. In particular, some types of collateral lead loans to carry lower risk weights than other types of collateral. For example, real estate and guarantees provided by financial institutions or governments carry much lower risk weights than accounts receivables, inventory or guarantees by individuals and firms. We therefore hypothesize that treated banks are more likely to grant loans with collateral that lead to loans with low risk weights after the shock than control banks. Furthermore, we hypothesize that this effect is prevalent but less so for relationship borrowers. This leads to our second hypothesis (H2) :

H2: *Following the capital exercise, collateralized loans granted by treated banks are more likely to have 'low-risk-weight collateral' than those by control banks, but less so for relationship borrowers.*

Formally, within the set of collateralized loans, we test the following:

$$z_{i,j,k,t} = \alpha + \beta * relationship\ length_{i,j} + \delta * relationship\ length_{i,j} * Dummy_{ebabank} * Post+$$
$$\delta_1 * relationship\ length_{i,j} * Dummy_{ebabank} + \delta_2 * Dummy_{ebabank} * Post+$$
$$\delta_3 * relationship\ length_{i,j} * Post + \theta * x_{i,k,t} + \gamma * f_{i,t} + \eta * b_{j,t} + \lambda_j + \varepsilon_{i,j,k,t} \tag{3}$$

and:

$$z_{i,k,t} = \alpha + \beta * Cum.\ relationship_{i,j} + \delta * Cum.\ relationship_{i,j} * Dummy_{ebabank} * Post+$$

$$\delta_1 * Cum.\ relationship_{i,j} * Dummy_{ebabank} + \delta_2 * Dummy_{ebabank} * Post+$$

$$\delta_3 * Cum.relationship_{i,j} * Post + \theta * x_{i,k,t} + \gamma f_{i,t} + \eta * b_{j,t} + \lambda_j + \varepsilon_{i,j,k,t} \quad (4)$$

where $z_{i,j,k,t}$ is a dummy for *low risk weight collateral* and is equal to 1 if the collateral securing loan k granted by bank j to firm i in month t induces the loan to carry a 'low risk weights', and zero otherwise. $x_{i,k,t}$ denotes log of the loan volume, $f_{i,t}$ and $b_{j,t}$ denote time-varying firm and bank characteristics, while λ_j denotes bank fixed effects. Depending upon the specification, we further include firm or firm*time fixed effects.

3. 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.[10] Any loan above 50 euros is recorded in the CRC, implying full coverage. Our sample covers the entire population of loans to non-financial firms 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 and the status of outstanding credit (good, overdue etc.). In most of our exercises, we focus on borrowers who have at least two banking relationships. In the robustness section, we conduct additional exercises.

Banks started reporting information on collateral to the CRC in January 2009.[11] Our analysis is based on all newly generated loans during our event window (more details below). We define a new loan being granted (*New loan*

10. The CRC also consists 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, and is often truncated to be equal to the loan if the value of collateral exceeds the

=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 construct two variables to measure a firm's relationship status. Our first main independent variable is the elapsed time (number of months) since the first interaction between a firm and a bank, the *relationship length*. We take advantage of the long time span of the CRC to build bank-firm relationship variables, based on borrowing history, starting from January 2005: this means that for a bank-firm interaction during our sample period in, for instance, 2011, the relationship length is measured using all relationship history from 2005. In our empirical specifications, we use the natural log of relationship length.

The second measure is *cumulative relationship* (or *cum. relationship*) - the relationship strength as proxied by the *frequency of interactions* up to the point of origination of the loan under consideration. Unlike relationship length that measures the time elapsed from first interaction until the current period, the cumulative relationship 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 first interaction. Thus, for any given point in time, the measure shows the cumulative number of interactions since the start. This *active* length may capture better the depth of the information acquired by the bank. As in the *relationship length* measure, this variable is also computed starting in January 2005.

We then combine the CRC database with bank and firm information. Firm characteristics such as size, age, profitability 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 banks' balance sheet items (such as total assets and capital and liquidity ratios) is taken from the

loan amount. Furthermore, the reporting requirements for collateral are not uniform across all financial institutions. Therefore, for our analysis, we will only use the information if a loan is collateralized or not and not the actual value of collateral.

Bank of Portugal's Prudential Database (PD). These statistics are reported monthly.

The summary statistics on new loans are provided in Table 1. The descriptives about the dependent variables and the relationship variables are for borrowers with at least two banking relationships, and hold for our event window running from January 2011 to June 2012. Our purpose is to track collateralization of new loans only. Accordingly, our main 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.[12] Table 1 shows that about 51 percent of all new loans is collateralized. Our second dependent variable *low risk weight collateral* shows that 25 percent of all collateralized loans have collateral inducing loans to carry low risk-weights. The table further shows that the mean *cum. relationship* and *relationship length*, are 14 (interactions) and 53 (months), respectively, with a high variation in the sample.

The bottom part of the table provides summary statistics for the firm specific variables measured before the EBA capital exercise. 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 of firms

12. One potential concern is that lenders can use existing collateral from 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 in the Credit Registry and is broken down into its sources when backed by more than one collateral. 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 reasons. Furthermore, legally, banks can only use the collateral for the specific loan under consideration. In Portugal it is not possible to create a floating charge or floating lien which would automatically extend towards all loans.

with multiple relationships has 2 banking relationships whereas the maximum number of banking relationships is 14.

All variables are defined in Appendix A.

	Mean	Median	SD	Min	Max
Dependent variable					
Collateral dummy	0.51	1.00	0.51	0.00	1.00
Low risk weight collateral	0.25	0.00	0.43	0.00	1.00
Relationship variables (firm-level)					
Relationship length (months)	52.83	54	27.76	1	108
Cumulative relationship	14.42	12.81	9.98	1	92
Firm 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

Table 1. Summary Statistics

Source: Authors' calculations.

We report summary statistics of bank characteristics by bank status just before the EBA Capital exercise in Table 2. As can be seen from the table, the banks in the two groups have comparable observables except for their size. While the banks were comparable in their CT1 capital ratios, treated banks are much larger, and they needed an additional capital buffer to cover for risks associated with sovereign holdings, according to the EBA. The large size divergence is due to the implementation rule of the EBA capital exercise. We address the difference in bank size in the empirical section where we describe the *matched control* group.

4. Results

4.1. Test of H1

In this subsection, we focus on the 2011 to Q2:2012 period, where we use a set of difference-in-difference estimators to quantify the effect of the EBA capital

Bank status	**Assets**	**Liquidity ratio**	**Capital ratio**	**Loan ratio**	**Deposit ratio**
Treated	20.6	0.092	0.077	0.307	0.297
	(8.80)	(0.021)	(0.045)	(0.129)	(0.121)
Control	2.41	0.070	0.079	0.584	0.175
	(4.78)	(0.135)	(0.107)	(0.318)	(0.222)
Matched Control	16.1	0.092	0.108	0.332	0.158
	(8.82)	(0.016)	(0.113)	(0.016)	(0.037)

TABLE 2. **Bank characteristics:** The table shows mean (standard deviation) of bank characteristics by bank status. Assets are in hundreds of million of Euros. All variables are defined in Appendix A.

Source: Authors' calculations.

exercise on treated banks' borrowers. We test the main hypothesis; treated banks are more likely to ask collateral following the EBA capital exercise, but less so for the relationship borrowers. In Table 3, columns 1-4 (5-8) we show the results where we employ *relationship length* (*cum. relationship*) as our relationship strength indicator. In Table 3, we use pre- and post-EBA windows to quantify the diff-in-diff and triple-difference effects. The pre-EBA period each time includes the first 6 months of 2011, i.e., Q1 and Q2 of 2011, preceding the EBA announcement. For the post-EBA capital exercise period, we use different windows of 6 months after the announcement. In columns 1 and 5 we use two quarters immediately following the *start of* the exercise as the *Post* period, that is, Q4:2011 and Q1:2012. In the rest of the table, we allow for a 3-month adjustment after the start of the exercise, i.e., using Q1 and Q2 of 2012 as the *Post* period. 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.

Table 3 shows that the double interaction coefficient on $(Post * Dummy_{ebabank})$ is positive and statistically significant in most specifications (except the one with firm fixed effects standalone): treated banks increase collateral requirements after the EBA capital exercise. The triple interaction instead shows a statistically significant and negative coefficient in all specifications, consistent with H1. The results show qualitatively and quantitatively significant effects. In column 1 and 2, while affected banks increase collateral requirements by 2.8 percentage points $(Dummy_{ebabank} * Post = 0.028)$, which is about 6 percent of unconditional mean, they do so less for relationship borrowers. In particular, a borrower with a one-standard-deviation higher relationship length (standard deviation of log of relationship length is 0.92), would see a significantly lower collateralization increase from treated banks, namely 1.7 percentage points less ($\approx$ 0.028 - 0.012*0.92). This means that relationship borrowers are about 40 percent less likely to face collateralization increases compared to their transactional peers with (one standard deviation) lower relationship length. When we move to the cumulative relationship variable in columns 5-8, the corresponding triple-difference "discount" increases further: in column 6, a borrower with a one standard deviation ($= 0.75$) longer *cum.relationship* would be about 50 percent less likely to face increased collateral requirements compared to a new borrower. We do not go further than June 2012 as some banks of the treated and control group received solvency support after that.

In our empirical model, we assumed that all treated banks received the same treatment intensity. We now repeat our analysis by taking into consideration the magnitude of the treatment the banks were subject to. In particular, we consider the total *shortfalls* that the banks had to cover with respect to both the new CT1 level and the sovereign capital buffer they had to meet. The numbers are public information and are taken directly from the EBA's website. These shortfalls, as a percentage of risk-weighted assets are 2.34, 3.7, 2.36 and 5.48 for BES, BCP, CGD and BPI, respectively. The results of our empirical model where we replace $Dummy_{ebabank}$ by $Shortfall$ are presented in Table 4. As can be seen from the table, we find that the impact of the treatment depends on the treatment intensity. For instance, in terms of the average effect at 3.5 percentage point shortfall, the double coefficient shows an increase of $3.5 \times 0.006 = 0.021$ increase in collateralization for treated banks on average in column 2.

4.2. Test of H2

We now turn to our second hypothesis relating the EBA capital exercise to the type of collateral pledged. Capital regulation specifies that loans carry lower risk weights when they are collateralized with higher quality collateral. Our collateral data contains information about 6 types of collateral: real estate;

	(1) Q4,Q1	(2) Q1,Q2	(3) Q1,Q2	(4) Q1,Q2	(5) Q4,Q1	(6) Q1,Q2	(7) Q1,Q2	(8) Q1,Q2
$RelationshipLength$	-0.026***	-0.025***	-0.027***	-0.031***				
	[0.001]	[0.001]	[0.001]	[0.001]				
$RelationshipLength * Dummy_{ebabank}$	0.019***	0.019***	0.010***	0.011***				
	[0.002]	[0.002]	[0.003]	[0.003]				
$RelationshipLength * Post$	0.010***	0.013***	0.012***	0.012***				
	[0.002]	[0.002]	[0.002]	[0.002]				
$RelationshipLength * Post * Dummy_{ebabank}$	-0.012***	-0.015***	-0.010***	-0.011***				
	[0.003]	[0.003]	[0.003]	[0.003]				
$Post * Dummy_{ebabank}$	0.028***	0.028***	0.013	0.023*	0.036***	0.029***	0.007	0.016
	[0.010]	[0.011]	[0.011]	[0.013]	[0.009]	[0.009]	[0.009]	[0.011]
$Cum.relationship$					-0.055***	-0.054***	-0.059***	-0.063***
					[0.002]	[0.002]	[0.002]	[0.002]
$Cum.relationship * Dummy_{ebabank}$					0.010***	0.009***	0.003	0.015***
					[0.003]	[0.003]	[0.003]	[0.003]
$Cum.relationship * Post$					0.010***	0.012***	0.012***	0.014***
					[0.002]	[0.002]	[0.002]	[0.003]
$Cum.relationship * Post * Dummy_{ebabank}$					-0.017***	-0.019***	-0.009***	-0.013***
					[0.003]	[0.003]	[0.003]	[0.004]
Loan volume	0.134***	0.134***	0.143***	0.143***	0.134***	0.135***	0.143***	0.144***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Firm Time FE	N	N	N	Y	N	N	N	Y
R-squared	0.40	0.40	0.56	0.59	0.40	0.40	0.56	0.59
Number of obs.	570962	541711	540487	564579	570962	541711	540487	564579

TABLE 3. **EBA capital exercise and loan collateralization: relationship versus transactional borrowers.** The dependent variable is *collateral dummy*. *Relationship length* is the elapsed relationship time (measured in log of months) since the first interaction between a bank and a firm. *Cum. relationship* measures the (log of) cumulative number of interactions. $Dummy_{ebabank}$ is a dummy equal to 1 for Portuguese banks that were affected by EBA capital exercise and 0 otherwise. In columns 1-4, our independent variable is *relationship length* whereas columns 5-8 use the *cum. relationship* as the main independent variable. The pre-shock period is Q1 and Q2 of 2011, preceding the announcement of EBA capital exercise. *Post* is an indicator variable which is equal to 1 for quarters after the implementation date. As indicated on the top of the columns, columns 1 and 5 consider the immediate impact of the shock (Q4:2011 and Q1:2012) while the other columns allow for a quarter of adjustment (Q1 and Q2 of 2012). All variables are defined in Appendix A. Standard errors are clustered at the bank level.

Source: Authors' calculations.

financial collateral; guarantees by state or financial institution; movable assets (like machines, cars); other guarantees; personal guarantees by a firm or an individual. Capital regulation puts lower risk weights for the first three types of collateral (BCBS 2006). We therefore create a dummy variable *low risk weight collateral* equal to one when the collateral type is real estate, financial collateral, or guarantees by state or financial institution, and zero otherwise (i.e., when the collateral type is movable assets (like machines, cars), other guarantees, and personal guarantees by a firm or an individual)

The results of estimating equations (3) and (4) using the *low risk weight collateral* dummy as dependent variable are presented in table 5. The sample is

	(1) Q4,Q1	(2) Q1,Q2	(3) Q1,Q2	(4) Q1,Q2	(5) Q4,Q1	(6) Q1,Q2	(7) Q1,Q2	(8) Q1,Q2
$RelationshipLength$	-0.025***	-0.023***	-0.025***	-0.028***				
	[0.001]	[0.001]	[0.001]	[0.001]				
$RelationshipLength * Shortfall$	0.004***	0.003***	0.002***	0.002***				
	[0.001]	[0.001]	[0.001]	[0.001]				
$RelationshipLength * Post$	0.008***	0.010***	0.010***	0.011***				
	[0.002]	[0.002]	[0.002]	[0.002]				
$RelationshipLength * Post * Shortfall$	-0.002***	-0.003***	-0.002***	-0.003***				
	[0.001]	[0.001]	[0.001]	[0.001]				
$Post * Shortfall$	0.004	0.006**	0.002	0.006*	0.006**	0.006**	0.001	0.005
	[0.003]	[0.003]	[0.003]	[0.004]	[0.002]	[0.003]	[0.003]	[0.003]
$Cum.\ relationship$					-0.053***	-0.052***	0.000	-0.049***
					[0.002]	[0.002]	[.]	[0.002]
$Cum.\ relationship * Shortfall$					0.003***	0.002***	0.001	0.002**
					[0.001]	[0.001]	[0.001]	[0.001]
$Cum.\ relationship * Post$					0.006***	0.007***	-0.048***	0.005***
					[0.002]	[0.002]	[0.002]	[0.002]
$Cum.\ relationship * Post * Shortfall$					-0.003***	-0.004***	-0.002**	-0.004***
					[0.001]	[0.001]	[0.001]	[0.001]
$Loan\ volume$	0.134***	0.134***	0.143***	0.144***	0.134***	0.135***	0.143***	0.144***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Firm Time FE	N	N	N	Y	N	N	N	Y
R-squared	0.40	0.40	0.56	0.59	0.40	0.40	0.56	0.59
Number of obs.	570962	541711	540487	536549	570962	541711	540487	536549

TABLE 4. **EBA capital exercise and loan collateralization: intensity of treatment.** The dependent variable is *collateral dummy*. *Relationship length* is the elapsed relationship time (measured in log of months) since the first interaction between a bank and a firm. *Cum. relationship* measures the (log of) cumulative number of interactions. $Shortfall$ is the percentage shortfall of capital (as a fraction of risk-weighted assets) for Portuguese banks that were treated by EBA capital exercise. In columns 1-4, our independent variable is *relationship length* whereas columns 5-8 use the *cum. relationship* as the main independent variable. The pre-shock period is Q1 and Q2 of 2011, preceding the announcement of EBA capital exercise. *Post* is an indicator variable which is equal to 1 for quarters after the implementation date. As indicated on the top of the columns, columns 1 and 5 consider the immediate impact of the shock (Q4:2011 and Q1:2012) while the other columns allow for a quarter of adjustment (Q1 and Q2 of 2012). All variables are defined in Appendix A. Standard errors are clustered at the bank level.

Source: Authors' calculations.

now restricted to collateralized loans only. The structure of the table is similar as before; Columns 1 and 5 take Q4:2011 and Q1:2012 as the post period whereas the other columns employ the first two quarters of 2012 as post period. The first four columns present the results for Equation (3), i.e., *relationship length*, and the last four columns for Equation (4), i.e., *cum. relationship*. The table shows that treated banks were about 25-30 percent more likely to ask 'low risk weight collateral' compared to unaffected banks following the EBA capital exercise. However this effect is muted by about 20 percent for borrowers with a one standard deviation higher relationship measure (for instance in column 1 the total effect is $0.33 - 0.92 * 0.078 \approx 0.26$, and in column 5, it is

$0.25 - 0.75 * 0.078 \approx 0.19$). This result supports H2 as the EBA capital exercise leads to a more intensive pledging of *low risk weight collateral*, but less so for relationship borrowers.[13]

	(1) Q4,Q1	(2) Q1,Q2	(3) Q1,Q2	(4) Q1,Q2	(5) Q4,Q1	(6) Q1,Q2	(7) Q1,Q2	(8) Q1,Q2
$RelationshipLength$	0.018***	0.012***	0.020***	0.020***				
	[0.001]	[0.001]	[0.002]	[0.002]				
$RelationshipLength * Dummy_{ebabank}$	0.016***	0.024***	0.024***	0.027***				
	[0.001]	[0.001]	[0.001]	[0.002]				
$RelationshipLength * Post$	0.044***	0.038***	0.026***	0.028***				
	[0.003]	[0.003]	[0.003]	[0.003]				
$RelationshipLength * Post * Dummy_{ebabank}$	-0.078***	-0.079***	-0.049***	-0.063***				
	[0.005]	[0.003]	[0.004]	[0.005]				
$Post * Dummy_{ebabank}$	0.332***	0.309***	0.190***	0.239***	0.254***	0.231***	0.144***	0.175***
	[0.018]	[0.013]	[0.015]	[0.018]	[0.014]	[0.010]	[0.012]	[0.014]
$Cum.relationship$					-0.015***	-0.020***	-0.004*	-0.002
					[0.001]	[0.002]	[0.002]	[0.002]
$Cum.relationship * Dummy_{ebabank}$					0.022***	0.031***	0.032***	0.035***
					[0.001]	[0.001]	[0.002]	[0.002]
$Cum.relationship * Post$					0.041***	0.035***	0.024***	0.022***
					[0.004]	[0.003]	[0.003]	[0.004]
$Cum.relationship * Post * Dummy_{ebabank}$					-0.075***	-0.076***	-0.049***	-0.060***
					[0.005]	[0.003]	[0.004]	[0.005]
Loan volume	0.025***	0.026***	0.021***	0.020***	0.025***	0.026***	0.021***	0.020***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Firm-time FE	N	N	N	Y	N	N	N	Y
R-squared	0.03	0.03	0.31	0.35	0.03	0.03	0.30	0.35
Number of obs.	346565	329563	326636	320608	346565	329563	326636	320608

TABLE 5. **The EBA capital exercise and collateral type: relationship versus transactional borrowers.** The dependent variable is *low risk weight collateral* taking the value of 1 if collateral type is real estate, a guarantee backed by government or a financial institution or financial collateral, and 0 if the loan is collateralized by other collateral. The sample only includes collateralized loans. $Dummy_{ebabank}$ is a dummy equal to 1 for Portuguese banks that were affected by EBA capital exercise and 0 otherwise. The pre-EBA window is Q1 andQ2 of 2011. As indicated on top of the columns, Columns 1 and 5 use Q4:2011 and Q1:2012 as the treatment period. The other columns use Q1 and Q2 of 2012 as the treatment period. Columns 1-4 (5-8) present results for Equation 3 (4). All variables are defined in Appendix A. Standard errors are clustered at the bank level.

Source: Authors' calculations.

In table 6 we take our analysis one step further by investigating the *treatment intensity* as measured by *Shortfall*. We expect that firms dealing with banks suffering a more intense treatment to require more often *low risk weight collateral* rather than other collateral after the treatment, but less so for relationship borrowers. The results of our empirical model where we

13. We also follow Mayordomo et al. (2018) and group collateral into *real* versus *personal* collateral. We do not find any significance for the double and triple interaction terms in explaining this grouping of collateral. This suggests that risk-weights are the determining factor in our analysis.

replace $Dummy_{ebabank}$ by $Shortfall$ are presented in Table 6. As can be seen from the table, we find that the impact of the treatment depends on the treatment intensity. For instance, in terms of the average effect at 3.5 percentage point shortfall, the double coefficient shows an increase of $3.5 \times 0.055 = 0.192$ percentage point increase in *low risk weight collateral* for treated banks on average in column 3. Again the effect is muted when having longer relationships.

	(1) Q4,Q1	(2) Q1,Q2	(3) Q1,Q2	(4) Q1,Q2	(5) Q4,Q1	(6) Q1,Q2	(7) Q1,Q2	(8) Q1,Q2
$RelationshipLength$	0.020***	0.015***	0.022***	0.022***				
	[0.001]	[0.001]	[0.002]	[0.002]				
$RelationshipLength * Shortfall$	-0.020***	-0.020***	-0.013***	-0.017***				
	[0.001]	[0.001]	[0.001]	[0.001]				
$RelationshipLength * Post$	0.037***	0.030***	0.021***	0.023***				
	[0.003]	[0.002]	[0.003]	[0.003]				
$RelationshipLength * Post * Shortfall$	-0.020***	-0.020***	-0.013***	-0.017***				
	[0.001]	[0.001]	[0.001]	[0.001]				
$Post * Shortfall$	0.090***	0.083***	0.055***	0.068***	0.070***	0.065***	0.044***	0.054***
	[0.005]	[0.004]	[0.004]	[0.005]	[0.004]	[0.003]	[0.003]	[0.004]
$Cum.\ relationship$					-0.012***	-0.015***	0.000	0.002
					[0.001]	[0.002]	[.]	[0.002]
$Cum.\ relationship * Shortfall$					0.005***	0.006***	0.007***	0.008***
					[0.000]	[0.000]	[0.000]	[0.000]
$Cum.\ relationship * Post$					0.033***	0.028***	0.019***	0.018***
					[0.003]	[0.003]	[0.002]	[0.004]
$Cum.\ relationship * Post * Shortfall$					-0.019***	-0.020***	-0.014***	-0.017***
					[0.001]	[0.001]	[0.001]	[0.001]
$Loan\ volume$	0.026***	0.027***	0.021***	0.021***	0.026***	0.027***	0.021***	0.021***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y
Firm FE	N	N	Y	N	N	N	Y	N
Firm Time FE	N	N	N	Y	N	N	N	Y
R-squared	0.03	0.03	0.31	0.35	0.03	0.03	0.31	0.35
Number of obs.	346565	329563	326636	320608	346565	329563	326636	320608

TABLE 6. **EBA capital exercise and collateral type: intensity of treatment.** The dependent variable is *low risk weight collateral* taking the value of 1 if collateral type is real estate, a guarantee backed by government or a financial institution or financial collateral, and 0 if the loan is collateralized by other collateral. The sample only includes collateralized loans. The pre-EBA window is Q1 and Q2 of 2011. As indicated on top of the column, Columns 1 and 5 use Q4:2011 and Q1:2012 as the treatment period. The other columns use Q1 and Q2 of 2012 as the treatment period, allowing for a three month adjustment period. Columns 1-4 (5-8) present results for Equation 3 (4). $Shortfall$: the percentage shortfall of capital (as a fraction of risk-weighted assets) for Portuguese banks that were treated by EBA capital exercise. All variables are defined in Appendix A. Standard errors are clustered at the bank level.

Source: Authors' calculations.

5. Robustness

In the robustness section, we first focus on the validity of the parallel trends assumption. Afterwards, we turn to several robustness tests for each of our hypotheses.

5.1. Validity of the parallel trends assumption

In this subsection 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 in terms of loans' collateral requirements.

A potential concern in the diff-in-diff analysis is that the underlying assumption of parallel trends does not hold: absent our capital exercise, 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 run up to the event period.

Yet, this exercise is challenging due to the volatile markets before 2011. Until late 2009 and early 2010, the sustainability of the Portuguese sovereign debt was not perceived as a concern for the markets.[14] 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 afterward, investors began to be concerned about the solvency and liquidity of the public debt issued by the troubled countries, including Portugal. The higher sovereign risk since early 2010 in the Euro area 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 had 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

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

sovereign are quite closely linked.[15] Uncertain economic conditions eventually also affected firm risk. Banks may demand higher returns when lending to them as a compensation for holding additional risk. This mechanism - the *firm risk channel* - has been shown to be quite important quantitatively (Bocola, 2016).[16] A decline in the repayment probability can then increase banks' required compensation, in form of higher collateral requirements and higher interest rates.[17] In line with findings from other countries (see for instance Gropp et al., 2018; Juelsrud and Wold, 2018), the overall lending did decrease during the period.

In table 7, we analyze the rate of loan collateralization by all banks in *non-EBA* periods during 2009-2010, i.e., covering windows before the EBA capital exercise. In Table 7 we show that there is no change in the use of collateral by treatment versus control banks in our pre-event period. To conserve space, we only report the coefficients for the doubIe and triple interaction terms of interest. In columns 1-3, pre-EBA periods are analyzed for the *relationship length* measure. Column 1 and 2, show the results for the window around end of 2009 (*Post9* is a dummy variable that takes value 1 for periods after year 2009, and 0 before end of 2009) and mid 2009 (*Postmid9* is a dummy variable that takes value 1 for periods after Q2 2009, and 0 otherwise), respectively. Column 3 uses *postmid10* as the indicator variable which takes a value of 1 from July 2010 and 0 earlier. As the double coefficients in the table confirm, treated banks did not increase collateral requirements (if anything, they in fact somewhat decreased it albeit this is mostly statistically insignificant). At the same time, the triple coefficients confirm that there was no differential treatment

15. 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 interlinkages between banks and sovereigns.

16. 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.

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

for relationship borrowers by treated banks compared to the control banks. The last 3 columns use the cumulative relationship length as the relationship variable instead of the relationship length. Again we observe that the triple interaction terms are not significant. Two of the double interactions terms are marginally statistically significant but negative. All in all, in the absence of treatment during the period leading to the EBA, we find no difference between treatment and control group in the outcome.

	[1] Post9	[2] Postmid9	[3] Post10	[4] Post9	[5] Postmid9	[6] Post10
$Post * Dummy_{ebabank}$	-0.004	-0.064	-0.044	-0.011	-0.115*	-0.052*
	[0.021]	[0.040]	[0.023]	[0.038]	[0.066]	[0.030]
$RelationshipLength * Post * Dummy_{ebabank}$	-0.000	-0.000	0.000			
	[0.000]	[0.001]	[0.000]			
			[0.000]			
$Cum.relationship * Post * Dummy_{ebabank}$				0.001	0.018	0.006
				[0.008]	[0.012]	[0.009]
R-squared	0.42	0.42	0.43	0.42	0.72	0.43
Number of obs.	563549	570495	539272	563549	570495	539272

TABLE 7. **Falsification** The dependent variable is *collateral dummy*. The *Post* indicator employed in each specification is shown on top of the column. Columns 1 and 4 use as pre window Q3 and Q4 of 2009, whereas the post window is Q1 and Q2 2010 (denoted as Post9). Columns 2 and 5 use as pre window Q1 and Q2 of 2009 and postmid9 is 1 for Q3 and Q4 of 2009. Columns 3 and 6 use Q1 and Q2 of 2010 as the pre window and postmid10 is equal to 1 for Q3 and Q4 of 2010. Columns 1-3 (4-6) use *relationshiplength* (*cum.relationship*) as a proxy for relationship strength. All variables are defined in Appendix A. Standard errors are clustered at the bank level.

Source: Authors' calculations.

5.2. Robustness tests

To study the robustness of our results, we consider a number of specifications related to firm and bank cohorts, and the definition of the main right-hand side variables. We present robustness regarding our findings related to both hypotheses.

We start with robustness exercises related to our first hypothesis on the likelihood of collateral being pledged. First, in columns 1-4 of Table 8, we drop foreign subsidiaries of our dataset. We do so, because the EBA capital exercise was conducted at the consolidated level, and so the effect on a subsidiary may not be comparable to the one on the consolidated balance sheet of a Portuguese bank. Our results continue to hold qualitatively, and are slightly larger in magnitude: across all specifications in columns 1 to 4, we see that treated banks increase collateral by over 4 to 4.5 percentage points (9 percent of the unconditional mean) more after the treatment for their transactional borrowers. At the same time, a borrower with a one standard deviation higher measure of relationship length (or cumulative relationship length), is 40 percent less likely to experience the increase in collateral requirements (the standard deviation of the two measures in log are 0.92 and 0.75).

Second, 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 the unobservable factors that change differently for large and small banks), we create a *matched control* sample of banks containing the other 4 large banks in Portugal. This is also possible because there are foreign banks operating in Portugal and there is a non-trivial overlap in bank size. The descriptives of the *matched control* banks are shown in Table 2. We learn that after matching, *treated* and *matched control* banks are much more comparable in terms of asset size. The results using only the new loans granted by the treated and matched control banks are reported in columns 5-8 of table 8. When restricting our sample of control firms dealing with banks from this matched control group, we find that results are similar (if anything slightly larger) as in our main analysis. This confirms the validity of our results, for both relationship measures.

Thus far, we have focused only on firms with multiple lending relationships. In columns 9 and 10 we use all firms, including firms with single-bank relationships. Since for these firms, firm level fixed effects is not possible to use, we follow Degryse et al. (2018), and employ industry-location-size clusters to control for firm demand. In particular, we create bins based on a 2-digit industry classification (77), 22 districts, and 4 size bins (micro, small, medium and large). This gives us 2100 non-empty ILS bins. Columns 9 and 10 confirm that the results continue to hold qualitatively. While the double coefficient effect is somewhat smaller, the effect on relationship borrowers remains quantitatively robust too.

	(1) no foreign	(2) no foreign	(3) no foreign	(4) no foreign	(5) matched	(6) matched	(7) matched	(8) matched	(9) all	(10) all
RelationshipLength	-0.033***	-0.039***			-0.069***	-0.037***			-0.028***	
	[0.001]	[0.002]			[0.002]	[0.003]			[0.001]	
$RelationshipLength * Dummy_{ebabank}$	0.023***	0.010***			0.035***	0.013***			0.032***	
	[0.003]	[0.003]			[0.003]	[0.004]			[0.002]	
$RelationshipLength * Post$	0.016***	0.019***			0.046***	0.022***			0.014***	
	[0.002]	[0.003]			[0.002]	[0.003]			[0.002]	
$RelationshipLength * Post * Dummy_{ebabank}$	-0.019***	-0.021***			-0.049***	-0.023***			-0.014***	
	[0.003]	[0.004]			[0.003]	[0.004]			[0.003]	
$Post * Dummy_{ebabank}$	0.043***	0.046***	0.040***	0.043***	0.075***	0.042**	0.072***	0.019	0.022**	0.021**
	[0.012]	[0.015]	[0.010]	[0.012]	[0.013]	[0.017]	[0.011]	[0.014]	[0.010]	[0.008]
Cum.relationship			-0.059***	-0.068***			-0.091***	-0.065***		-0.059***
$Cum.relationship * Dummy_{ebabank}$			0.008***	0.002			0.022***	0.004		0.018***
			[0.003]	[0.004]			[0.003]	[0.004]		[0.003]
$Cum.relationship * Post$			0.016***	0.022***			0.044***	0.023***		0.013***
			[0.002]	[0.003]			[0.003]	[0.004]		[0.002]
$Cum.relationship * Post * Dummy_{ebabank}$			-0.022***	-0.026***			-0.051***	-0.021***		-0.016***
			[0.003]	[0.004]			[0.004]	[0.005]		[0.003]
Loan volume	0.143***	0.152***	0.143***	0.152***	0.134***	0.144***	0.135***	0.144***	0.140***	0.141***
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y		
Firm FE	Y	N	Y	N	Y	N	Y	N	N	N
Firm-time FE	N	Y	N	Y	N	Y	N	Y	N	N
ILS FE	N	N	N	N	N	N	N	N	Y	Y
R-squared	0.41	0.61	0.41	0.61	0.72	0.62	0.72	0.62	0.43	0.43
Number of obs.	491197	485342	491197	485342	431336	424561	431336	424561	700947	700947

TABLE 8. **EBA capital exercise and loan collateralization: Robustness.** The dependent variable is the *collateral dummy*. As indicated on the top of the columns, columns 1 to 4 drop all foreign subsidiaries, while columns 5-8 keep only large banks in the control group. Columns 9 and 10 use all firms, including those with single-bank relationships. ILS stands for industry-location-size fixed effects. All variables are defined in Appendix A. Standard errors are clustered at the bank level.

Source: Authors' calculations.

Finally, we perform similar robustness tests regarding our second hypothesis regarding the usage of *low risk weight collateral*. Our dependent variable is now *low risk weight collateral* as in Table 6 and the sample covers only collateralized loans. Table 9 shows the results. The first four columns again exclude the foreign banks in our control group. Independent of our relationship strength variable employed, we note that the coefficient on the double interaction term $Post * Dummy_{ebabank}$ is positive. It indicates that treated banks are around 30 percentage points more likely to ask for *low risk weight collateral* after the treatment to their transactional borrrowers compared to control banks. The triple interaction coefficients with *RelationshipLength* and *Cum.Relationship* are negative showing that this increase applies less for firms with stronger relationships. Columns 5 to 8 control for similar matched control banks and we learn that the magnitudes are somewhat larger. Finally, columns

9 and 10 show that our main findings are robust to the inclusion of single-relationship firms, while controlling for industry-location-size fixed effects.[18]

	(1) no foreign	(2) no foreign	(3) no foreign	(4) no foreign	(5) matched	(6) matched	(7) matched	(8) matched	(9) all	(10) all
RelationshipLength	-0.035***	-0.028***			0.073***	0.084***			0.010***	
	[0.001]	[0.002]			[0.002]	[0.003]			[0.001]	
$RelationshipLength * Dummy_{ebabank}$	0.053***	0.059***			0.037***	0.043***			0.025***	
	[0.001]	[0.001]			[0.001]	[0.002]			[0.001]	
$RelationshipLength * Post$	0.036***	0.023***			0.122***	0.112***			0.045***	
	[0.003]	[0.004]			[0.004]	[0.006]			[0.002]	
$RelationshipLength * Post * Dummy_{ebabank}$	-0.088***	-0.071***			-0.170***	-0.160***			-0.091***	
	[0.003]	[0.005]			[0.004]	[0.007]			[0.003]	
$Post * Dummy_{ebabank}$	0.335***	0.268***	0.371***	0.327***	0.693***	0.643***	0.434***	0.384***	0.361***	0.252***
	[0.013]	[0.018]	[0.010]	[0.014]	[0.017]	[0.025]	[0.013]	[0.020]	[0.012]	[0.009]
Cum.relationship			-0.064***	-0.048***			0.041***	0.053***		-0.033***
			[0.002]	[0.002]			[0.002]	[0.004]		[0.002]
$Cum.relationship * Dummy_{ebabank}$			0.064***	0.072***			0.049***	0.057***		0.035***
			[0.001]	[0.002]			[0.002]	[0.002]		[0.001]
$Cum.relationship * Post$			0.057***	0.041***			0.096***	0.092***		0.043***
			[0.003]	[0.004]			[0.004]	[0.007]		[0.003]
$Cum.relationship * Post * Dummy_{ebabank}$			-0.121***	-0.108***			-0.137***	-0.125***		-0.082***
			[0.003]	[0.005]			[0.005]	[0.007]		[0.003]
Loan volume	0.023***	0.018***	0.023***	0.018***	0.023***	0.015***	0.026***	0.015***	0.028***	0.029***
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Bank FE	Y	Y	Y	Y	Y	Y	Y	Y		
Firm FE	Y	N	Y	N	Y	N	Y	N	N	N
Firm-time FE	N	Y	N	Y	N	Y	N	Y	N	N
ILS FE	N	N	N	N	N	N	N	N	Y	Y
R-squared	0.08	0.35	0.07	0.35	0.32	0.37	0.31	0.37	0.06	0.05
Number of obs.	316011	307208	316011	307208	255089	245375	255089	245375	421642	421642

Table 9. **EBA capital exercise and low risk weight collateral: Robustness.** This table uses all loans that are collateralized. The dependent variable is the *low risk weight collateral* dummy. As indicated on top of the column, columns 1 to 4 drop all foreign subsidiaries, while columns 5-8 keep only large banks in the control group. Columns 9 and 10 use all firms, including those with single-bank relationships. ILS stands for industry-location-size fixed effects. All variables are defined in Appendix A. Standard errors are clustered at the bank level.

Source: Authors' calculations.

6. Conclusion

Banks possess several technologies to reduce asymmetric information problems. Collateral is one of them. It is an essential feature in debt contracts but is costly for banks and borrowers. Information acquired during lending relationships is another way to reduce asymmetric information problems in credit markets. We exploit a quasi-natural experiment that changed the relative cost of extending collateralized loans compared to uncollateralized ones. In particular, in October 2011 the European Banking Authority imposed stricter capital requirements on some major European banking groups as a result of risks linked to their

18. In unreported regressions, we have also studied the role of securitization. During our sample period only about 3.32% of loans (by value) were securitized. Our results are robust to the exclusion of these exposures.

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 withheld against them. Using detailed loan-level data and a difference-in-difference-in-differences approach, we find that treated banks in general are 3-5 percentage points (6-10 percent) more likely to require collateral. However, for high-relationship borrowers (those with one standard-deviation higher relationship length) the treated banks' increase in required collateralization is reduced by about 40 percent. Furthermore, following the quasi-natural experiment, treated banks were requiring more often collateral that saves more on regulatory capital than control banks, but less so for relationship borrowers.

Banks have several margins to adjust to higher capital requirements. Next to raising new capital or cutting lending, our paper documents a novel channel of higher capital requirements. In particular, banks change the composition of lending towards collateralized loans. This effect is muted for relationship borrowers. For borrowers that have insufficient supply of collateral, this suggests an increased access to credit when having strong relationships. In sum, we show that relationship banking is an empirically important driver of collateral decisions also in environments with stricter capital requirements.

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Appendix A: Variable Definition

Variable	Source	Description
Collateral Dummy	CRC	A dummy that takes a value of 1 if collateral is pledged, on a new loan, within a firm-bank pair in a given month & 0 otherwise.
Low risk weight collateral	CRC	A dummy equal to 1 if loan is collateralized by real estate, a guarantee backed by government or a financial institution, or financial collateral, and 0 if other type of collateral is pledged within a firm-bank pair in a given month.
Relationship Length	CRC starting 2005	Number of months since first loan with bank. Raw data in descriptives table. Ln in the regressions.
Cumulative Relationship	CRC starting 2005	Number of times a new loan has been granted up to loan origination. Raw data in descriptives table. Ln (1+) in the regressions.
Loan volume	CRC	Log of outstanding credit in a firm-bank pair in a given month.
Max. banking relationships	Constructed using CRC 2005-2013	Maximum number of banks a firm has had a relationship with
Firm age	IES	Number of years since creation of the firm
Firm num. of employees	IES	Number of employees on a firm's payroll during the given year.
Firm assets	IES	firm's total assets (in thousand Euro's) during the given year.
Bank total assets	PD	Total assets of the bank reported at monthly frequency
Bank liquidity ratio	PD	Cash and short-term securities (less than 1Y) normalized by total assets.
Bank capital ratio	PD	Tier-1 core capital divided by risk-weighted assets.
Bank loan ratio	PD	Loans divided by total assets.
Bank deposit ratio	PD	Deposits divided by total assets.

Appendix B: Risk-weights

During our sample period the prudential requirements applied to credit institutions were defined by the Directive 2006/48/EC (the original CRD) with the changes introduced by the Directive 2009/111/EC (CRD II) and Directive 2010/76/EU (CRD III). In Portugal, the prudential rules of credit risk were published in the Notice No. 5/2007 of the Bank of Portugal (Aviso do Banco de Portugal, numero 5/2007). Most banks in Portugal use the Standardized approach. Under this approach, exposures or any part of an exposure fully and completely secured, to the satisfaction of the competent authorities, by mortgages on residential property which is or shall be occupied or let by the owner, or the beneficial owner in the case of personal investment companies, shall be assigned a risk weight of 35%.

In the case of exposures secured by mortgages on offices or other commercial premises situated within their territory may be assigned a risk weight of 50%. The 50% risk weight shall be assigned to the Part of the loan that does not exceed a limit calculated according to either of the following conditions: (a) 50% of the market value of the property in question; (b) 50% of the market value of the property or 60% of the mortgage lending value, whichever is lower, in those Member States that have laid down rigorous criteria for the assessment of the mortgage lending value in statutory or regulatory provisions. A 100% risk weight shall be assigned to the remaining part of the loan. The same principle applies to guarantees as well. As per article 113 of the Directive 2006/48/EC, asset items constituting claims carrying the explicit guarantees of central governments, central banks, international organizations, multilateral development banks or public sector entities, where unsecured claims on the entity providing the guarantee would be assigned a 0% risk weight.

Under the IRB approach, the institutions have to estimate the PDs and sometimes also the LGD, when authorized to use the advanced IRB approach. In the case of advanced IRB approach, the LGD estimates will depend mostly on the evolution of the market value of the property. However, it is clear that the existence of collateral (assuming that the guarantee fulfills all the conditions required by relevant authorities to be accepted as an eligible form of credit risk mitigation) will imply a reduction of the LGD. The detailed procedure for the calculation of PDs and LDs can be consulted in the Directive 2006/48/EC.

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