Bank Response To Higher Capital Requirements: Evidence From A Natural Experiment

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ABSTRACT

This paper studies the effect of higher capital requirements on banks' balance sheet adjustments and the transmission of this effect to the real economy. The paper uses the 2011 EBA capital exercise as a natural experiment. We exploit exogenous variation in the EBA bank selection rule and use a difference-in-difference matching estimator to identify the effect of higher capital requirements. First, we document that EBA banks increased their regulatory capital ratio by 1.9 percentage points more than otherwise similar banks not subject to higher capital requirements. EBA banks did not achieve this by increasing their levels of equity, but primarily by reducing credit supply. Finally, we show that in the short run this reduction in credit supply by EBA banks resulted in a reduction in firm-, investment- and sales growth for firms which obtain a larger share of their bank credit from EBA banks.

JEL classification: G21, G28, G38, E44

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In the wake of the financial crisis Basel III increased capital requirements significantly. The higher capital requirements will become fully effective in 2019. However, at this point the economic implications of such higher capital requirements are unclear. Banks can meet higher capital requirements through a number of different measures. For example, banks can increase equity by retaining more of their profits. They may also issue fresh equity. Rather than increasing their equity, they may also reduce risk-weighted assets, the denominator of the capital ratio (Admati, DeMarzo, Hellwig, and Pfleiderer, 2010). However, asset shrinkage has potentially adverse effects on the real economy if a large fraction of financial institutions simultaneously decides to shrink its assets (Hanson, Kashyap, and Stein, 2011). How banks adjust their balance sheets in response to higher capital requirements is thus an empirical question of crucial importance for understanding the real implications of the higher capital requirements imposed recently under Basel III.

The empirical identification of the effect of higher capital requirements on banks behavior faces a number of challenges. The most important challenge is to find exogenous variation in capital requirements. Capital requirements tend to vary little over time. When they do change, they change for all banks in a given economic area at the same time, leaving no cross-sectional variation to exploit. In the case when supervisors make use of discretion and impose bank-specific requirements, they will be correlated with bank characteristics and thus not exogenous with regard to banks balance sheets. Finally, in order to assess the effects of capital requirements on bank lending, one needs to disentangle credit supply and credit demand.

We address these empirical challenges by exploiting the 2011 capital exercise conducted by the European Banking Authority (EBA) as a natural experiment. The capital exercise required a subset of European banks to reach and maintain a 9 percent core tier 1 capital ratio by the end of June 2012.[1] The institutional features of the capital exercise are particularly well-suited to address the above mentioned empirical challenges. First, the required core tier 1 ratio of 9 percent constituted an economically significant increase in capital requirements compared to the previously required 5 percent. Second, since the capital exercise came largely unexpected only a few months after

[1]The core tier 1 ratio is defined as a bank's core tier 1 capital over a bank's risk-weighted assets, whereas core tier 1 capital comprises only the highest quality capital instruments (common equity), disclosed reserves and hybrid instruments provided by governments (EBA, 2011b)

the 2011 EBA stress test in June, banks are unlikely to have taken preemptive measures.[2] Most importantly, the country-specific bank selection rule allows disentangling the effect of capital requirements from effects associated with bank size. The EBA used a country-specific selection rule and included banks "in descending order of their market shares by total assets in each Member State" such that the exercise covered "50% of the national banking sectors in each EU Member State" (EBA, 2011a).[3] Since national banking sectors in Europe differ with regard to their total size, the country-specific selection threshold yields a considerable overlap in size between banks participating and not participating in the capital exercise. Moreover, as the EBA included banks according to an explicit selection rule based on bank size, selection into the capital exercise was based on observable characteristics. We exploit this exogenous variation in the selection rule and use a difference-in-difference matching estimation approach to examine how banks subject to higher capital requirements adjusted their balance sheets compared to otherwise similar banks not subject to a change in capital requirements.

The main findings are as follows. First, this paper documents that EBA banks[4] raised their core tier 1 capital ratios by 1.9 percentage points compared to banks not subject to higher capital requirements. The paper shows that EBA banks achieved this by reducing their levels of risk-weighted assets by 16 percentage points relative to the matched control group, rather than by increasing their levels of capital. The control group is crucial for uncovering this finding: EBA banks did increase their levels of core tier 1 capital by 21 percentage points, but similar large European banks in the control group raised their levels of core tier 1 capital by the same magnitude. Banks can reduce risk-weighted assets in two different ways: They can either shift from riskier assets into safer assets while keeping total asset size constant (risk reduction), or they can reduce total asset size while keeping the average asset risk constant (asset shrinking). The paper shows that the relative reduction of risk-weighted assets by EBA banks can mainly be attributed to asset shrinking, rather than risk reduction. We show that the asset shrinking can mainly attributed to a reduction in

[2]The Financial Times (2011) reported after the first announcement of the capital exercise that the 9 percent requirement was "well beyond the current expectations of banks and analysts". The estimated capital buffer of €115 billion was also well above the €2.5 billion estimate of the EBA stress test disclosed five months earlier.

[3]The EBA used the same selection procedure for the banks participating in the EBA stress test in June 2011. Selection was therefore not based on bank-specific events in the months before the capital exercise.

[4]The paper adopts the following terminology: "EBA Banks" are banks participating in the 2011 EBA capital exercise; "Non-EBA banks" are other European banks not participating in the 2011 EBA capital exercise.

outstanding customer loans relative to banks in the matched control group. We further show that the results are driven by banks that were significantly below the 9 percent core tier 1 target ratio in the pre-exercise period.

One concern is that the reduction in outstanding customer loans of EBA banks is driven by a reduction in credit demand, rather than a reduction in credit supply. In order to disentangle credit supply and demand, we use syndicated loan data, and exploit multiple bank-firm relationships to control for credit demand. Specifically, we use a modified version of the Khwaja and Mian (2008) estimator, which estimates the change in outstanding syndicated loans of a bank to country x industry firm clusters (see also Acharya, Eisert, Eufinger, and Hirsch (2016)). In the loan-level analysis part of the paper we show that EBA banks reduced their syndicated loan exposures by 27 percentage points relative to banks in the control group.

Ultimately, the degree to which a reduction in credit supply from EBA banks has real effects depends on the extent to which other banks, not subject to higher capital requirements, pick up the slack. Hence, we investigate how the effect of higher capital requirements on bank lending for the subset of EBA banks affects the growth of firms which obtain a large share of their bank credit form EBA banks. We find that the growth in total assets, investment and sales of firms with a high EBA borrowing share was lower after the EBA capital exercise, which suggests that the EBA capital exercise had negative real effects. As EBA banks cover more than 65 percent of the European banking sector, high switching costs or limited access to other sources of external funding could explain why EBA firms were not able to fully substitute EBA bank credit for other funding.

A number of falsification and placebo tests suggest that our inferences are not confounded by other factors. Banks with sovereign exposures reduced lending in the sovereign debt crisis, but Popov and Van Horen (2014) show that this already started in 2010, one year prior to the capital exercise. Therefore, we conduct a placebo test for the period before the capital exercise (2009-2010) and show that EBA banks and control group banks exhibit a similar evolution in their levels of core tier 1 capital and risk-weighted assets during this placebo period. If the 2010 sovereign debt crisis affected EBA banks differentially, the placebo test should have shown differences between EBA and

control group banks already over this period. One other concern is that there are other contaminating events, such as moral suasion by governments (Becker and Ivashina (2014);Ongena, Popov, and Van Horen (2016)) and the ECB's longer-term refinancing operations (LTRO) (Carpinelli and Crosignani, 2015) which possibly provide alternative explanations for our results. However, Becker and Ivashina (2014) and Van Rixtel and Gasperini (2013) document that in particular banks in Greece, Ireland, Italy, Portugal and Spain (GIIPS) increased their exposures to domestic sovereign debt and made use of the ECB's LTRO program. We therefore test whether our results are driven by banks from these countries, but we do not find evidence for this hypothesis. To rule out that the results are driven unobserved country-specific time-varying effects, we additionally conduct a standard regression analysis including country-year fixed effects, and show that this does not affect our main results.

The primary contribution of this study is to provide empirical evidence on banks' responses to higher capital requirements. The paper is related to the literature examining the effect of capital requirements on bank lending. For example, an early study by (Bernanke and Lown, 1991) developed state-level equations linking bank loan growth to bank capital ratios. Berger and Udell (1994) study the impact of the Basel Accords, but without the benefit of exogenous variation in capital requirements.[5] To date, few papers have sought to alleviate this concern, although Brun, Fraisse, and Thesmar (2013) and Jimenéz, Ongena, Peydró, and Saurina (2013) are important exceptions. Hanson, Kashyap, and Stein (2011) use data for the US and focus on loan rates, rather than quantities. They show in a model-based calibration approach that the long-run steady-state impact on loan rates to households and corporations will be modest. Mésonnier and Monks (2015) also study the impact of the EBA capital exercise but do not study real effects. While most papers in the literature focus on the effect of higher capital requirements on bank lending, our paper investigates in detail the adjustment measures taken by banks on both the asset- and liability side of the balance sheet and the transmission of this effect to the real economy. Most recently, Kisin and Manela (2016) take a complementary tack to this paper and estimate the private cost of capital using a costly loophole, by which banks were able to avoid holding capital before 2008. They find that an

[5] More recent papers are Francis and Osborn (2012), Bridges, Gregory, Nielsen, Pezzini, Radia, and Spaltro (2014) and Berrospide and Edge (2010).

increase in capital requirements by one percentage point increases the cost to the average bank by a negligible dollar amount. Their paper, however, estimates the costs of complying with regulation, rather than the cost of issuing new equity versus the cost of reducing risk-weighted assets.

The remainder of the paper is organized as follows. Section I describes the institutional details of the 2011 EBA capital exercise. Section II explains the empirical strategy and describes the data. Section III presents the results and Section IV presents a number of robustness checks. Section V concludes.

I. The 2011 EBA Capital Exercise

This section describes the objectives and institutional details of the EBA capital exercise, which was announced by the EBA on October 26, 2011. The objective of the exercise was to restore confidence in the EU banking sector by ensuring that banks had sufficient capital to insure against unexpected losses. To achieve this objective, the EBA required 61 banks to build up additional capital buffers to reach a level of 9 percent core tier 1 ratio by the end of June 2012.[6] After the capital exercise, the EBA kept monitoring the banks' compliance with the 9 percent core tier 1 ratio. The 61 EBA banks were selected based on total asset size. In each country, the EBA included"banks in descending order of their market shares by total assets as of end of 2010", such that the exercise covered "at least 50 percent of each national banking sector in terms of total consolidated assets" (EBA, 2011a).[7] For example, consider a country with banks A, B and C with €41, €30, €10 billion in total assets respectively. The total size of the banking sector is 81 billion euros, with bank A covering more than 50 percent of the banking sector in terms of total assets. Therefore, in this example the EBA would include only bank A in the capital exercise. The assignment of bank A to the EBA capital exercise is therefore unconfounded, that is, based on observable

[6]The capital exercise was an official "Recommendation" issued by the EBA. According to article 16(3) of the EBA regulation as established by the European Parliament, national supervisory authorities must make every effort to comply with the "Recommendation". The EBA capital exercise did not coincide with other changes in the capital requirements for European banks. In particular, the EU only started with the gradual introduction of Basel III in 2013 (Capital Requirements Directive IV).

[7]From the initial 71 banks, the EBA excluded during the capital exercise banks which were "undergoing a deep restructuring", namely Dexia,Österreichische Volksbank AG, West LB, all six Greek banks (EFG Eurobank Ergasias S.A., National Bank of Greece, Alpha Bank, Piraeus Bank Group, Agricultural Bank of Greece (ATEbank), TT Hellenic Postbank S.A.) and Bankia. The paper does not consider these banks in the analysis.

variables only. The EBA used the same selection procedure as in the EBA stress test in June 2011. Selection was therefore not based on bank-specific events in the months prior to the capital exercise. Importantly, the EBA set no formal requirements how banks should increase their core tier 1 ratios.[8] This implies that banks had discretion which measures to take to comply with the higher capital requirements. In theory, banks can increase their capital ratios in two fundamentally different ways: they can increase their levels of capital (the numerator of the capital ratio), or they can shrink their risk-weighted assets (the denominator of the capital ratio) (Admati, DeMarzo, Hellwig, and Pfleiderer, 2012). While raising capital is generally considered "good deleveraging" by regulators, reducing assets has potentially adverse effects if many banks simultaneously engage in cutting lending or selling assets (Hanson, Kashyap, and Stein, 2011).

EBA banks increased their capital positions by more than €200 billion between December 2011 and June 2012. In the final report, the EBA states that "banks' capital strengthening has been achieved mainly via new capital measures such as retained earnings, new equity and liability management" and "capital strengthening has not led directly to a significant reduction in lending into the real economy" (EBA, 2012). In contrast, the financial press reported during the capital exercise that "EU banks could shrink to hit capital rules"[9]. How banks adjusted their balance sheets in response to the EBA capital exercise is thus an empirical question.

II. Empirical Strategy and Data

This paper exploits the 2011 EBA capital exercise to identify how banks adjust their balance sheets in response to higher capital requirements and how this adjustment process affects firms, which obtain a significant share of their borrowing from EBA banks.

A. Empirical Strategy

Taking advantage of the cross-sectional variation in the change in capital requirements induced by the 2011 EBA capital exercise, we want to trace out how this variation affects EBA banks balance

[8] In contrast, the 2009 US Supervisory Capital Assessment Program (SCAP) required banks with capital needs "to raise additional capital, either in public markets or by issuing mandatory convertible preferred securities" (Hirtle, Schuermann, and Stiroh, 2009).

[9] Financial Times, "EU banks could shrink to hit capital rules", October 12 2011.

sheet adjustments and how these adjustments are transmitted to the firm level. Hence, we first analyze at the bank level the extent to which the exercise changed bank behavior, in particular outstanding credit volumes. Next, we move to the individual loan level in order to exclude the possibility that our bank-level findings are driven by demand effects. Finally, we examine asset-, investment-, employment- and sales growth at the firm level.

The setup of the capital exercise, which constitutes an increase in capital requirements for the subgroup of EBA banks (our treatment group) while leaving requirements unchanged for other European banks (our control group pool), naturally lends itself to a difference-in-difference research design. However, participation in the capital exercise was not randomly assigned to banks. Instead, the EBA selected banks according to a selection rule based on bank size, resulting in EBA banks being larger on average than non-EBA banks. This would preclude causal inference if large banks differ from small banks, perhaps due to different business models and funding strategies, and would behave differently even in the absence of a change in capital requirements.

We make use of one particular feature of the EBA selection rule to address this potential selection problem. Figure 1 shows the distribution of bank size for EBA banks and Non-EBA banks across different countries. While EBA banks are on average larger than Non-EBA banks, the selection rule yields a considerable overlap in size between banks participating and not participating in the capital exercise. For example, while the smallest bank included in the EBA exercise, the Slovenian bank Nova Kreditna banka Maribor, had €6 billion in total assets as of end of 2010, the largest European bank not included, the French bank Crédit Mutuel, had €591 billion in total assets in the same year. Knowledge about the selection rule based on observable characteristics (total assets) in combination with the overlap in size allows us to combine the difference-in-difference framework with an appropriate matching methodology by matching banks from the treatment group to similar banks from the control group pool.

[Figure 1 about here]

The paper uses the Abadie and Imbens (2002) matching estimator, which has recently been used by Almeida, Campello, Laranjeira, and Weisbenner (2011), Campello and Giambona (2013) and Kahle

and Stulz (2013) in a corporate finance setting.[10] To alleviate concerns that our results are driven by bank characteristics other than size, this paper also matches on pre-treatment levels of the core tier 1 ratio, the share of customer loans, the net interest income as a share of the total operating revenue, the share of total depository funding and the return on assets. These covariates capture potential differences in the capital structure, business model, funding strategy and profitability of similarly sized banks prior to the capital exercise. The baseline matching strategy matches one EBA bank to four non-EBA banks based on the six matching covariates.[11]

In addition to simply matching EBA banks with non-EBA banks, the paper also uses three alternative matching strategies. Firstly, the paper matches EBA banks to non-EBA banks in the subsample of banks which are larger than the smallest EBA bank and smaller than the largest non-EBA bank. Figure 1 illustrates this approach and shows that the overlap in the size distribution of EBA banks and non-EBA banks results in an *overlap sample* with 36 EBA banks and 91 non-EBA banks. Excluding the smallest non-EBA banks and largest EBA banks (e.g. Deutsche Bank and Barclays) from the sample reduces the size difference between the two groups and rules out that the results are driven by the largest EBA banks. The *overlap matching strategy* matches one EBA bank to one non-EBA bank and matches on bank size only. The main purpose of the overlap matching strategy is to examine whether the results hold up when the size difference between EBA and non-EBA banks is completely removed. Secondly, the paper compares EBA and non-EBA banks *around the selection threshold within the same country.* The paper constructs the *threshold sample* which includes the two smallest EBA banks to the two largest non-EBA banks within a country. Figure 1 illustrates this approach for Portugal. This approach relies on the idea that banks just above and below the threshold in a given country are similar, except for being subject and not being subject to an increase in capital requirements. Since the threshold is based on the total size of a country's banking system, banks cannot manipulate the selection threshold. In this approach,

[10] In contrast to standard propensity score matching, the Abadie-Imbens estimator minimizes the Mahalanobis distance between a vector of observed matching covariates across banks in the treatment group and banks in the control group pool and introduces a bias-correction to account for inexact matches on continuous variables. The bias-adjusted Abadie-Imbens matching estimator has the advantage of generally lowering the estimation bias (but increasing the variance) compared to matching estimators based on the estimated propensity score.

[11] Regarding the number of matches, in our baseline specification we follow Abadie and Imbens (2011) and choose four matches, which was found to be a good trade-off between bias (which is increasing in the number of matches) and variance (decreasing in the number of matches) of the matching estimator.

banks are matched only with other banks within the same country. Thus, it rules out that the results are driven by cross-country differences in regulatory interventions and business cycles. The main purpose of the *within-country matching strategy* is to address concerns that our results are driven by the ECB's LTRO program, which mainly altered the funding structure of Greek, Italian and Spanish banks (Van Rixtel and Gasperini, 2013). However, by construction, EBA banks above the threshold are larger than non-EBA below the threshold. This matching strategy therefore does not remove the size difference. The third alternative matching strategy uses the threshold sample and matches EBA banks just above the threshold to similar non-EBA banks just below the threshold in the same region (GIIPS countries and non-GIIPS countries). This matching approach reduces the size difference between EBA banks and non-EBA banks, but relies on the assumption that the regulatory and economic circumstances of EBA and non-EBA banks are the same across countries within the same region. This *within-region matching strategy* addresses the concern that our results are driven by the European sovereign debt crisis, which mainly affected banks in GIIPS countries (Acharya, Eisert, Eufinger, and Hirsch, 2016). Table I gives an overview of our baseline matching strategy and the three alternative matching strategies.

[Table I about here]

For all four matching strategies, we estimate the average treatment effect on the treated (ATT) using the Abadie and Imbens (2002) bias-corrected Mahalanobis matching estimator. The main outcome variables in the bank-level part of the paper are the changes in the core tier 1 ratio (Δ Core Tier 1 Ratio), its components (Δ Log Core Tier 1 Capital and (Δ Log Risk-Weighted Assets) and outstanding customer loans (Δ Log Customer Loans) between the period before the capital exercise (2009-2010) and the period after the capital exercise (2012-2013).

While bank balance sheet data is appropriate for investigating how banks adjust their balance sheets in response to higher capital requirements, it is not suitable for identifying the effect of higher capital requirements on bank lending. In particular, with bank balance sheet data one cannot disentangle credit supply and credit demand. Thus, to study the effect of higher capital requirements on bank lending, in the loan-level part of the paper we use data on syndicated loans and, as in Khwaja and Mian (2008), exploit multiple bank-firm relationships before and after the

capital exercise for identification. Syndicated loans often have long maturities and bank exposures to individual firms are therefore often constant over time. We thus modify the estimator similar to Popov and Van Horen (2014) and Acharya, Eisert, Eufinger, and Hirsch (2016) and aggregate firms into clusters based on their industry and country of incorporation. With the clustering at firm country $\times$ industry level we want to ensure that firms are subject to the same regional and sectoral shocks. We attribute the remaining variation to differences in the exposure to credit supply shocks.

For the loan-level analysis we estimate the following specification:

$$\Delta\text{Loan Exposure}_{bij} = \beta \cdot \text{EBA Bank}_{bi} + \gamma \cdot X_{bi} + \eta_i + \eta_j + \epsilon_{bij} \tag{1}$$

where ΔLoan Exposure$_{bij}$ is the change in loan exposure of bank b in country i to firm cluster j between the five quarters before the EBA capital exercise (2010q2-2011q2) and the five quarters after the capital exercise (2012q3-2013q3). The variable EBA Bank$_{bi}$ takes the value of one if the bank is part of the EBA capital exercise, and zero otherwise. The pre-treatment (2010q4) bank characteristics X_bi include the matching covariates form the bank-level analysis, namely total assets, CT1 capital ratio, total deposits over total assets, customer loans over total assets, net interest income over operating revenue and net income over total assets. We include firm-cluster fixed effects η_j which absorb all cluster-specific credit demand shocks. Moreover, we include bank country fixed effects η_i to absorb country-specific shocks, which affect all banks in a given country. Like Khwaja and Mian (2008), we follow Bertrand, Duflo, and Mullainathan (2004) and collapse our data into a pre- and post-period before differencing to produce standard errors that are robust to concerns of auto-correlation. In addition, standard errors are clustered at the bank level.

In the final empirical step, we aim to link the EBA banks' balance sheet and lending adjustments to real outcomes at the firm level. A reduction in credit supply of EBA banks would not necessarily be transmitted to the firm level if other banks, not subject to higher capital requirements, would pick up the slack. An increase in capital requirements for a subset of banks would then not affect the total supply of credit to the real economy and would not affect firms' corporate policies.

We construct the variable EBA Borrowing Share$_j$ to measure a firm j's dependence on borrowing from EBA banks prior to the capital exercise:

$$\text{EBA Borrowing Share}_j = \frac{\sum_{i[EBABanks]} \frac{1}{5} \sum_{t=2010Q2}^{2011Q2} OutstandingLoans_{ijt}}{\sum_{i[AllBanks]} \frac{1}{5} \sum_{t=2010Q2}^{2011Q2} OutstandingLoans_{ijt}} \tag{2}$$

where the numerator is the average amount of outstanding loans of firm j from EBA bank i in quarter t over the five quarters prior to the capital exercise (2010q2-2011q2), and the denominator is the average amount of total outstanding loans of firm j from all banks i over the same period. While we exclusively focused on banks from EBA countries in the loan-level analysis, we now include all banks in the Dealscan database into our control group, since European firms might also borrow from banks incorporated in non-European countries.

We then investigate how firms' dependence on EBA banks prior to the capital exercise affects firms' corporate policies by estimating the following equation:

$$\Delta Y_j = \beta \cdot \text{EBA Borrowing Share}_j + \gamma \cdot X_j + \eta_{jc} + \eta_{ji} + \epsilon_j \tag{3}$$

where ΔY_j is the change in firm-level outcomes (the change in log total assets, log fixed assets, log number of employees, and log sales)between the five quarters before (2010Q2-2011Q2) and the five quarters after (2012Q3-2013Q3) the capital exercise. Additionally we control for firm characteristics X_j (log total assets) and include both firm country fixed effects η_{jc} and industry fixed effects η_{ji}.

B. Data

We combine data from various sources. We use bank balance sheet data from the SNL Financial Company Database, loan-level data from the Thomson Reuters LPC's Dealscan database, and firm-level data from Bureau van Dijk's Amadeus Financials database.

For the bank-level part of the paper, we use annual bank balance sheet data from the SNL Financial Company Database. Our initial sample contains all 61 EBA banks and all 494 Non-EBA European commercial banks and savings banks from the SNL Financial universe. Since the EBA capital exer-

cise was conducted at the highest level of consolidation, the paper excludes all subsidiaries of EBA banks, non-EBA banks and foreign banks. As the paper wants to track the behavior of independent banks over time, the paper also excludes all banks which were acquired during the sample period, all banks which received capital injections during the pre-treatment period and all banks with negative levels of equity. Since no Belgian, Greek and Cypriot banks remain in our treatment group, the paper also excludes all Belgian, Greek and Cypriot banks from our control group pool. The sample construction procedure finally leaves us with a sample of 48 EBA banks and 145 non-EBA banks. The sample period spans two post-treatment years after the capital exercise (2012 and 2013) and a symmetrical time window of two pre-treatment years prior to the capital exercise (2009 and 2010).

For the loan-level part of the paper, we obtain data from Thomson Reuters LPCs Dealscan database, which contains detailed information on syndicated loan contract terms, loan types, and maturities. We collect data on all outstanding term loans and credit lines[12] from banks in our sample to non-financial corporate borrowers incorporated in EBA countries. Of the 76 banks in our matched control group, 44 were active in the syndicated loan market during our sample period and these banks constitute the control group in the loan-level part of the paper. Dealscan contains full information on the loan allocation between syndicate members for about 32% of all loans. For the remaining 68% we follow De Haas and Van Horen (2012) and divide the loan facility equally among all members of a syndicate. Our initial sample contains 6,037 syndicated loans from 96 banks to 2,449 companies. The LPC Dealscan database contains the issuance of new syndicated loans at the time of origination. In order to employ the Khwaja and Mian (2008) estimator, we transform the data and calculate the outstanding exposure of bank b in country i to firm cluster j in quarter q using the maturity variable contained in the database. We then collapse our data into a pre- and post-period to produce standard errors that are robust to concerns of auto-correlation (see Bertrand, Duflo, and Mullainathan (2004)). Thus, the unit of observation is the change is the change in log loan exposure of bank b in country i to firm cluster j between the five quarters before the EBA capital exercise (2010q2-2011q2) and the five quarters after the capital exercise (2012q3-2013q3).

[12]For term loans and credit lines, we follow the variable definition of Berg, Saunders, and Steffen (2016).

For the firm-level part of the paper, we use information on firm's balance sheet and profit and loss statements from Bureau van Dijk's Amadeus Financials database. The database additionally contains information on a firm's country of incorporation, its SIC industry code, and whether the firm is publicly quoted. We have access to the sample of firms classified as *Very Large*, *Large*, and *Medium* by Amadeus. Since the Dealscan database and the Amadeus database share no common firm identifier, we hand-merge the two datasets with the help of the *adist* algorithm in *R*. This leaves us with sample of 1,655 firms for the firm-level part of the paper.

C. Summary Statistics and Common Trends

In this section, we provide summary statistics for the sample of EBA banks, non-EBA banks and matched control group banks under the different matching strategies. The goal is to show that the matching methodology reduces the differences between EBA banks and non-EBA banks in observable dimensions. Table II shows the median *pre-treatment values* of the matching covariates for both EBA Banks, non-EBA banks and control group banks as of end of 2010, the year immediately prior to the capital exercise. The paper uses the continuity corrected Pearson χ^2 test statistic to test for differences in the median between the two groups.

[Table II about here]

Panel A compares the 48 EBA banks with 145 non-EBA banks. As expected, EBA banks significantly differ from Non-EBA banks along a number of important dimensions. Due to the capital exercise being carried out on the largest banks in each country, the median EBA bank is more than 20 times bigger than the median Non-EBA bank. The two groups of banks also significantly differ in terms of their business models, with the median EBA bank being less engaged in customer lending and generating less of its revenue from interest income than the median Non-EBA bank. While the two groups of banks do not differ significantly with regard to their pre-treatment core tier 1 ratios, the median EBA bank is significantly less reliant on customer deposits (i.e. more reliant on wholesale funding) than the median Non-EBA bank. In addition, the loan share of the total assets and the share of interest income of the total operating revenue is also lower for EBA banks compared with non-EBA banks. These large differences between EBA banks and Non-EBA banks

in terms of important characteristics emphasize the necessity of employing a matching procedure.

For our baseline matching strategy, we match four Non-EBA banks to each EBA bank based on the Mahalanobis distance of all matching covariates as of end of 2010. Panel B of Table II shows the median values of EBA banks and matched control group banks. The matching procedure significantly reduces the differences between EBA banks and control group banks, especially with regard to our measures for banks business models. Some differences, however, remain significant, albeit at a much lower level compared to the unmatched sample. While EBA banks are still bigger than control group banks in the matched sample, our matching procedure reduced this difference from EBA banks being more than 20 times bigger to EBA banks being roughly 10 times bigger. To reduce the size difference between the EBA banks and non-EBA banks, the paper uses the *overlap sample*, which includes all banks larger than the smallest EBA bank and smaller than the largest non-EBA bank. Panel C of Table II shows that this matching strategy reduces the size difference to€30 billion, which is statistically insignificant.[13] In addition, only matching on size also reduces the differences in the business model and funding strategy of the EBA and control group banks. A disadvantage of the overlap matching strategy is that the number of control group banks reduces from 76 banks under the baseline strategy to 16 banks only.

The second alternative matching strategy matches the two largest control group banks with the two smallest EBA banks in each country using the *threshold sample*. Panel D of Table II shows that this reduces the size difference, in comparison with the baseline strategy, but the difference continues to be significant. From the other matching covariates, only the net interest income to operating revenue ration remains significant at the 10 percent level. The advantage of this strategy is that we compare banks within the same countries, which ensures that our results are not driven by differences in macro-economic environments or regulatory interventions across countries.

The third alternative matching strategy also uses the threshold sample, but matches the two smallest EBA banks of a country, with to the two most similar Non-EBA banks within the same region

[13]Bank size might still be a concern and therefore, the paper provides additional tests, showing that the results are not driven by bank size. In Section 7, the paper tests in a standard regression framework whether the results are driven by the largest EBA banks. The main results are robust to the alternative tests.

(GIIPS vs non-GIIPS countries). This strategy also reduced the size difference compared with the baseline matching strategy and additionally has the advantage of comparing banks within similar macroeconomic environments to address concerns that our results are driven by banks in GIIPS countries, which were especially exposed to the European sovereign debt crisis.[14]

Identification in a difference-in-difference framework crucially relies on the parallel trend assumption to hold. We therefore examine the pre-treatment trend in the core tier 1 ratio for both EBA banks and the sample of matched control group banks according to our baseline matching strategy. The main outcome variables in the bank-level part of this study are the core tier 1 ratio and its components, core tier 1 capital and risk-weighted assets. Figure 2 shows a general upward trend in the core tier 1 ratios for both groups. This increase was parallel up to 2010, the year immediately prior to the capital exercise. Starting in 2011, EBA banks begin to increase their core tier 1 ratios significantly more than non-EBA banks in the matched control group.

[Figure 2 about here]

Figure 3 and Figure 4 shows the trends in core tier 1 capital (the numerator of the core tier 1 ratio) and risk-weighted assets (the denominator of the core tier 1 ratio) normalized at the value of one for the year 2011. Both the levels of core tier 1 capital and risk-weighted assets evolved parallel for EBA banks and matched control group banks in the years leading up to the capital exercise. However, while levels of core tier 1 continued their parallel increase after the capital exercise, EBA banks started reducing their risk-weighted assets significantly compared to banks in the matched control groups.

[Figure 3 and Figure 4 about here]

The three graphs provide evidence that our matching procedure does a good job at balancing EBA banks and Non-EBA banks with regard to their pre-treatment trends in the core tier 1 ratio and its components. Moreover, the graphs indicate that EBA banks increased their levels of core tier 1 capital compared to the matched control group and that they did so not by increasing their levels of equity, but by reducing their levels of risk-weighted assets relative to the control group.

[14] To test whether the results are driven by time varying unobservable country characteristics, the standard regression framework in section 7 includes specifications with country $\times$ year fixed effects. This parametric test shows that the main results are not driven by time varying unobservable country characteristics.

III. Main Results

In this section, we first present the baseline empirical results of the bank-level analysis for both our baseline matching strategy and the results of the three alternative matching strategies. Subsequently we present the loan loan-level and firm firm-level results.

A. Bank-Level Results

We study how banks adjust their core tier 1 ratios after an increase in capital requirements. We first examine whether EBA banks did indeed increase their core tier 1 ratios in response to higher capital requirements, and whether they did so via increasing their levels of capital (adjustment via the numerator) or via a reduction of risk-weighted assets (adjustment via the denominator).

The first column of Panel A of Table III shows how both EBA banks and control group banks adjusted their core tier 1 ratios around the 2011 EBA capital exercise. The table reports the before-after differences for both EBA banks and the control group banks, the difference-in-difference results with regard to the control group, as well as the Abadie-Imbens matching estimator for the average treatment effect on the treated (ATT) with regard to the differential change in core tier 1 ratios. Both EBA banks and control group banks increased their core tier 1 ratios in the two years after the capital exercise, reflecting a general upward trend among European banks which can also be seen in Figure 2. However, while control group banks increased their core tier 1 ratios by only 1.79 percentage points on average, EBA banks did so by 3.02 percentage points and thus significantly more than banks not subject to higher capital requirements. The ATT is equal to 1.85 percentage points and significant at the 1 percent level, indicating that the increase in capital requirements did indeed affect the core tier 1 ratios held by banks participating in the capital exercise.

[Table III about here]

The core tier 1 ratio measures a bank's level of core tier 1 capital relative to its level of risk-weighted assets of the bank (core tier 1 capital / risk-weighted assets). To test whether EBA banks adjusted the numerator or denominator to increase their core tier 1 ratios, the paper estimates the percentage changes in core tier 1 capital and risk-weighted assets of EBA banks after the capital exercise,

relative to the changes in core tier 1 capital and risk-weighted assets of matched control group banks. The second column of Table III shows that EBA banks increased their levels of core tier 1 capital by 19 percent around the 2011 EBA capital exercise. However, as the comparison with the matched control group indicates, this increase seems to reflect a general development in the European banking system, rather than an effect of the capital exercise. This general development may well have reflected market pressure on banks to increase capital and can not be attributed to the capital exercise. European banks not participating in the capital exercise exhibited an identical percentage increase in their levels of core tier 1 capital, rendering the ATT insignificant. This finding provides evidence that EBA banks did not respond to the increase in capital requirements by raising new capital. In contrast, there is a significant difference in the change of risk-weighted assets between EBA banks and the sample of matched control group banks in the time window around the capital exercise, as can be seen in the third column. While EBA banks reduced their levels of risk-weighted assets by 10 percent over our sample period, control group banks even increased their levels of risk-weighted assets. The ATT indicates that EBA banks reduced their risk-weighted assets by 16 percentage points compared to our sample of matched control group banks which were not subject to an increase in capital requirements. The combined findings in Table II are the first central result of the bank-level part of the paper. They provide evidence that banks, when faced with an increase in capital requirements, adjust their capital ratios by reducing their levels of risk-weighted assets (adjustment via the denominator) rather than by raising new capital (adjustment via the numerator). While our baseline matching procedure considerably reduces the size difference between EBA banks and Non-EBA banks, we acknowledge that bank size might still be a concern and thus present results based on three alternative matching procedures. In panels B, C and D of Table III we show that these results hold when using alternative matching strategies. In all cases the coefficients suggest that EBA banks significantly reduced their risk-weighted assets compared to banks in the control group.

The EBA capital exercise required EBA banks to increase their core tier 1 ratio to 9 percent over the period from December 2011 to June 2012. EBA banks, which already met this criterion in December 2011, also faced higher capital requirements, but were not required by the EBA to further increase their core tier 1 ratio beyond the target ratio of 9 percent. Therefore, our results

should be driven by weakly capitalized EBA banks. To test this prediction, the paper divides the sample into a sub-sample of banks with a pre-treatment core tier 1 ratio lower than 9 percent (Ex-ante below) and a sub-sample of banks with a pre-treatment core tier 1 ratio higher or equal to 9 percent (Ex-ante above). Within these sub-samples, the paper matches EBA banks to non-EBA banks using the same matching methodology as applied before. The results are presented in Table IV and show that weakly capitalized EBA banks did indeed increase their core tier 1 ratio and reduce their risk-weighted more than matched banks in the respective control group. The standard difference-in-differences estimator shows that weakly capitalized EBA banks increased their core tier 1 ratio by 2.02 percentage points more than weakly capitalized non-EBA banks.[15] They do did so by reducing their risk weighted assets by 19 percentage points relative to the matched control group, which is higher than the estimate in the full sample. The results for the sub-sample of banks with a pre-treatment capital ratio higher or equal to 9 percent are weaker in magnitude and only significant at a 10 percent level. Although sufficiently capitalized EBA banks did not have to increase their core tier 1 ratio in response to the capital exercise, they might have done so for precautionary reasons.

[Table IV about here]

A reduction in risk-weighted assets could be the result of a reduction in asset risk if a bank changes its asset composition from riskier assets into safer assets (*risk reduction*), or could be the result of a reduction in total assets (*asset shrinking*) while keeping asset risk at the same level. Asset allocation into safer assets has potentially beneficial effects if capital requirements provide an incentive for banks to screen loans more carefully or to invest in safer credit classes. Asset shrinking has potentially negative effects for the real economy if a large fraction of banks decreases lending simultaneously. The paper employs various tests to examine whether banks reduced their risk-weighted assets by engaging in asset allocation or by engaging in asset shrinking. A reallocation of assets to make the average asset less risky would reduce risk-weighted assets, but would not change unweighted total assets. This implies that the ratio of risk-weighted assets to total assets

[15] Note that the matching estimator produces extreme results in Column (1) and (2) of Table IV due to the bias-correction combined with a very low number of observations. However, the bias-correction works in favor of our results that weakly capitalized EBA banks reduced their risk-weighted assets and did not increase core tier 1 capital compared to banks in the matched control group.

would decrease. The estimates in Panel A of Table V, however, show that there is no statistically significant difference in the changes in the ratio of risk-weighted assets to total assets between EBA banks and banks in the matched control group. In addition the average loan loss reserves, which are estimated losses on loans due to defaults and nonpayment, do also not change, suggesting that EBA banks did not change their asset allocation to reduce risk-weighted assets.

[Table V about here]

The EBA's final report on the capital exercise claims that "capital plans have not led directly to a significant reduction of lending into the real economy" (EBA, 2012). Panel B in Table V shows that EBA banks indeed did not reduce their total assets, consumer loans and total securities after the capital exercise. However, the table also shows that banks in the matched control group actually increased their total assets and customer loans by 10 and 8 percentage points respectively. The matching estimator therefore shows that EBA banks reduced their total assets and customer loans by 14 and 12 percentage points compared to banks in the control group. In Section IV, the paper employs a battery of exercises to study the robustness and internal validity of the results, including a placebo test and a standard regression analysis.

B. Loan-Level Results

In the loan-level part, we follow Khwaja and Mian (2008) and study both the intensive and extensive margin of our sample. The intensive margin sample includes only firm clusters to which EBA banks lend both before and after the EBA exercise. Thus, this sample excludes firm clusters that entirely stop borrowing after the EBA capital exercise or did not borrow prior to the capital exercise. These firm clusters are large outliers in the first-difference log-specification given in Equation 1 and would therefore unduly influence the magnitude of the estimates. Table VI presents the results of specification 1. We regress the change in the log value of outstanding syndicated loans of bank of bank b in country i to firm cluster j on the EBA Bank_{bi} dummy variable. Since the EBA capital exercise occurs at the bank level, changes in outstanding loans from the same bank may be correlated. Therefore, standard errors in all loan-level regressions are clustered at the bank level.

Figure 5 shows the evolution of the syndicated loan volume for EBA banks and control group banks over time normalized to one in 2011q2, the quarter immediately prior to the capital exercise. As can be seen, syndicated loan volume follows a parallel trend up to the second quarter of 2011, after which loan volumes for EBA banks drop visibly compared to the control group. Column (1) of Table VI shows that EBA banks reduce their exposures in the syndicated loan market by 14 percentage points after the capital exercise compared to banks in the control group. This specification includes bank country fixed effects which absorb unobserved shocks affecting all banks in a given country. One concern when comparing banks within the same country, is that differences in bank characteristics are correlated with changes in credit demand, in particular bank size. In order to test this, specification (2) includes bank-specific control variables. The magnitude of the coefficient increases to 25 percentage points and remains statistically significant at a 5 percent level. Credit demand shocks could conceivably also occur outside the bank's home country. For example, Deutsche Bank might reduce its exposures to Spanish firms due to changes in credit demand in Spain. To address this concern, the paper includes borrower country fixed effects in column (3). Credit demand shocks could also occur at the industry level, and therefore specification (4) also includes industry fixed effects. The paper defines firm clusters at the borrower country $\times$ industry level, because credit demand shocks might affect industries differently across countries. To control for borrower country $\times$ industry specific demand shocks, specification (5) introduces borrower country $\times$ industry fixed effects. The results are robust to all of these different specifications.

[Figure 5 about here]

[Table VI about here]

Table VII studies the extensive margin to show whether EBA banks stopped lending to specific firm clusters. The paper defines a dummy variable *Exit* which takes the value of one if bank b stopped lending to firm cluster j after the EBA capital exercise, and zero otherwise. The results in columns (1) to (3) suggest that this is not the case and that all adjustment appear to have taken place on the intensive margin. The paper also defines the variable *Entry* which takes the value of one if a bank starts lending to a firm cluster after the capital exercise, and zero otherwise. The results in column (4) suggest that EBA banks may have been less likely to start lending to new

clusters, however this result becomes insignificant once adding bank characteristics and borrower country × industry fixed effects. The results therefore show that the EBA capital exercise primary affected lending on the intensive margin.

[Table VII about here]

The results presented in this section are in line with the evidence presented in Section III.A, which showed that EBA banks reduced their risk risk-weighted assets to increase their core tier 1 ratio and that this reduction in risk-weighted assets can mainly be attributed to a reduction in lending.

C. Firm-Level Results

The previous sections show that EBA banks reduced their lending more than the control group of non-EBA banks. However, reduction of EBA bank lending would have no adverse effects on the economy if other banks, not subject to higher capital requirements, would pick up the slack. To test this hypothesis, we investigate whether firms that were more dependent on EBA banks before the capital exercise experienced a lower growth in total assets, investment, employment and sales. We construct the variable EBA Borrowing Share$_j$ in equation 2 as the share of outstanding loans of firm j from EBA banks in relation to firm j's total outstanding loans from all banks over the five quarters prior to the capital exercise. The average EBA borrowing share of a firm in the sample is 57.5 percent and the standard deviation is 32.9 percentage points.

Table VIII presents the main firm-level results estimating regression equation 3. Column (1) of Panel A shows that the EBA borrowing share of a firm is negatively correlated with firm growth between the period before and after the capital exercise. The interpretation of the coefficient is that a firm with an EBA borrowing share of 100 percent reduces total assets by 7 percentage points compared to a firm with an EBA borrowing share of 0 percent. A one standard deviation increase in EBA borrowing share reduces total asset growth by 2.3 percentage points. The paper includes firm-level controls, borrower country fixed effects and industry fixed effects in column (2) to (4) respectively. The inclusion of these controls does not affect the magnitude of the coefficient. Panel B, C and D present analogous results for investment (measured by the change in fixed assets as in Campello and Larrain (2016)), employment and sales. We find that a one unit increase in the

EBA borrowing share (from 0 percent to 100 percent) is associated with a 11 percentage point reduction in investment growth and 8 percentage point reduction in sales growth. Thus, a one standard deviation increase in the EBA borrowing share is associated with a 3.3 percentage point decrease in investment growth and a 2.4 percentage point decrease in sales growth. We find no corresponding effects for employment growth.

[Table VIII about here]

The ease of substitution of bank loans for other sources of external finance is higher for firms which have access to capital markets. The paper tests whether non-listed firms are more likely to experience real effects than public listed firms. In all panels the coefficient of publicly listed firms is smaller in magnitude and insignificant, confirming the hypothesis that our firm-level results are driven by non-listed banks.

IV. Robustness Checks

In this section, the paper shows that the benchmark results are robust and internally consistent. First, the paper performs a placebo test and shows that the bank-level results could not be explained by a change in the capitalization of EBA banks between 2009 and 2010, the years preceding the capital exercise. In addition, the paper shows that the results are robust to alternative specifications of the matching estimator. Using a standard regression methodology, the paper shows that the results are not driven by time-varying country-specific effects, and are neither by the largest banks in the sample and nor by EBA banks from GIIPS countries. The paper then shows that the results are driven by a reduction in the risk weighted assets for credit risk. Banks reduce their risk-weighted assets for credit risk, by shrinking their credit supply, while keeping the average riskiness of the assets, measured by the average risk weight per asset, the same.

A. Placebo Test: Core Tier 1 Ratios in 2009 vs. Core Tier 1 Ratios in 2010

The matching methodology employed in Section 4 compares the effect of the capital exercise on EBA banks with similar non-EBA banks. Given the similarity between EBA banks and control group banks, the evidence presented is indicative of a causal effect of higher capital requirements

on bank policies. In order to provide more evidence for this result, the paper replicates the same test for the *placebo period*, 2009 and 2010, the two years before the capital exercise. If the results in Section 4 are driven by the effect of the capital exercise, then there should be no significant differences between EBA banks and control group banks in the placebo period.

The results from the placebo test are reported in Table IX. The results show that over the period 2009 2010 both EBA banks and control group banks increased their core tier 1 ratio by 0.5 and 0.6 percentage points respectively. The average treatment effect on the treated (ATT) in this case is 0.17 and statistically insignificant. The results show that EBA banks decreased their risk-weighted assets by 6 percentage points more than control group banks between 2009 and 2010. However, the magnitude is smaller compared to the risk-weighted assets reduction of 16 percentage points in Section and not significant at the 5 percent level. The placebo test therefore shows that the differences between EBA banks and control group banks observed in the main analysis do not appear in the period between 2009 and 2010 before the capital exercise.

[Table IX about here]

B. Standard Regression Tests: Difference-in-differences in Core Tier 1 Ratios

One concern regarding the matching approach is that EBA banks get matched to non-EBA banks from different countries with different macroeconomic environments (in particular demand for financial intermediation) and supervisory regimes, which could potentially confound the findings. This section addresses this concern by running the following standard difference-in-difference regression including country-year fixed effects:

$$Y_{ict} = \alpha + \beta \cdot \text{EBA}_{ic} + \gamma \cdot \text{After}_t + \delta \cdot (\text{EBA}_{ic} \times \text{After}_t) + \sum_k \theta^k X_{i,t-1} + \eta_i + \eta_{ct} + \epsilon_{ict} \qquad (4)$$

where Y_{ict} is the bank policy of bank i in country c in year t, specifically the bank's core tier 1 ratio, log core tier 1 capital, and log risk-weighted assets. The variable EBA_{ic} takes on the value one for the 48 EBA banks and 0 for the 145 non-EBA banks. The variable $After_t$ takes on the value one for the years 2012 and 2013, and 0 for the years 2009 and 2010. In our preferred specification, bank fixed effects η_i and country-year fixed effects η_{ct} are included, whereas the inclusion of the

former absorbs the level effect of the EBA_{ic} variable. Furthermore, the regression parametrically controls for differences across EBA banks and non-EBA banks by including a range of lagged bank characteristics$X_{i,t-1}$, namely the log of total assets, the deposit share and loan share of total assets, net interest income as a share of operating revenue, as well as net income over total assets.[16] The results of the difference-in-difference regression are shown in Table X. Column (1) contains a benchmark specification including year instead of country-year fixed effects, and column (2) contains our favorite specification including country-year fixed effects. Importantly, the inclusion of country-year fixed effects does not alter the results. First, in our favorite specification EBA banks increased their core tier 1 ratio by 1.53 percentage points more than non-EBA banks (Panel A), confirming the main findings in Section 2. Moreover, EBA banks did not increase their levels of core tier 1 capital (Panel B), but instead reduced their risk-weighted assets by 11 percent compared to non-EBA banks (Panel C). Column (3) tests whether the results are driven by large EBA banks. It therefore includes an additional interaction term containing the variables $textLargeBanks_{ic}$, which takes on the value one for all banks larger than the median EBA bank in terms of pre-treatment levels of total assets, and zero otherwise. This interaction term is not significant and does not alter the results in any of the panels, providing evidence that the results are not driven by large banks in the sample. Column (4) tests whether differences in funding strategies between EBA banks and non-EBA banks can explain the results. It therefore includes an additional interaction term containing the variables $textDepositFunding_{ic}$, which takes on the value 1 for all banks with a larger than median deposit share of total assets, and 0 otherwise. Again, this interaction term is not significant in any of the panels, suggesting that the results are not driven by differences in the funding strategy between EBA banks and non-EBA banks. Finally, Column (5) tests whether the results are purely driven by EBA banks from GIIPS countries. It therefore includes a triple interaction term containing the variable GIIPS, which takes on the value 1 for banks from GIIPS countries, and 0 otherwise. The results remaining unchanged provides evidence that the results are not purely driven by EBA banks from GIIPS countries.

[Table X about here]

[16] These variables are the same as the matching covariates in Section .

V. Conclusion

In this paper, we exploit the EBA capital exercise as natural experiment to study the effect of higher capital requirements on banks' balance sheet adjustments and the transmission of this effect to the real economy. Using a matching strategy that exploits the selection rule of the EBA capital exercise, we show that EBA banks increase their core tier 1 ratio more than non-EBA banks in response to an increase in capital requirements. This suggests that the capital exercise was an effective policy instrument to improve the capitalization of the largest European banks. However, the analysis also shows that banks do not raise their capital ratios by increasing their core tier 1 capital, but by reducing credit supply, which in turn has significant effects on the corporate sector. Firms which are more reliant on EBA banks reduce investment and grow more slowly than firms less reliant on EBA banks. This suggests that firms were unable to fully compensate for the reduction in credit supply from EBA banks by increasing their borrowing from non-EBA banks. EBA banks cover more than 65 percent of the European banking sector. High switching costs or limited access to other sources of external funding could explain why EBA firms were not able to obtain other sources of external funding. In our paper we use syndicated loan data which are mainly used by large publicly listed firms, which have better access to alternative sources of external funding. Therefore, our estimates indicate a lower bound of the real effects of higher capital regulation.

An important policy implication of our paper is that capital requirements which target the regulatory capital *ratio* have potentially adverse effects on the real economy. As suggested by Hanson, Kashyap, and Stein (2011), targeting the absolute amount of new capital that has to be raised instead the capital ratio could mitigate this problem, an approach which has been successfully applied in the U.S. stress tests conducted in 2009. In this context, our paper highlights the risks associated with capital regulation that focuses on capital ratios as the policy target variable while leaving it to the discretion of banks how to increase their capital ratios.

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Appendix A: Figures

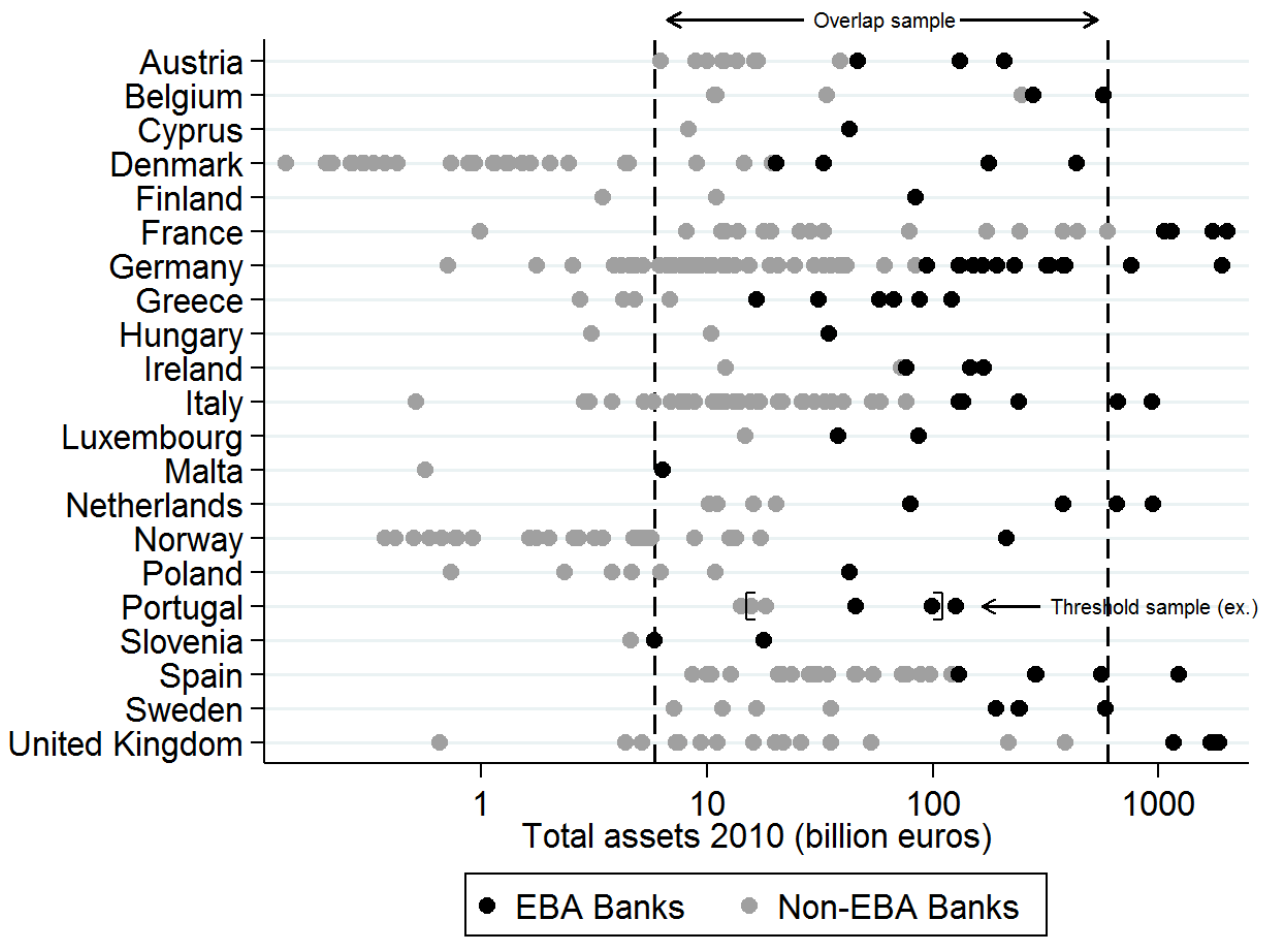

Figure 1. Bank size distribution by country. Figure 1 shows the bank size distribution (total assets as of end of 2010) of EBA banks and Non-EBA banks by country. The graph includes all ultimate parent banks headquartered in EBA supervised countries included in the SNL database. The figure illustrates the construction of the overlap sample, which is determined by the smallest EBA bank (left vertical line) and the largest Non-EBA bank (right vertical line) respectively. The figure also exemplifies the construction of the threshold sample, which is determined by the two smallest EBA banks just above and the two largest Non-EBA banks just below the selection threshold within each country, for the case of Portugal.

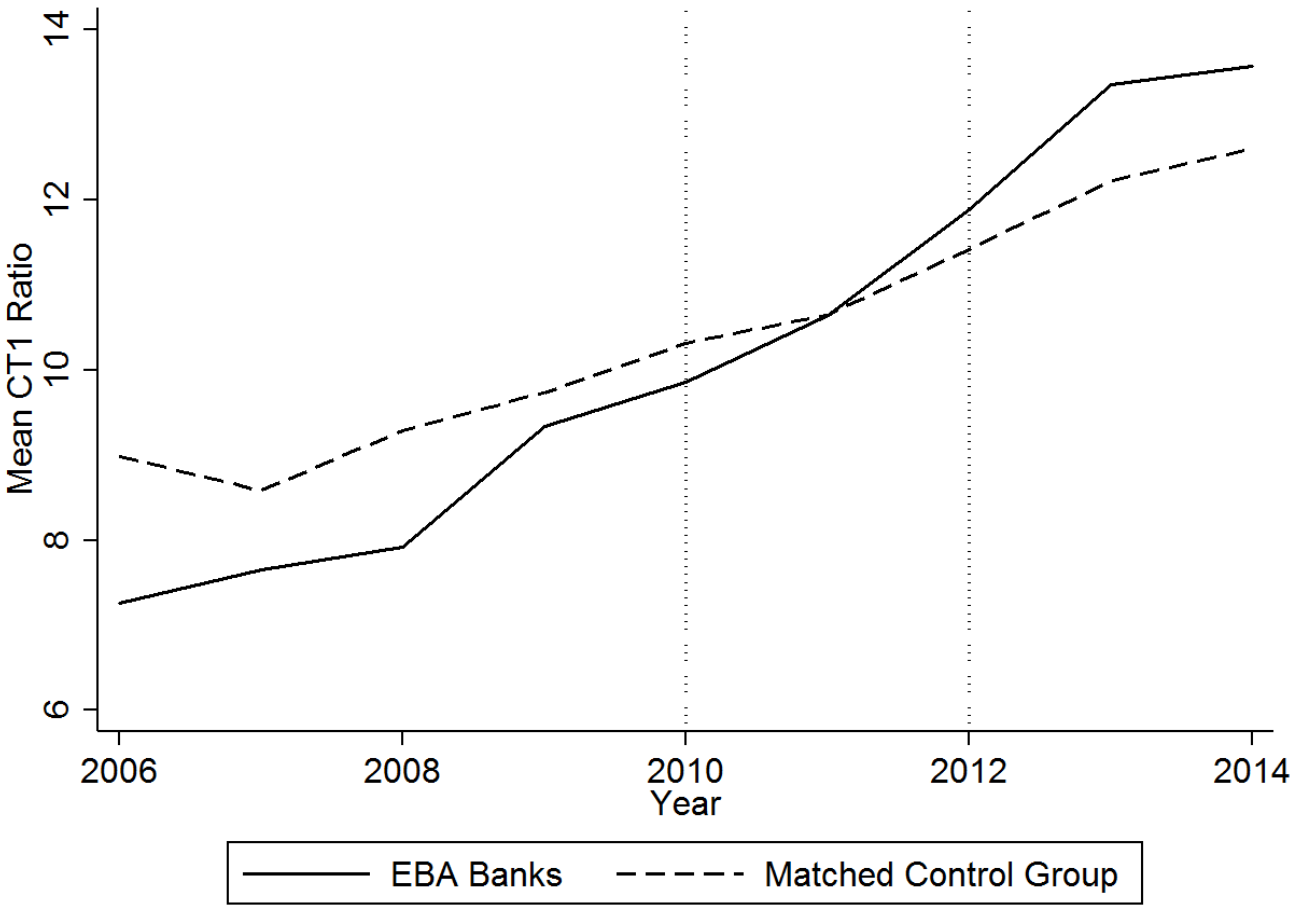

Figure 2. CT1 ratios over time. Figure 2 shows the evolution of the mean core tier 1 ratio over time for both 48 EBA banks in the treatment group and 76 Non-EBA banks in the matched control group. The two vertical lines mark 2010 and 2012, the years immediately before and after the capital exercise.

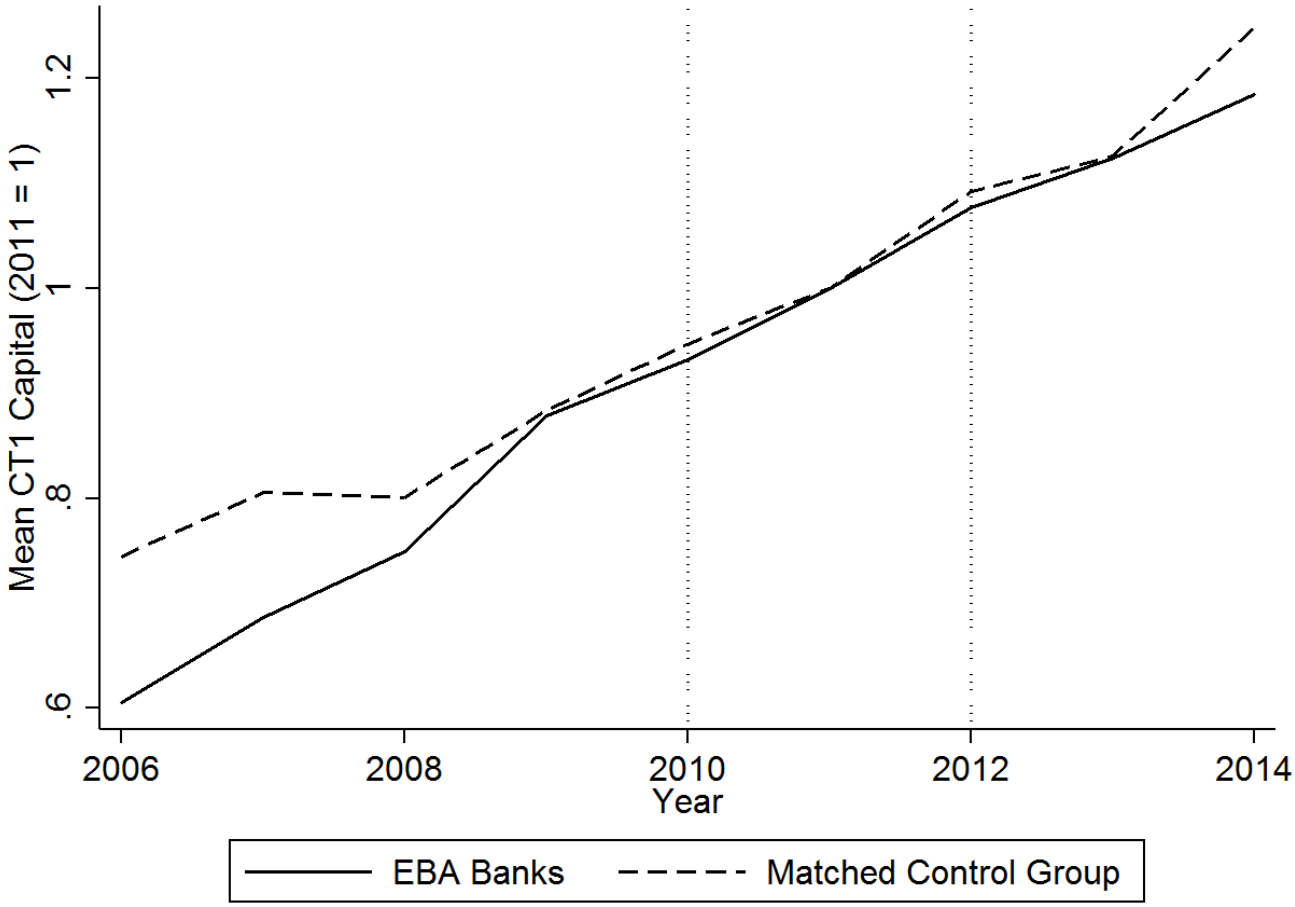

Figure 3. CT1 ratios over time. Figure 3 shows the evolution of the levels of mean core tier 1 capital over time for both 48 EBA banks in the treatment group and 76 Non-EBA banks in the matched control group. The two vertical lines mark 2010 and 2012, the years immediately before and after the capital exercise.

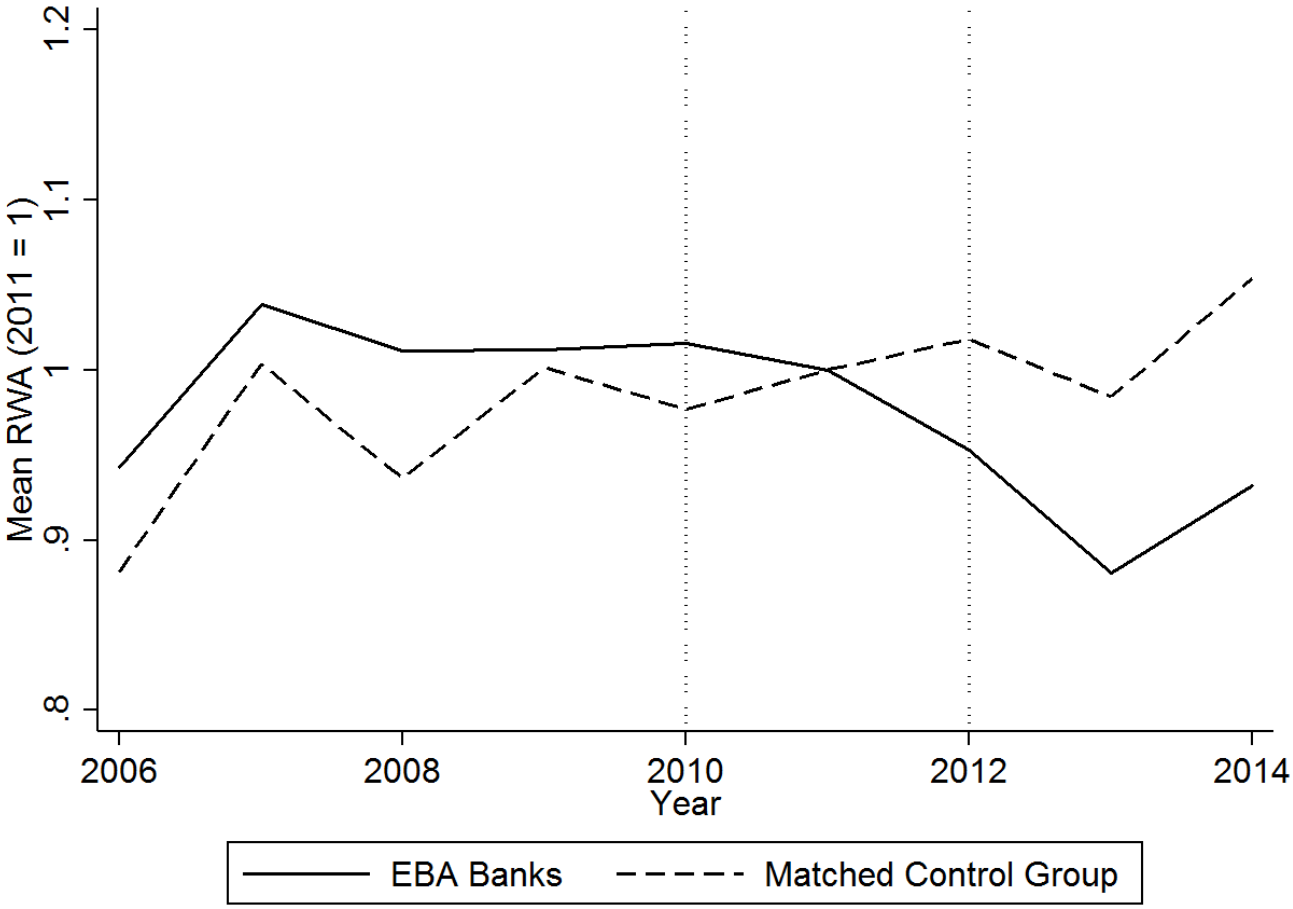

Figure 4. CT1 ratios over time. Figure 4 shows the evolution of the levels of mean risk-weighted assets over time for both 48 EBA banks in the treatment group and 76 Non-EBA banks in the matched control group. The two vertical lines mark 2010 and 2012, the years immediately before and after the capital exercise.

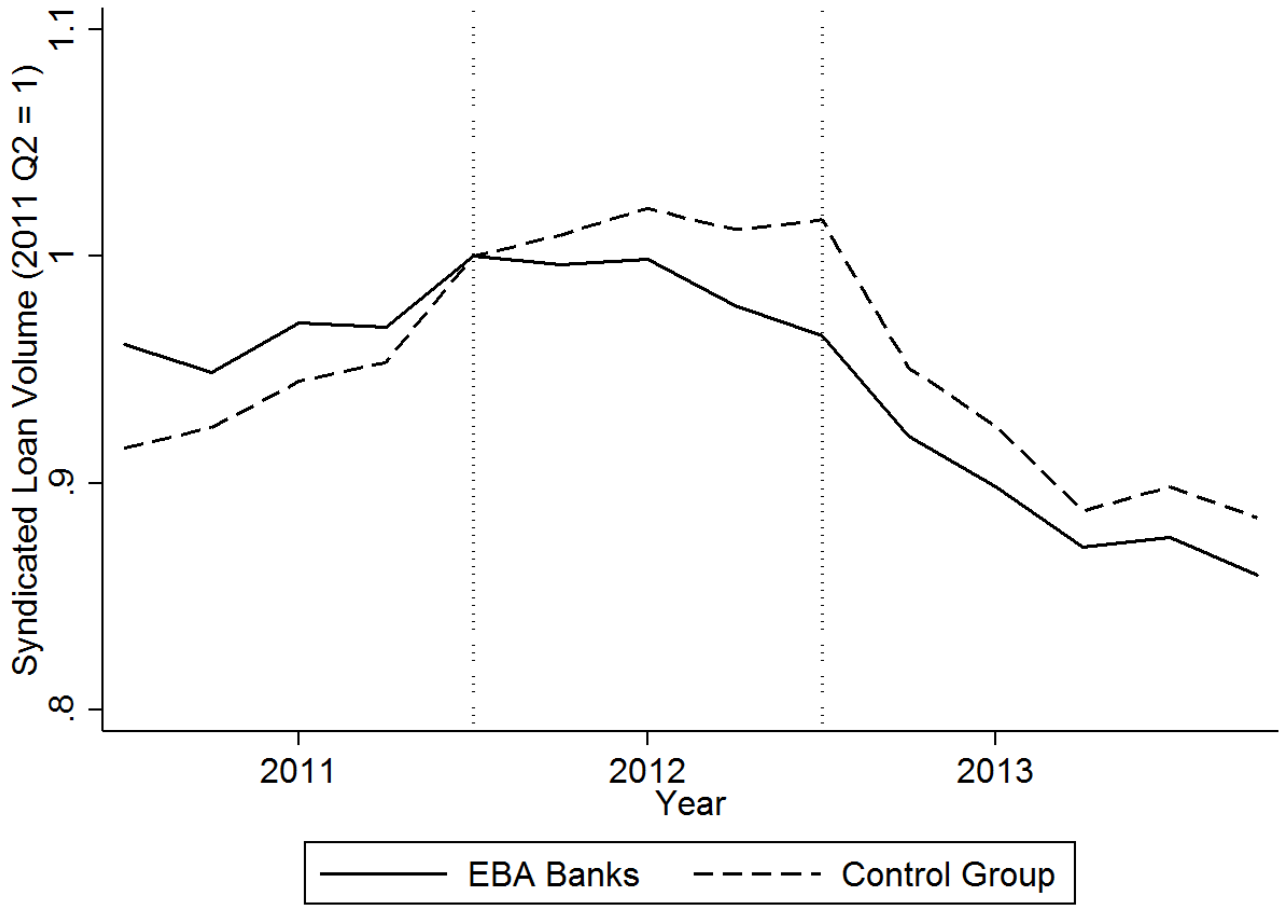

Figure 5. Syndicated loan volume over time. Figure 5 shows the loan volume of EBA banks and Non-EBA banks in the syndicated loan market over the period 2010q1-2013q4, normalized to one in 2011Q2. The two vertical lines mark 2011q2 and 2012q2, the quarters immediately before and after the capital exercise.

Appendix B: Tables

Table I
Matching Strategies

Table I displays the baseline matching strategy and three alternative matching strategies employed in the paper. The *Baseline Sample* includes 48 EBA banks and 145 non-EBA banks. The *Overlap Sample* includes all banks larger than the smallest EBA bank and smaller than the largest Non-EBA bank. The *Threshold Sample* includes the two smallest EBA banks and the 2 largest Non-EBA Banks per county. The Number of matches refers to the number of control group banks matched to each EBA bank. The matching covariate *Region* takes the value of one if the bank is headquartered in Greece, Ireland, Italy, Portugal or Spain, and zero otherwise.

Matching Strategy	Baseline	Overlap	Within Country	Within Region
Sample Used	Baseline	Overlap	Threshold	Threshold
Number of Matches	1:4	1:1	1:2	1:4
Matching covariates				
Total Assets	√	√	√	√
CT1 Capital Ratio	√		√	√
Total Deposits / Total Assets	√		√	√
Customer Loans / Total Assets	√		√	√
Net Int. Inc. / Op. Rev.	√		√	√
Net Income / Total Assets	√		√	√
Country			√	
Region				√

Table II
Pre-Treatment Characteristics of Banks

Table II provides pre-treatment summary statistics on EBA banks, Non-EBA banks and control group banks (median comparisons). The paper tests for differences in medians using the continuity corrected Pearson 2 test statistic (*, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively). Panel A compares the median values of the 48 EBA banks and 145 Non-EBA banks in the unmatched sample. Panel B compares the 48 EBA banks to the sample of matched control group banks based on the Mahalanobis matching estimator. Panel C-D compare EBA banks to the sample of matched control group banks using the alternative matching strategy 1 (Overlap sample), 2 (Within country) and 3 (Within region) respectively.

	# Banks	Total Assets	CT1 Ratio	Deposits / TA	Loans / TA	NII / Op. Rev.	Net Inc./ TA
Panel A: Unmatched Sample							
EBA Banks	48	183.21	9.21	40.47	60.03	57.94	0.40
Non-EBA Banks	145	9.05	10.54	56.25	70.62	68.97	0.29
Δ		174.16***	-1.32	−15.78***	−10.60***	−11.03**	0.11
Panel B: Baseline Matching							
EBA Banks	48	183.21	9.21	40.47	60.03	57.94	0.40
Control Group Banks	76	18.39	10.04	50.29	64.73	65.08	0.39
Δ		164.83***	-0.83	−9.82***	−4.70*	-7.14	0.01
Panel C: Alternative Matching Strategy 1 (Overlap Sample)							
EBA Banks	36	130.43	9.31	43.24	62.49	64.04	0.41
Control Group Banks	16	97.10	10.95	56.74	59.28	55.99	0.37
Δ		33.33	-1.64	−13.50***	3.20	8.06	0.04
Panel D: Alternative Matching Strategy 2 (Within Country)							
EBA Banks	26	130.43	9.80	44.55	64.57	60.67	0.42
Control Group Banks	26	10.55	10.85	43.29	67.62	66.86	0.34
Δ		119.88***	-1.04	1.26	-3.05	-6.19	0.08
Panel E: Alternative Matching Strategy 3 (Within Region)							
EBA Banks	26	130.43	9.80	44.55	64.57	60.67	0.42
Control Group Banks	26	30.48	9.88	51.60	65.65	60.23	0.38
Δ		99.95**	-0.08	-7.05	-1.08	0.44	0.04

Table III
Adjustment of Core Tier 1 Ratios

Table III presents the estimates of the change in core tier 1 ratios and its components around the 2011 EBA capital exercise. The dependent variables are the change in the core tier 1 ratio, the change in the logarithm of core tier 1 capital and the change in the logarithm of the risk-weighted assets. The first row contains the difference in the outcome variable for EBA banks between the before (2009 and 2010) and the after (2012 and 2013) period, and the second row contains difference in the outcome variable for matched control group banks over the same period. The paper tests for differences-in-means using the Welch two-sample t-test. The third row contains the DID estimate comparing the treatment group of EBA banks to the matched control group. The unmatched difference-in-difference estimates are computed via a two sample t-test for the change in the outcome variable. The fourth row contains the estimate for the average treatment effect on the treated (ATT) based on the bias-adjusted Mahalanobis matching estimator (Abadie and Imbens, 2002). Panel A presents the results for the the baseline matching strategy, Panel B the results for the overlap sample matching strategy, Panel C presents the results for the within country matching strategy and Panel D the results for the within region matching strategy *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

Dependent Variable	ΔCT1 Ratio	ΔLog CT1 Capital	ΔLog RWA
	(1)	(2)	(3)
Panel A: Baseline Matching			
EBA Banks: Before - After	3.02***	0.19***	−0.10***
Control Group: Before - After	1.79***	0.17***	0.03
DID: EBA vs. Control Group	1.23***	0.02	−0.13***
Matching Estimator (ATT)	1.85***	0.02***	−0.16***
Number of observations	48	48	48
Panel B: Alternative Matching Strategy 1 (Overlap Matching)			
EBA Banks: Before - After	3.08***	0.18***	−0.11***
Control Group: Before - After	2.40***	0.29***	0.08**
DID: EBA vs. Control Group	0.68	−0.11**	−0.19***
Matching Estimator (ATT)	0.71	−0.10	−0.19**
Number of observations	36	36	36
Panel C: Alternative Matching Strategy 2 (Within Country Matching)			
EBA Banks: Before - After	3.16***	0.17***	−0.10***
Control Group: Before - After	2.26***	0.21***	0.02
DID: EBA vs. Control Group	0.90	−0.04	−0.12**
Matching Estimator (ATT)	1.05*	−0.09*	−0.16***
Number of observations	26	26	26
Panel D: Alternative Matching Strategy 3 (Within Region Matching)			
EBA Banks: Before - After	3.16***	0.17***	−0.10***
Control Group: Before - After	2.13***	0.25***	0.05***
DID: EBA vs. Control Group	1.03***	−0.08***	−0.15***
Matching Estimator (ATT)	1.02**	−0.07	−0.14**
Number of observations	26	26	26

Table IV
Adjustment of Core Tier 1 Ratios of Low- and High-Capitalized Banks

Table IV presents the estimates of the change in core tier 1 ratios and its components around the 2011 EBA capital exercise for the subsample of lowly (Panel A) and highly (Panel B) capitalized banks. Banks are defined as lowly (highly) capitalized if they exhibit a core tier 1 ratio below (above) 9 percent as of end of 2010 prior to the capital exercise. The dependent variables are the change in the core tier 1 ratio, the change in the logarithm of core tier 1 capital and the change in the logarithm of the risk-weighted assets. The first row contains the difference in the outcome variable for EBA banks between the before (2009) and 2010) and the after (2012 and 2013) period, and the second row contains difference in the outcome variable for matched control group banks over the same period. The paper tests for differences-in-means using the Welch two-sample t-test. The third row contains the DID estimate comparing the treatment group of EBA banks to the matched control group. The unmatched difference-in-differences were computed via a two sample t-test for the change in the outcome variable. The fourth row contains the estimate for the average treatment effect on the treated (ATT) based on the bias-adjusted Mahalanobis matching estimator (Abadie and Imbens, 2002) matching four Non-EBA banks to each EBA bank. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

Dependent Variable	ΔCT1 Ratio	ΔLog CT1	ΔLog RWA
	(1)	(2)	(3)
Panel A: Lowly Capitalized Banks			
EBA Banks: Before - After	3.75***	0.21***	−0.18***
Control Group: Before - After	1.73***	0.20***	0.01
DID: EBA vs. Control Group	2.02***	0.01	−0.19***
Matching Estimator (ATT)	−0.09	−0.98***	−1.02***
Number of observations	22	22	22
Panel B: Highly Capitalized Banks			
EBA Banks: Before - After	2.40***	0.16***	−0.04*
Control Group: Before - After	2.09***	0.19***	0.05
DID: EBA vs. Control Group	0.31	−0.03	−0.09***
Matching Estimator (ATT)	1.24*	0.01	−0.10**
Number of observations	26	26	26

Table V
Asset Reduction versus Asset Shrinking

Panel A of Table V presents the estimates of the percentage point change in measures associated with risk reduction behavior. The dependent variables are the *change in the ratio of risk-weighted assets over total assets* and the *change in the ratio of loan loss reserves over total net customer loans*. Panel B of Table V presents the estimates of the percentage change in measures associates with asset shrinking. The dependent variables are the emphchange in the logarithm of total assets, the emphchange in the logarithm of total net customer loans and the emphchange in the logarithm of total securities.The first row in each panel contains the difference in the outcome variable for EBA banks between the before (2009 and 2010) and the after (2012 and 2013) period, and the second row in each panel contains difference in the outcome variable for matched control group banks over the same period. The paper tests for differences-in-means using the Welch two-sample t-test. The third row in each panel contains the DID estimate comparing the treatment group of EBA banks to the matched control group. The unmatched difference-in-difference were computed via a two sample t-test for the change in the outcome variable. The fourth row in each panel contains the estimate for the average treatment effect on the treated (ATT) based on the bias-adjusted Mahalanobis matching estimator (Abadie and Imbens, 2002) matching four Non-EBA banks to each EBA bank. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

Panel A: Risk Reduction

Dependent Variable	Δ (RWA/TA)	Δ (LLR/ Cust.Loans)
	(1)	(2)
EBA Banks: Before - After	-5.93^{**}	1.53^{***}
Control Group: Before - After	-4.12^{**}	1.08^{**}
DID: EBA vs. Control Group	-1.81^{*}	0.45
Matching Estimator (ATT)	-0.57	0.69
Number of observations	193	164

Panel B: Asset Shrinking

Dependent Variable	ΔLog Total Assets	ΔLog Cust. Loans	ΔLog Total Securities
	(1)	(2)	(3)
EBA Banks: Before - After	0.03	0.01	0.07
Control Group: Before - After	0.10^{***}	0.08^{**}	0.15^{***}
DID: EBA vs. Control Group	-0.07^{**}	-0.07^{**}	-0.08
Matching Estimator (ATT)	-0.14^{***}	-0.12^{***}	-0.17^{**}
Number of observations	193	193	193

Table VI
Syndicated Lending: Intensive Margin

Table VI presents the estimates of the change in lending around the 2011 EBA capital exercise. All quarterly data for a given firm cluster are collapsed to a single before and after period. The dependent variable in all specifications is the change in the loan exposure of bank b in country i to firm cluster j between the period before (2010q2-2011q2) and after (2012q3-2013q3) the EBA capital exercise. The intensive margin sample includes firm clusters to which banks lend before and after the after the capital exercise. Bank characteristics include: Total Assets, CT1 Capital Ratio, Total Deposits / TA, Customer Loans / TA, Net Interest Income / Operating Revenue, and Net Income / TA, measured in the before period. Standard errors are clustered at the bank level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

	(1)	(2)	(3)	(4)	(5)
EBA Bank	-0.14^{**}	-0.25^{**}	-0.26^{***}	-0.27^{***}	-0.27^{***}
	(0.06)	(0.10)	(0.10)	(0.10)	(0.09)
Bank Country FE	YES	YES	YES	YES	YES
Bank Characteristics		YES	YES	YES	YES
Borrower Country FE			YES	YES	
SIC FE				YES	
Borrower Country x SIC FE					YES
Treatment Banks	45	45	45	45	45
Control Group Banks	44	44	44	44	44
Adjusted R^2	0.03	0.03	0.06	0.08	0.29
Observations	2,254	2,254	2,254	2,254	2,254

Table VII
Syndicated Lending: Extensive Margin

Table VII presents the estimates of the entry and exit of firm clusters (from borrowing) around the 2011 EBA capital exercise. Columns (1)-(3) study the exit of banks and include all bank firm-clusters with outstanding exposures before the capital exercise. The outcome variable in columns (1)-(3) is *exit* and takes the value of 1 if bank b in country i stops lending to firm cluster j after the EBA capital exercise, and 0 otherwise. Columns (4)-(6) study the entry of banks and include all bank firm-clusters with outstanding exposures after the capital exercise. Bank characteristics include: Total Assets, CT1 Capital Ratio, Total Deposits / TA, Customer Loans / TA, Net Interest Income / Operating Revenue, and Net Income / TA, measured in the before period. Standard errors are clustered at the bank level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

Dependent Variable	Exit			Entry		
	(1)	(2)	(3)	(4)	(5)	(6)
EBA Bank	−0.02	0.04	0.03	−0.11***	−0.03	−0.02
	(0.02)	(0.04)	(0.03)	(0.03)	(0.03)	(0.03)
Bank Country FE	YES	YES	YES	YES	YES	YES
Bank Characteristics		YES	YES		YES	YES
Borrower Country x SIC FE			YES			YES
Treatment Banks	45	45	45	45	45	45
Control Group Banks	45	45	45	50	50	50
Adjusted R^2	0.01	0.02	0.23	0.07	0.08	0.28
Observations	2,439	2,439	2,439	2,469	2,469	2,469

Table VIII
Firm-Level Outcomes

Table VIII presents the estimates of the firm real effect of the 2011 EBA capital exercise. The dependent variables are ΔLog Total Assets, ΔLog Fixed Assets, ΔLog Number of Employees and ΔLog Sales in Panels A-D respectively. The sample consist of the sample consists of all firms in the intersection of DealScan and Amadeus, located in one of the EBA supervised countries. EBA borrowing share is the fraction of the total outstanding syndicated loans provided by EBA banks. Firm-level controls include the total asset size. All firm-level control variables measured in 2010. Regressions include in addition borrower country fixed effects and industry fixed effects. Standard errors are clustered at the industry x country level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

Panel A: Δ Log Total Assets	(1)	(2)	(3)	(4)	(5)	(6)
					Non-Listed Firms	Listed Firms
EBA Borrowing Share	−0.07***	−0.07***	−0.08***	−0.11***	−0.14**	−0.04
	(0.02)	(0.02)	(0.02)	(0.03)	(0.05)	(0.05)
Firm-Level Controls		YES	YES	YES	YES	YES
Borrower Country FE			YES	YES	YES	YES
Industry FE				YES	YES	YES
Number of Firms	1,655	1,655	1,655	1,655	1,201	454

Panel B: Δ Log Fixed Assets	(1)	(2)	(3)	(4)	(5)	(6)
					Non-Listed Firms	Listed Firms
EBA Borrowing Share	−0.10***	−0.11***	−0.11***	−0.11***	−0.13**	−0.07
	(0.03)	(0.03)	(0.03)	(0.03)	(0.04)	(0.05)
Firm-Level Controls		YES	YES	YES	YES	YES
Borrower Country FE			YES	YES	YES	YES
Industry FE				YES	YES	YES
Number of Firms	1,655	1,655	1,655	1,655	1,201	454

Table VIII (cont.)

Panel C: Δ Number of Employees	(1)	(2)	(3)	(4)	(5) Non-Listed Firms	(6) Listed Firms
EBA Borrowing Share	−0.02	−0.03	−0.03	−0.03	−0.04	0.01
	(0.03)	(0.03)	(0.02)	(0.02)	(0.03)	(0.04)
Firm-Level Controls		YES	YES	YES	YES	YES
Borrower Country FE			YES	YES	YES	YES
Industry FE				YES	YES	YES
Number of Firms	1,655	1,655	1,655	1,655	1,201	454

Panel D: Δ Log Sales	(1)	(2)	(3)	(4)	(5) Non-Listed Firms	(6) Listed Firms
EBA Borrowing Share	−0.08**	−0.08**	−0.08**	−0.08**	−0.08**	0.05
	(0.03)	(0.03)	(0.03)	(0.03)	(0.05)	(0.06)
Firm-Level Controls		YES	YES	YES	YES	YES
Borrower Country FE			YES	YES	YES	YES
Industry FE				YES	YES	YES
Number of Firms	1,655	1,655	1,655	1,655	1,201	454

Table IX
The Placebo Test: Changes in Core Tier 1 Ratios between 2009-2010

Table IX presents the estimates of the change in core tier 1 ratios and its components around the 2011 EBA capital exercise using an alternative time window. The outcome variable in the first column is the *change in the core tier 1 ratio*, in the second column the *change in the logarithm of core tier 1 capital* and in the third column the *change in the logarithm of the risk-weighted assets*. The first row contains the difference in the outcome variable for EBA banks between the before (2009) and the after (2010) period, and the second row contains difference in the outcome variable for matched control group banks over the same period. The paper tests for differences-in-means using the Welch two-sample t-test. The third row contains the DID estimate comparing the treatment group of EBA banks to the matched control group. The unmatched difference-in-differences were computed via a two sample t-test for the change in the outcome variable. The fourth row contains the estimate for the average treatment effect on the treated (ATT) based on the bias-adjusted Mahalanobis matching estimator (Abadie and Imbens 2002) matching four Non-EBA banks to each EBA bank. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

Dependent Variable	ΔCT1 Ratio	ΔLog CT1 Capital	ΔLog RWA
	(1)	(2)	(3)
Panel A: Baseline Matching			
EBA Banks: Before - After	0.53	0.06***	0.01
Control Group: Before - After	0.57	0.06**	0.03*
DID: EBA vs. Control Group	−0.04	0.00	−0.02
Matching Estimator (ATT)	0.17	−0.02	−0.06*
Number of observations	48	48	48

Table X
Standard Regression Tests

Table X presents the estimation results of the following difference-in-difference regression:

$$Y_{ict} = \alpha + \beta \cdot \text{EBA}_{ic} + \gamma \cdot \text{After}_t + \delta\,(\text{EBA}_{ic} \times \text{After}_t) + \sum_k \theta^k X_{i,t-1} + \eta_i + \eta_{ct} + \epsilon_{ict}$$

where Y_{ict} is the core tier one ratio of bank i in country c in year t. The variable EBA_{ic} takes on the value 1 for the 48 EBA banks and 0 for the 145 non-EBA banks in our base sample. The variable After_t takes on the value 1 for the years 2012 and 2013, and 0 for the years 2009 and 2010. In our favorite specification the paper includes bank fixed effects $_i$ and country-year fixed effects $_{(}ct)$. The dependent variable Y_{ict} is the core tier 1 ratio in Panel A, the logarithm of core tier 1 capital in Panel B, and the logarithm of risk-weighted assets in Panel C. The variable *Large Banks* takes on the value 1 for all banks large than the median EBA bank in terms of pre-treatment levels of total assets, and 0 otherwise. The variable *Deposit Funding* takes takes on the value 1 for all banks with a larger than median deposit share of total assets, and 0 otherwise. The variable *GIIPS* takes on the value 1 for banks from GIIPS countries, and 0 otherwise. Standard errors are clustered at the bank level. *, **, and *** indicate statistical significance at the 10%, 5%, and 1% level respectively.

Panel A: Core Tier 1 Ratio

	(1)	(2)	(3)	(4)	(5)
EBA × After	1.40***	1.53***	1.61***	1.66***	1.42***
	(0.37)	(0.34)	(0.38)	(0.37)	(0.40)
Large Banks × After			−0.15		
			(0.49)		
Deposit Funding × After				0.44	
				(0.38)	
EBA × After × GIIPS					0.41
					(0.80)
Bank Controls	YES	YES	YES	YES	YES
Bank FE	YES	YES	YES	YES	YES
Year FE	YES				
Country×Year FE		YES	YES	YES	YES
EBA Banks	48	48	48	48	48
Non-EBA Banks	145	145	145	145	145
Observations	749	749	749	749	749

Table X (cont.)

	(1)	(2)	(3)	(4)	(5)
Panel B: Log Core Tier 1 Capital					
EBA × After	0.05	0.05	0.04	0.06*	0.04
	(0.03)	(0.03)	(0.04)	(0.03)	(0.04)
Large Banks × After			0.01		
			(0.05)		
Deposit Funding × After				0.03	
				(0.03)	
EBA × After × GIIPS					0.04
					(0.07)
Bank Controls	YES	YES	YES	YES	YES
Bank FE	YES	YES	YES	YES	YES
Year FE	YES				
Country×Year FE		YES	YES	YES	YES
EBA Banks	48	48	48	48	48
Non-EBA Banks	145	145	145	145	145
Observations	744	744	744	744	744
Panel C: Log Risk-Weighted Assets					
EBA × After	−0.11***	−0.11***	−0.13***	−0.11***	−0.09***
	(0.03)	(0.03)	(0.04)	(0.03)	(0.03)
Large Banks × After			0.04		
			(0.05)		
Deposit Funding × After				0.02	
				(0.03)	
EBA × After × GIIPS					−0.08
					(0.07)
Bank Controls	YES	YES	YES	YES	YES
Bank FE	YES	YES	YES	YES	YES
Year FE	YES				
Country×Year FE		YES	YES	YES	YES
EBA Banks	48	48	48	48	48
Non-EBA Banks	145	145	145	145	145
Observations	749	749	749	749	749