Banking Supervision, Monetary Policy and Risk-Taking: Big Data Evidence from 15 Credit Registers*

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Abstract

We analyse the role of banking supervision for banks' risk-taking behaviour, and its interactions with monetary policy. We exploit a new, proprietary dataset based on 15 European credit registers, in conjunction with the centralization of bank supervision for some banks at the supranational level, over a period of unprecedented monetary policy action. We find that: (1) banks with higher ex-ante non-performing loans (NPL) supply more credit toward riskier firms, with *identical* effects for banks headquartered in stressed and non-stressed countries. Results are identical to considering a measure of NPL that excludes the borrower's industry, and also to the inclusion of a large set of controls, such as borrower-lending matching and time-varying unobserved borrower and lender fundamentals that explain 70 p.p. of the R-squared, thereby suggesting strong exogeneity of our results to credit demand and other bank characteristics; (2) For banks operating in stressed countries *only*, centralized supervision compresses lending to riskier firms, although by a smaller extent for banks with higher NPL. Effects are similar if we include only banks around the threshold of eligibility for centralized supervision, and effects are only significant after the centralization of supervision; (3) Monetary policy easing increases bank risk-taking, but– *only* in stressed countries– this is partly offset by centralized supervision, with weaker effects for banks with higher NPLs. Overall, results show that leveraging on multiple credit registers –as done in this paper for the first time– is crucial for analysing heterogeneous effects and for the external validity.

JEL: G01, G21, G28, E51, E52, E58.

Keywords: Supervision, risk-taking, non-performing loans, AnaCredit, monetary policy.

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* **This draft is from December 2018**. We would like to thank Luisa Carpinelli, Kristopher Gerardi, Victoria Ivashina, Atif Mian, Giorgio Primiceri, Ricardo Reis, Enrico Sette, Lars Svensson, conference participants at the ECB 2018 conference on Monetary Policy, 2018 annual meeting of the Central Bank Research Association (CEBRA), the 6th Workshop in Macro Banking and Finance (Alghero), Central Bank of Ireland Workshop on "Banking, Credit and Macroprudential policy: What Can We Learn from Micro Data?", and seminar participants at Bank of Portugal for their helpful comments and suggestions. We especially thank Maria Dimou for the excellent research assistance. The opinions in this paper are those of the authors and do not necessarily reflect the views of the European Central Bank or the Eurosystem. Peydró acknowledges financial support from both the Spanish Ministry of Economics and Competitiveness Feder EU (project ECO2015-68136-P) and the European Research Council Grant (project 648398). Carlo Altavilla, Miguel Bouchina and Frank Smets are from the European Central Bank. José-Luis Peydró is from ICREA-Universitat Pompeu Fabra, CREI, Barcelona GSE, Imperial College London and CEPR. Emails: Carlo Altavilla: carlo.altavilla@ecb.europa.eu; Miguel Boucinha: Miguel.Boucinha@ecb.europa.eu; José-Luis Peydró: jose.peydro@gmail.com; and Frank Smets: Frank.Smets@ecb.europa.eu.

1. Introduction

Public regulation is widespread in modern societies, with governments prevalently intervening throughout the marketplace (Stigler, 1971; Tirole, 2014). However, enforcement requires effective supervision (Laffont and Tirole, 1993). Supervision of banks is substantially more challenging than that of other industries (Dewatripont and Tirole, 1994), due to e.g. the opacity of bank assets (Morgan, 2002). The financial crisis highlighted this issue as the prevailing regulatory and supervisory framework proved ineffective in preventing excessive risk-taking, thereby fostering a policy debate on changes to the institutional setting. Part of this debate was focused on potential benefits of supranational supervision. Local supervisors may have better information than more centralized supervisors but, on the other hand, they may be more lenient, especially during crisis times. Hence, centralized (supranational) supervision may be less prone to capture and avoid national biases (Agarwal et al., 2014, Carletti et al. 2016; Repullo 2017).

In this paper we analyse the impact of supervision on bank risk-taking, in particular centralized versus local supervision. As monetary policy easing can induce banks to take on more risk (e.g. based on the risk-taking channel of monetary policy), we also analyse the interactions between banking supervision and monetary policy. The euro area provides an excellent context for empirical identification, as (i) there has been a change in the institutional setting, with the centralisation of bank supervision for some banks; (ii) there is a new, unique dataset consisting of the credit registers of 15 countries; (iii) there has been unprecedented monetary policy action during the last years; (iv) high levels of bank non-performing loans (NPLs), which emerge as a major problem in every financial crisis, constitute a crucial problem in Europe with substantial heterogeneity both across countries and (within countries) across banks.

Our results first show that banks with higher ex-ante NPLs supply more credit toward riskier firms. The estimated effects are *identical* for banks headquartered in stressed and non-stressed countries.[1] Second, banks operating *only* in stressed

[1] We define as "stressed" countries those whose 10-year sovereign yield exceeded 6% (or, equivalently, four percentage points above the German yield) for at least one quarter in our sample period. Specifically, throughout the paper, the term stressed countries refers to Italy, Spain, Ireland, Portugal and Slovenia; non-stressed countries are instead Germany, France, Austria, Belgium, Malta, Lithuania, Latvia and Slovakia. Non-euro-area countries are Romania and Czech Republic.

countries – but not those in other countries – reduce their lending to riskier firms when centrally supervised; in addition, this credit tightening for risky firms is attenuated for banks with higher NPLs. Third, monetary policy easing increases risk-taking, but in stressed countries this is partly offset by centralized supervision, with weaker effects for banks with a higher NPLs.

A key contribution of our paper is that, despite a large emerging literature on bank regulation, there is scant evidence on the implications of *supervision* for risk-taking, with no study focusing on the interactions between both supervision and monetary policies. Moreover, different from the literature that has exclusively analysed *all* banking questions using single credit registers, we show – using multiple credit registers – that important questions yield very different results across countries, though other ones yield identical results.[2] Therefore, multiple credit registers are not only crucial for achieving external validity of estimated effects but also for testing academic theories and assessing the effects of public policies.

In Section 2 we explain the institutional setting, data and empirical strategy. High levels of bank non-performing loans (NPLs) emerge as a crucial problem in every financial crisis and are nowadays a major problem and a supervisory priority in Europe, amounting to about €650 billion in June 2018 significantly down from more than €1 trillion at the end of 2014. However, this bank vulnerability is heterogeneous across Europe, with some countries holding a disproportionate amount of low quality legacy assets (e.g. Italy, Spain and Portugal).

As banks with higher NPL may lend (be matched) to riskier borrowers, a credit register with borrower-lender data is essential for identification. Moreover, as effects may be different across countries, multiple credit registers are also critical. Finally, monetary policy surprises and changes across time and banks in centralized versus country-level supervision are also crucial for identification.

Europe offers all these critical elements. We have access to 15 European credit registers. We use the unique confidential granular credit register data collected in the context of the AnaCredit preparatory phase by the European System of Central Banks. This data represents the only supervisory loan-level dataset available for many Euro

[2] Credit register data is necessary to separate credit demand and supply and also to isolate risk-taking.

area countries (although it also covers some non-Euro area countries). Data collection is biannual, covering loans to non-financial firms over the period from June-2012 to December-2017. The total number of observations is large: more than 280 million observations. We collapse our big data at the *bank-borrower-time* level, with information on e.g. bank NPLs, size, borrower risk, and loan volume. Given the significant cross-country heterogeneity in the Euro area, we analyse separately two groups of countries: "stressed" and "non-stressed". We also use non-euro area countries' credit registers for robustness, as a placebo test.

In November 2014 the Single Supervisory Mechanism became operational, a crucial step towards the European Banking Union. We assess this institutional change by exploiting the associated heterogeneity across time and banks. The criteria for classifying significant institutions to be supervised by the ECB (SSM) is based on bank size; in particular one of the following conditions should be satisfied: (i) total bank assets exceeding €30 billion (more precisely, €27 billion including the 10% margin of deviation); (ii) the ratio of total bank assets over GDP of the participating member state exceeding 20% (more precisely, 18% including the 10% margin of deviation); or (iii) among the three largest credit institutions in the participating member state. The first condition applies for large countries, whereas the other two apply for some smaller countries.

Moreover, since 2012 there have been unprecedented monetary policy actions with the introduction and subsequent recalibrations in (targeted) long-term liquidity provision operations, quantitative easing and negative interest rates. To compute the impact of monetary policy announcements on lending, we measure the surprise component of each policy action using high-frequency movements over a wide spectrum of maturities of the risk-free curve. Looking at the medium- and long-term part of the yield curve is crucial as some policy actions (e.g. the quantitative easing) mostly affect the long-end segment of the term structure whereby an analysis on monetary policy focusing on the short-term policy rate would largely underestimate the impact of the policy.

Exploiting the data at the *borrower-bank-time* level is crucial for controlling exhaustively for multiple unobserved heterogeneity, analysing risk-taking, and also allows to test whether our main bank-level risk measure is exogenous to a large set of

unobservables, including firm-level credit demand and other (bank and firm) fundamentals. First, as bank size is of crucial importance for ECB supervision, controlling fully for it is critical. Bank*time fixed effects (which are dummies for each bank in each time period) are essential as they fully capture not only observed time-varying characteristics such as bank size, value, profits, capital and liquidity, but also unobserved ones (e.g. business models). In addition, we also analyse the impact of supervision for a subset of banks with similar size around the threshold of eligibility for centralized supervision, or for the non-euro area countries, which are not included in the single supervisory mechanism. In the latter case, the hypothesis to test is the absence of any relationship between banks in non-euro area countries and the establishment of the centralised supervision in the euro area. Second, as banks with higher NPLs may be matched with riskier borrowers, bank*firm fixed effects are essential to control for sticky bank-firm lending relationships; and in addition, firm*time fixed effects control exhaustively for time-varying unobserved borrower fundamentals, notably firm-level credit demand, growth opportunities and risk. Moreover, if our main estimated coefficient changes (or not) when we include all these fixed effects (bank*time, firm*time and bank*firm), it will be crucial to measure how unobservables are correlated with bank NPL in explaining risk-taking (following the literature by Altonji et al., 2005).

In Section 3 we discuss our results.

First, higher ex-ante NPLs does not lead to overall changes in credit supply. More interestingly, banks with higher ex-ante NPL (even from other industries) increase risk-taking by supplying more credit to ex-ante riskier borrowers (proxied by worse credit history).[3] Despite the stark difference in the distribution of bank NPLs in stressed versus non-stressed Euro area countries, results are strikingly *identical* between the two groups of countries. Moreover, results are robust to very different set of controls, from no controls whatsoever to fully saturating the regressions with different sets of fixed effects. Importantly, the estimated coefficients are identical despite the R-squared increasing by more than 70 percentage points (p.p.) by including firm*time, bank*time and bank*firm fixed effects that control exhaustively for time-

[3] Results also show that lending in general is reduced to borrowers with higher ex-ante risk, with similar coefficient between banks in stressed and non-stressed countries.

varying unobserved borrower- and lender-level fundamentals, and time-invariant borrower-lender matching. Following the literature that Altonji et al (2005) started, and also the related Oster (2017)'s test, these results suggest strong exogeneity of our measure of bank NPL on credit supply to riskier borrowers to a huge set of unobservables, that explain for example firm-level overall credit demand and bank-level balance-sheet strength other than bank NPL.[4]

Second, centralisation of supervision at the ECB *only* changes risk-taking in stressed-countries, where centralised (ECB) supervision reduces the overall lending to riskier borrowers, though this credit tightening is reduced for banks with higher NPLs. Centralised supervision reduces overall risk-taking in stressed countries – that is, the direct effect of reducing lending to riskier borrowers dominates the weaker effects on the banks with higher NPLs. Estimated coefficients on the impact of bank NPLs on risk-taking depending on ECB supervision change across different specifications, showing the importance of controlling for unobserved heterogeneity. We exploit the change in the supervisory process from national to supranational, for treated versus non-treated banks (which remained supervised at the country level), and control also for bank*time fixed effects (in addition to the other fixed effects). Moreover, effects are similar if we include only banks around the threshold to be supervised by the ECB and are absent for banks in non-euro-area countries. Although the official establishment of the central supervisory authority (the SSM) took place in November 2014, banks had precise information on the regulatory change since October 2013, i.e. when the SSM Regulation was published and the comprehensive assessment was announced. Therefore, we tests the effective time from which centrally supervised banks changed their risk-taking behavior. Our results show that the change in the supply of loans towards weak borrowers by banks centrally supervised in stressed countries took place before the official establishment of the SSM while intensified as the supranational authority became operational.

Third, exploiting monetary policy surprises, measured as the impact on different segments of the term structure of risk-free rates around official ECB policy decisions, we find that monetary policy easing increases bank risk-taking, but only in stressed

[4] Our results show this exogeneity on a particular question (bank NPL to risky credit supply), of course not on all possible questions of bank NPLs.

countries this risk-taking is partly cancelled by centralized supervision, with weaker effects for banks with higher NPLs.

Our contribution to the literature is threefold.

First, to our knowledge, the large empirical literature on bank lending channel has analysed *all* banking questions using single credit registers (with previous literature even working with more aggregate data at either the country- or the bank-level).[5] A key contribution of this paper that goes beyond bank supervision and risk-taking consists of analysing all economic questions posed in the paper with multiple credit registers. This is crucial not only for identification but also for analysing heterogeneous effects across different countries. We show that some important academic and policy questions – although not all – yield very different results depending on the country analysed. External validity is important, and local estimates from single countries cannot always be generalized. In our case, we show that bank risk-taking is identical across banks headquartered in stressed and non-stressed countries, but results are totally different for risk-taking depending on centralized (supranational) versus local-level supervision, including the ones associated to the monetary policy transmission.[6]

Second, we contribute to the literature on supervision. There is scant evidence on bank supervision as there are substantially less institutional and policy changes in supervision than in regulation. In a path-breaking paper, Agarwal et al. (2014), analysing supervisory decisions of U.S. banking federal versus state supervisors, find that federal regulators are systematically tougher than state regulators. Our paper addresses a different question, and hence provides different, new findings. We analyse the difference between centralized and local supervision on new credit supply, and its interaction with monetary policy. We find that risk-taking decisions for banks operating in non-stressed countries are independent of the supervisory setting. Results are different for banks in stressed countries. In these countries, centralized (ECB)

[5] Aggregate data have severe limitations: for example, bank-level one cannot identify credit demand and supply. In addition, the use of multiple credit registers allow us to explore possible heterogeneous effects across the economies included in the study therefore substantially attenuating potential issues related to the external validity of the results obtained in the empirical analysis.

[6] Due to confidentiality constraints, we show the results for groups of countries (stressed and non-stressed) but not country-specific results.

supervision reduces the overall lending to riskier borrowers, but this credit tightening is reduced for the riskier banks (the ones with higher NPLs), similarly for monetary policy easing. In addition, there is a growing literature on the effects of bank NPLs (e.g., Accornero et al., 2017, and Angelini et al. 2017 for Italy). In line with this literature, we show that bank NPL are not key for overall credit supply, but we contribute by showing that bank NPLs are critical for risk-taking strategies.

Finally, we contribute to the large literature of the bank lending and risk-taking channels of monetary policy (e.g. Bernanke and Blinder, 1988 and 1992; Bernanke and Gertler, 1995; Kashyap and Stein, 2000; Adrian and Shin, 2009; Jimenez, Ongena, Peydró and Saurina, 2012 and 2014; Dell'Ariccia, Laeven and Suarez, 2017) by showing how the transmission of monetary policy through bank risk-taking depends on the level and nature of banking supervision.

2 Big Data

The analysis uses unique confidential granular credit data collected in the context of the AnaCredit preparatory phase by the European System of Central Banks. Importantly, this data represents the only credit register dataset available for more than one country. The dataset covers many euro area countries as well as some non-euro area countries. The Euro area countries included in are: Austria, Belgium, Germany, Spain, France, Ireland, Italy, Lithuania, Latvia, Malta, Portugal, Slovenia and Slovakia. Ireland, Latvia, Malta and Slovenia are excluded due to data quality issues. The European countries outside the euro area included in the dataset are the Czech Republic and Romania.

Data collection is biannual and covers the period from June-2012 to December-2017.[7] The total number of observations is extremely large: more than 280 million observations. This makes the dimension of the dataset unique and it thereby represents the most comprehensive dataset on loan contracts, as previous analysis has been conducted by using a single credit register. Moreover, the dataset includes information on important bank and borrower characteristics, in particular loan size, defaults, ex-

[7] Confidential data collected under Decision ECB/2014/6.

ante risk, the sector of activity of the borrowers, bank size and NPL ratios as well as whether a given bank is directly supervised by the ECB.

Table 1 reports, for each country, the granularity of the data (either borrower- or loan-level), the reporting threshold of the individual credit register, the initial number of observations available in the dataset and the final number of observation obtained after cleaning and harmonising the data. The table shows that notwithstanding the substantial data cleaning, about two thousand banks are operational in the selected countries over the sample used in the empirical analysis thereby providing ample cross-sectional variation.

Insert Table 1 here

Given the significant heterogeneity in the euro area participating economies, we conduct the empirical analysis separately for two groups of countries: "stressed" (Italy, Portugal, and Spain) and "non-stressed" (Austria, Belgium, France, Germany, Lithuania and Slovakia). We define as "stressed" – that is, subject to high sovereign stress – countries whose 10-year sovereign yield exceeded 6% (or, equivalently, four percentage points above the German yield) for at least one quarter in our sample period. As a third sample, we test the robustness of reslts using non-euro area countries.

Table 2 reports the descriptive statistics for the main variables used in the empirical analysis over the available sample for the two groups of countries. Significant cross-country heterogeneity emerges when looking at the average loan volumes (the total loans and credit lines at the borrower level in euro thousands) with the credit granted in stressed countries being substantially lower than the one in non-stressed countries: 500 vs. 1700 thousands euro, respectively. This difference in part reflects the higher reporting thresholds in non-stressed countries (as reported in Table 1).

Insert Table 2 here

The NPL ratio measures, for each bank, the share of non-performing loans to total loans. Borrower quality indicates, for each borrower, the ratio between credit exposures in arrears and total credit exposures. The definition of arrears i is

homogenous across countries and refers to the delayed principal amount or/and the delayed interest payments that are past due more than 90 days. Centralised supervision is a dummy variable that takes value one for banks supervised at supranational level (i.e. directly by the ECB) and zero for banks supervised at country level.

Figure 1 reports the aggregate measure of NPL in selected jurisdictions (panel A) and the same measure (panel B) for two groups of euro area countries. Looking at the time evolution of the NPL ratio across countries (Panel A) it seems evident that in all countries the stock of NPL had been growing before the great recession. In Japan, United Kingdom and the US the NPL ratio peaked in 2008 and then started to decrease, reaching lately levels in line with historical regularities. In the euro area, on the contrary, the NPL ratio continued to grow also after 2008, inverting the trend only in 2014, when the stock of NPL was more than €1 trillion, and steadily decreasing until June 2018 (the latest available observation).

The NPL ratio however, is highly heterogeneous across euro area countries.[8] Panel B shows the cumulative distribution of non-performing loan ratios in stressed countries (IT, ES, PT) and non-stressed countries (AT, BE, DE, LT, SK, FR), with different percentiles of NPL reported on the x-axis. The NPL ratio in stressed countries is substantially higher than in non-stressed countries. The distribution of NPL across banks for stressed countries seems to steadily diverge over the different percentiles, reaching a maximum of around 50% at the very end of the distribution. The median bank presents an NPL ratio just below 20%. The picture is completely different for the banks operating in non-stressed countries, where the NPL ratio is above 20% only at the 95th percentile. The median NPL is around 4% for banks in non-stressed countries. The distribution also shows a pronounced skewness whereby in the last 5% the share of deteriorated assets reaches almost 30% of the total bank exposures. The fact that the distribution of NPL in non-stressed countries is relatively more skewed implies that there is a smaller share of banks with relatively high NPL.

[8] It is important to notice that the definition of the ratio between non-performing exposure and total loans varies across countries. Depending on the national definition the NPL status might be defined as one of the following: i) non-performing but not in default; ii) default because of unlikely to pay; iii) default because of past due more than 90 days; iv) default because of both unlikely to pay and past due more than 90 days; v) default. Appendix X report the definition used for each country.

Insert Figure 1 here

Figure 2 shows that over the past recent years there has been a substantial improvement in asset quality (NPLs), especially for banks operating in financially stressed countries. Interestingly, the movement in the density approximation of the NPL distribution in non-stressed countries between 2014 and 2017 is concentrated in the upper tail of the distribution pointing to an improvement in the asset quality for banks that in 2014 had a high level of NPLs. For banks operating in stressed countries, instead, the distribution materially shifted to the left signalling a general improvement in the overall banking system.

Insert Figure 2 here

Importantly, the figure also highlights that there is substantial variation in NPL ratios across banks, both across stressed and non-stressed countries and also within each group of countries. In general, this variation appears to be larger than the one observed for other key balance sheet items like capital ratios and can be exploited in the empirical analysis for identification issues.

3 Empirical analysis

This section presents the empirical results of the paper and is divided into three subsections. First, the analysis focuses on the impact of NPLs on bank risk taking behaviour. Second, we concentrate on the effect that different levels of bank supervision (centralized vs. country-level supervision) might have on bank lending decisions. Finally, we study the interaction between banking supervision and monetary policy.

3.1 Bank NPL, lending and risk-taking

The first two questions we focus on in the empirical analysis are the following: Do banks with higher NPL reduce the supply of credit extended to non-financial firms? And, do banks with higher NPL divert credit supply towards riskier firms? To study the credit supply and risk-taking behaviour of banks, we exploit information on both

bank strength and borrower quality. Specifically, the regression model used in the analysis is the following:

$$Loans_{b,f,t} = \alpha^{FE} + \gamma NPL_{b,t-1} + \delta BQ_{f,t-1} + \beta\left(NPL_{b,t-1} \times BQ_{f,t-1}\right) + \epsilon_{b,f,t} \quad (1)$$

The dependent variable ($Loans_{b,f,t}$) is the (log-)credit granted (drawn and undrawn) by bank "b" to firm "f" at time "t". The explanatory variable ($NPL_{b,t-1}$) is the share of non-performing credit granted to total credit for bank "b" at time "t-1"; $BQ_{f,t-1}$ is a measure of borrower quality constructed for each borrower as the ratio between credit exposures in arrears and total credit exposures. This measure ranges between zero – when firms have no arrears – and one – when all of the firm's exposures are in arrears.[9] The regression model also includes an interaction term between NPL and borrower quality $\left(NPL_{b,t-1} \times BQ_{f,t-1}\right)$. In this specification, the hypotheses we want to test are three: (i) $\gamma < 0$, implying that higher ex-ante NPL compresses loan origination; (ii) $\delta < 0$, that would indicate a positive association between poor borrower quality (higher level of BQ) and lower credit availability (i.e. weaker firms tend to receive less credit); and (iii) $\beta > 0$, implying that banks with ex-ante higher NPL take on more risk by lending to riskier borrowers.

In our empirical analysis we use different fixed effects to control for possible confounding factors. All specifications include county-time fixed effects ($\alpha_{c,t}$) that account for all possible observed and unobserved heterogeneity due to country-specific factors – such as differences in the macro outlook, including demand conditions varying at country level, and possible differences in the definition of variables across countries. Bank (α_b) or bank*time ($\alpha_{b,t}$) fixed effects control for time-invariant and time-varying bank-specific characteristics, respectively. These fixed effects ensure that γ captures the effect of differences in bank NPL which are not confounded by other sources of bank heterogeneity.

A different set of fixed effects is used to identify whether a change in lending dynamics is driven by supply (bank-related) or demand (firm-related) factors. Firm

[9] An alternative is to construct a dummy variable that takes the value one if a firm has a least one exposure in arrears, and zero otherwise. Results would not change.

(α_f) or firm*time $(\alpha_{f,t})$ fixed effects control for firm-specific characteristics. Importantly, including firm*time fixed effects translates into controlling for time-varying firm-level specific demand and risk factors thereby ensuring that the results capture supply side variation (see Khwaja and Mian, 2008). A possible caveat of including firm*time fixed effects is that this restricts the analysis to firms with multiple lending relationships. Figure A1 shows the share of borrowers with multiple lending relationships, ranging from 10 to just below 50%. Panel B of the figure shows that in terms of credit volume the share of multiple lending relationships is significantly higher, ranging from around 40 to close to 90%. In order to capture also firms with single lending relationships, we also estimate specifications using sector*time $(\alpha_{s,t})$ fixed effects to account for unobserved heterogeneity in demand and risk across sectors. The sectors of economic activity are grouped according to the 2-digit NACE2 industrial classification (i.e. we have 99 sectors).

Finally, bank-firm $(\alpha_{b,f})$ fixed effects control for possible (time-invariant) non-random matching between lenders and borrowers. The inclusion of these fixed effects implies that our estimates are identified by the time variation in lending within a bank-firm relationship. An example for why these controls are important is that a bank's ex-ante assessment of the creditworthiness of a borrower may persistently differ from that of another bank: a bank might simply believe that a firm is relatively safe (or have private information on it) and thereby be more willing to lend to it. At the same time, a firm might have a persistent preference towards a specific bank.

Results are reported in Table 3. The different set of fixed effects used in each of the 8 estimated specifications is indicated at the bottom of the table and also reported, for ease of interpretation, in the second row of the table.

Insert Table 3 here

The results highlight that the stock of NPL accumulated by a given bank is not negatively associated with loan supply. In general, the significance of relationship between stock of NPL and bank lending is not robust across the different specifications. For example, for banks headquartered in stressed countries, when

adding firm*time fixed effects the coefficient is not statistically different from zero.[10] In non-stressed countries there is no relationship whatsoever between lending origination and asset quality. These results are intuitive as the importance of the demand factors in stressed countries are most likely playing a major role in determining credit developments while in non-stressed countries the more resilient macroeconomic environment makes the additional control for individual firm demand less relevant.

Importantly, in both groups of countries emerges a prudent behaviour of banks whereby they tend to originate less credit to ex-ante riskier borrowers ($\delta < 0$). However, this relationship is weaker for banks with a higher stock of NPL ($\beta > 0$). That is, banks with higher ex-ante NPL increase their risk-taking by originating more credit to ex-ante riskier borrowers (either proxied with worse credit history).[11]

Despite the stark difference in the distribution of bank NPL ratios in stressed and non-stressed Euro area countries, results are strikingly *identical* between these two groups of countries. Moreover, results are very robust across very different set of controls: moving from no controls whatsoever to fully saturating the regressions with different sets of fixed effects results remain unchanged. Importantly, the estimated coefficients are identical despite of the R-square increasing by more than 70 percentage points (p.p.) by including firm*time, bank*time and bank*firm fixed effects that control exhaustively for time-varying unobserved borrower- and lender-level fundamentals, and time-invariant borrower-lender matching. Following the literature that Altonji et al (2005) started, and also the related Oster (2017)'s test, these results suggest strong exogeneity of our measure of bank NPL on credit supply to riskier borrowers to a large set of observables and unobservables, that explain for example firm-level overall credit demand and bank-level balance-sheet strength other than bank NPL.[12]

Figure 3 illustrates the results reported in column 8 of Table 3. The figure reports the marginal effect of a deterioration in borrower quality for different percentiles of

[10] The coefficient is relatively high despite not being statistically significant. However, note that the estimated coefficient would be smaller if we would not interact NPL with borrower quality.
[11] Results also show that lending in general is reduced to borrowers with higher ex-ante risk, with similar coefficient between banks in stressed and non-stressed countries.
[12] Our results show this exogeneity on a particular question (bank NPL to risky credit supply), of course not on all possible questions of bank NPLs.

the bank's NPL ratio. At higher level of NPL a decrease in borrower quality still produces a decrease in lending even though the effect is larger for low NPL banks. Moreover, the relationship between lending and borrower quality is basically the same in stressed and non-stressed countries.

An important consideration to keep in mind when comparing the results between stressed and non-stressed countries is that the percentiles of the NPL distribution are substantially different for the two groups of countries. Indeed, for the same level of NPL, results are very similar across country groups.

Insert Figure 3 here

3.2 Risk taking and banking supervision

This subsection provides evidence on whether changes in the institutional design of supervisory activities influence bank risk-taking behaviour. More in particular, we ask whether banks' lending decision might be influenced by the level of direct supervision: centralised (i.e. driven by a supranational authority) or local (i.e. driven by national regulatory authorities).

On the 4th of November 2014, centralised supervision became operational in the euro area. More precisely, since then, while national supervisory authorities supervise banks that are classified as "less significant", the Single Supervisory Mechanism (SSM) of the ECB is responsible for direct supervision over the so-called "significant institutions". The criteria for classifying a bank as significant institutions were announced in March 2013 and calculated at the highest level of consolidation in year-end 2012. More precisely, in order for a bank to be included in the list of significant institution directly supervised by the SSM it should respect the following criteria: i) Total assets exceeds €30 billion (€27 billion as a 10% margin of deviation was also considered); ii) Ratio total assets over GDP of the participating Member State exceeds 20% (18% as a 10% margin of deviation was also considered); and, iii) Among the three largest credit institutions in a participating Member State.

The SSM of the ECB, more specifically, has several prudential tools that can be used to ensure the safety and soundness of the European banking system, including: carrying out supervisory reviews (including stress tests), conducting on-site

inspections and investigations, granting or withdrawing banking licences, authorising banks' acquisitions of qualifying holdings, ensuring compliance with EU prudential rules, setting higher capital requirements ("buffers") in order to counter any financial risks, and imposing corrective measures and sanctions.

With these institutional changes in mind, the main question we want to answer is the following: does centralised supervision, as opposed to country-level supervision, influence bank risk-taking behaviour? Econometrically, the model specification used to answer this question is the following:

$$Loans_{b,f,t} = \alpha^{FE} + \gamma NPL_{b,t-1} + \delta BQ_{f,t-1} + \theta Sup_{b,t-1} + \lambda\left(BQ_{f,t-1} \times Sup_{b,t-1}\right) + \phi\left(NPL_{b,t-1} \times BQ_{f,t-1} \times Sup_{b,t-1}\right) + \Omega X_{b,f,t-1} + \epsilon_{b,f,t} \quad (2)$$

Where in addition to the variables already included in equation (1), the model also includes a variable that accounts for the level of supervision of each individual bank. More specifically, the variable $Sup_{b,t}$ is a dummy variable that takes value 1 for banks directly supervised by the SSM ($bank\ b \in SSM$) and zero otherwise.

$$Sup_{b,t} = \begin{cases} 1 & if\ b \in SSM\ and\ t \geq Dec.2014 \\ 0 & otherwise \end{cases}$$

Finally, $X_{b,f,t-1}$ is a vector of explanatory variables that contains lower level of interactions among $NPL_{b,t-1}, BQ_{f,t-1}, Sup_{b,t-1}$. The main hypotheses we want to test are the following: (i) $\lambda < 0$, once a bank becomes supervised by the SSM it lends to higher quality borrowers; and (ii) $\phi < 0$, being directly supervised by the SSM dampens the association between weak (high NPL) banks and riskier (low quality) borrowers. The results are reported in Table 4. The different set of fixed effects used in each specification is reported at the bottom of the table and also in the third row, for ease of interpretation.

Insert Table 4 here

The estimated coefficients reported in Table 4 indicate that centralised supervision is associated with lower lending to ex-ante riskier firms ($\lambda < 0$), especially in stressed countries. Moreover, in non-stressed countries, different from banks operating in stressed countries, this relationship seems to be driven by firm-specific factors, since when firm*time fixed affects are introduced (column 4) the size of the coefficient drops to virtually zero and loses statistical significance. Moreover, for banks operating in stressed countries and supervised at supranational level, the credit tightening for riskier firms is less pronounced when they have higher NPLs ($\phi > 0$). For banks in non-stressed countries, being centrally supervised does not impact credit supply to ex-ante riskier firms regardless of the bank's asset quality. All in all, supra-national supervision reduces overall risk-taking in stressed countries – that is, the direct effect of reducing lending to riskier borrowers dominates the weaker effects on the banks with higher NPLs.

Note that we exploit the change in the supervisory process from national to supranational, for treated versus non-treated banks (which remained supervised at the country level), and control also for bank*time fixed effects (in addition to the other fixed effects). Moreover, effects are similar if we include only banks around the threshold to be supervised by the ECB and are absent for banks in non-euro-area countries (see Table 5).

Insert Table 5 here

A graphical quantification of the estimated results reported in column 1 and 3 of Table 4 is presented in Figure 4. In this specification we use country*time, bank*time, bank*firm, and sector*time fixed effects, thereby allowing for firms with single lending relationships to be included in the sample. The figure reports, for different quantiles of bank NPL, the estimated effect of a deterioration of the ex-ante risk quality of borrowers. The figure shows that the results are economically significant: for a bank with median NPL operating in stressed countries, becoming centrally supervised leads to a 40% decrease in the lending to a firm with the lowest quality ($BQ = 1$) as compared to lending to a high quality firm ($BQ = 0$). For a one standard deviation deterioration in borrower quality this difference would be 8%.

Insert Figure 4

When introducing firm*time fixed effects (columns 2 and 4 of Table 4) the results change, especially for banks in non-stressed countries. Figure 5 illustrates the results for the specification with the strictest possible control for demand (i.e. controlling for country*time, bank*time, bank*firm, and firm*time fixed effects). It reports for both stressed and non-stressed countries the difference between centralised- and country-level supervision in the reaction of bank lending to a deterioration in the quality of their borrowers (from 0 to 1). This is assessed by exploiting the distribution of bank NPL, also highlighting (with solid line) the values of NPL corresponding to the interquartile range for the respective group of countries. The dashed lines evaluate the reaction of bank lending for NPL values corresponding to the interquartile range of the other group of countries.

The results points to strong cross-country heterogeneity. In stressed countries, becoming directly supervised at centralised level leads to a stronger decline in lending to riskier borrowers, especially for banks with low NPL. In non-stressed countries, the differences between the two levels of supervision in this specification is not economically or statistically significant.

Insert Figure 5

This result suggests that for this group of countries this relationship seems to be driven by firm-specific factors, since it is the introduction of firm*time fixed effects that leads the size of the coefficient to drop to virtually zero and lose statistical significance.

While the centralized supervisory authority became fully operational in November 2014, banks learned that they would become centrally supervised in October 2013, when the SSM Regulation was published and the comprehensive assessment was announced. Since this could have already influenced bank behavior, we further investigate since when centrally supervised banks changed their risk-taking behavior. Results in Figure 6 document that banks operating in stressed countries reduced their exposure towards weak firms already in 2013Q4. Importantly, the estimated

coefficient for the impact of supervision on risk-taking (BQ*Sup) in 2013Q2 in not significant in statistic or economic terms. On the contrary, moving ahead from 2013Q4 to 2015Q2 the coefficients become statistically significant with their size gradually increasing. This suggests that while banks effectively reacted to changes in supervision in 2013Q4, the intensity of their reaction kept increasing as the central supervisory mechanism was effectively established.

Insert Figure 6

In other words, the estimated change in the supply of loans towards weak borrowers happened already before the official establishment of the SSM, and intensified as the supranational authority became operational.

3.3 Banking supervision and monetary policy interactions

The final question we address is whether banks with higher NPL shift their credit supply to ex-ante riskier borrowers following periods of monetary policy accommodation, and how these effects interact with centralised vs local supervision.

Measuring the effects of monetary policy shocks in an environment where central banks have announced and implemented both conventional and unconventional policies poses special challenges. This is because we cannot rely on a single interest rate proxying the policy rate and providing information on the amount of policy accommodation provided by the monetary authority. In fact, as shown in Altavilla et al. (2018), while conventional monetary policy moves the front end of the yield curve, some unconventional measures exert a larger impact on longer maturities. Therefore, to fully capture the extent of policy easing provided by the central bank we proceed as follows. We construct a variable, $Shock^{MP}$, that measures the principal component of all monetary policy surprises from high-frequency intraday data on risk-free (overnight index swap, OIS) rates with different maturities, ranging from 1 month to 10 years. These surprises are calculated by measuring changes in risk free rates in a narrow time window around official monetary policy communications (see Altavilla et al. 2018). More precisely, we first measure from each Governing Council meeting the associated policy surprise as the principal component of OIS yield changes from 30

minutes before the press release to 30 minutes after the press conference, and then we cumulate them to match the frequency of the credit registers (biannual). As a result we obtain an indicator of policy surprises where positive (negative) numbers indicate monetary policy tightening (easing).

We use this variable in the following specification to study whether monetary policy easing has some amplification effect on the risk-taking behaviour of European banks:

$$\begin{aligned} Loans_{b,s,f,t} = {} & \alpha^{FE} + \gamma NPL_{b,t-1} + \delta BQ_{f,t-1} + \theta Sup_{b,t-1} + \mu Shock_{t-1}^{MP} \\ & + \psi\left(Shock_{t-1}^{MP} \times BQ_{f,t-1}\right) \\ & + \eta\left(Shock_{t-1}^{MP} \times BQ_{f,t-1} \times Sup_{b,t-1}\right) \\ & + \chi\left(Shock_{t-1}^{MP} \times BQ_{f,t-1} \times NPL_{b,t-1}\right) \\ & + \rho\left(Shock_{t-1}^{MP} \times BQ_{f,t-1} \times NPL_{b,t-1} \times Sup_{b,t-1}\right) + \Omega X_{b,f,t-1} \\ & + \epsilon_{b,s,f,t} \end{aligned} \tag{3}$$

Where $X_{b,f,t-1}$ includes all remaining double and triple interactions. The above model can be used to test whether monetary policy easing tends to increase lending towards riskier firms ($\psi < 0$) and whether centralized supervision can contrast this effect ($\eta > 0$). In addition, we are interested in analysing whether banks with higher NPLs behave differently. In other words, monetary accommodation might lead to a relative increase in risk-taking by weaker banks ($\chi > 0$) that can be however mitigated by centralized supervision ($\rho < 0$).

Table 6 reports the results for the different specifications varying according to the specific set of fixed effects introduced in the model as done in the previous tables. The results confirm that, overall, banks tend to originate less credit to ex-ante riskier borrowers and that banks with higher NPLs lend relatively more to riskier firms. Monetary easing activates risk-taking behavior by banks, whereby they originate more lending towards riskier firms. Importantly, this effect tends to be canceled by centralized supervision when banks operate in stressed countries. This does not happen in non-stressed countries. When focusing on the interaction between monetary policy and supervision for banks with higher NPLs, an additional interesting result emerges. Following a monetary policy easing, weaker banks increase relatively more their exposure to riskier firms, but only in stressed countries. Also in this case, centralized

supervision tends to cancel out the relative increase in risk-taking by weak banks. This does not happen in non-stressed countries.

Insert Table 6 here

All in all, exploiting monetary policy surprises, we find that while in general monetary policy easing tends to increase bank risk-taking, in stressed countries this risk-taking is partly cancelled by centralized supervision, with weaker effects for banks with higher NPLs.

4 Conclusions

Using a unique dataset comprising many credit registers and different policy changes, we analyse the impact of bank supervision on risk-taking, and its interactions with monetary policy. Different from the literature that has exclusively analysed *all* banking questions using single credit registers, we show – using multiple credit registers – that important questions yield very different results across countries, though other ones yield identical results. This is not only crucial for achieving external validity of estimated effects but also for testing academic theories and assessing the effects of public policies. In particular, we establish three sets of results for the euro area banking system.

First, banks with higher ex-ante NPL (even from other industries) increase risk-taking by supplying more credit to ex-ante riskier borrowers. Despite the different variation across bank NPLs within stressed versus non-stressed euro area countries, results are strikingly identical between the two groups of countries. Moreover, results are robust across specifications with very different set of controls, from no controls whatsoever to fully saturating the regressions with different sets of fixed effects. Following the literature that Altonji et al (2005) started, and also the related Oster (2017)'s test, these results suggest strong exogeneity of our measure of bank NPL on credit supply to riskier borrowers to a huge set of observable and unobservables, that explain for example firm-level overall credit demand and bank-level balance-sheet strength other than bank NPL.

Second, centralisation of supervision at the ECB only changes risk-taking in stressed-countries, where centralised (ECB) supervision reduces the overall lending to

riskier borrowers, though this credit tightening is reduced for banks with higher NPLs. Centralised supervision reduces overall risk-taking in stressed countries – that is, the direct effect of reducing lending to riskier borrowers dominates the weaker effects on the banks with higher NPLs. Moreover, effects are similar if we include only banks around the threshold to be supervised by the ECB and are absent for banks in non-euro-area countries.

Third, exploiting monetary policy surprises, measured as the impact on different segments of the term structure of risk-free rates around official ECB policy decisions, we find that monetary policy easing increases bank risk-taking, but only in stressed countries this risk-taking is partly cancelled by centralized supervision, with weaker effects for banks with higher NPLs.

References

Accornero M., P. Alessandri, L. Carpinelli and A.M. Sorrentino (2017) Non-performing loans and the supply of bank credit: evidence from Italy, *Bank of Italy Occasional Paper Number 374*.

Adrian T, and HS Shin (2009) Financial Intermediaries and Monetary Economics, *Handbook of Monetary Economics*, pp. 601-650.

Agarwal Sumit, David Lucca, Amit Seru, Francesco Trebbi (2014) Inconsistent Regulators: Evidence from Banking, *The Quarterly Journal of Economics*, Volume 129, Issue 2, 1 May 2014, Pages 889–938.

Altavilla Carlo, Luca Brugnolini, Refet Gürkaynak, Roberto Motto, and Giuseppe Ragusa (2018), Measuring Euro Area Monetary Policy, *ECB Working Paper forthcoming*

Altonji Joseph G., Todd E. Elder, and Christopher R. Taber (2005), "Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic Schools," *Journal of Political Economy* 113, no. 1 (February 2005): 151-184.

Angelini Paolo, Marcello Bofondi, and Zingales Luigi (2017) The Origins of Italian Non-Performing Loans, mimeo.

Bernanke, Ben S., and Alan S. Blinder, 1988, Credit, money, and aggregate demand, *American Economic Review* 78, 435–439.

Bernanke, Ben S., and Alan S. Blinder, 1992, The federal funds rate and the channels of monetary transmission, American Economic Review 82, 901–921.

Carletti Elena, Giovanni Dell'Ariccia, Robert Marquez (2016) Supervisory Incentives in a Banking Union, *IMF Working Papers 16/186*, International Monetary Fund.

Dell'Ariccia, Giovanni, Luc Laeven, and Gustavo Suarez, 2017, Bank leverage and monetary policy's risk-taking channel: Evidence from the United States, *Journal of Finance* 72, 613–654.

Dewatripont and Tirole, 1994, *The Prudential Regulation of Banks*, MIT Press.

Kashyap, Anil K., and Jeremy C. Stein, 2000, What do a million observations on banks say about the transmission of monetary policy? *American Economic Review* 90, 407–428. Khwaja, A I and A Mian (2008), "Tracing the impact of bank liquidity

shocks: Evidence from an emerging market," *The American Economic Review* 98: 1413-1442.

Jiménez Gabriel, Steven Ongena, José-Luis Peydró, Jesús Saurina (2012), "Credit supply and monetary policy: identifying the bank balance-sheet channel with loan applications", *American Economic Review*, 102(5): 2301-2326.

Jiménez Gabriel, Steven Ongena, José-Luis Peydró, Jesús Saurina (2014), Hazardous Times for Monetary Policy: What Do Twenty-Three Million Bank Loans Say About the Effects of Monetary Policy on Credit Risk-Taking?, *Econometrica*, Volume82, Issue2, Pages 463-505.

Laffont Jean-Jacques and Jean Tirole, 1993, A Theory of Incentives in Procurement and Regulation, MIT press.

Morgan, Donald, P. 2002. "Rating Banks: Risk and Uncertainty in an Opaque Industry" *American Economic Review*, 92 (4): 874-888.

Oster (2017) Unobservable Selection and Coefficient Stability: Theory and Evidence, *Journal of Business & Economic Statistics*, DOI: 10.1080/07350015.2016.1227711

Repullo Rafael (2017) Hierarchical Bank Supervision, *CEPR Discussion Paper No. DP12475.*

Stigler, G. (1971). The economic theory of regulation. *Bell Journal of Economics* 2, 3-21.

Tirole Jean (2014): *Market power and regulation*, Nobel Prize Lecture.

Table 1: Sample composition

	Granularity	Reporting Threshold	Initial Sample (in million)	# of banks Original Sample	Final Sample (in million)	# of banks Final Sample
Austria	Borrower-level	350,000	1.4	1601	0.5	65
Belgium	Borrower-level	0	13.3	144	6.2	36
Germany	Borrower-level	1,000,000	11.1	1828	4.7	498
Spain	Borrower-level	6,000	23.6	283	16.7	133
France	Borrower-level	25,000	37.7	522	24.8	295
Ireland	Loan-level	500	4.3	4	-	-
Italy	Borrower-level	30,000	148.2	1576	28.2	731
Lithuania	Loan-level	290	0.3	166	0.3	11
Latvia	Loan-level	0	12.7	109	-	-
Malta	Loan-level	5,000	0.1	26	-	-
Portugal	Borrower-level	50	8.8	198	6.2	107
Slovenia	Loan-level	0	0.2	26	-	-
Slovakia	Borrower-level	0	0.9	30	0.6	11
Romania	Borrower-level	4,440	20.2	96	2	52
Czech Republic	Loan-level	0	4.8	41	1.5	18

Note: the table reports for each country the reporting threshold of the individual credit register, the initial number of observation available in the dataset and the final number of observation obtained after cleaning and harmonising the data.

Table 2: Descriptive statistics

	Stressed Countries			**Non-Stressed Countries**		
	Mean	**St.Dev.**	**# obs.**	**Mean**	**St.Dev.**	**# obs.**
Exposure	516	12,078	48,507,843	1,716	15,649	8,526,222
NPL ratio	0.20	0.10	48,507,843	0.05	0.04	8,526,222
Borrower Quality	0.05	0.18	40,470,644	0.03	0.15	6,369,053
Centralised Supervision	0.34	0.47	48,507,843	0.50	0.50	8,526,222

Note: the table reports the descriptive statistics for the main variables used in the empirical analysis. Exposure is the total loans and credit lines at the borrower level in euro thousands. NPL ratio measures for each bank the share of non-performing exposure to total exposure. Borrower quality indicates for each borrower the ratio between exposures in arrears and total exposures. Centralised supervision is a dummy variable that takes value one for banks supervised at supranational level (i.e. directly by the ECB) and zero for banks supervised at country level.

Table 3: Risk taking: NPL and borrower quality

		(1) ct	(2) ct b f	(3) ct b st	(4) ct b ft	(5) ct st bf	(6) ct ft bf	(7) ct bt st bf	(8) ct bt ft bf
Stressed Countries									
	$NPL_{b,t-1}$	0.379	-0.570*	-0.619*	-0.283	-0.734**	-0.562	-	-
		(0.257)	(0.328)	(0.349)	(0.365)	(0.363)	(0.424)		
	$BQ_{f,t-1}$	-0.448**	-0.506***	-0.690***	-	-0.591***	-	-0.624***	-
		(0.201)	(0.0790)	(0.187)		(0.0815)		(0.0816)	
	$NPL_{b,t-1}$ x $BQ_{f,t-1}$	2.273**	2.142***	3.452***	2.379***	2.078***	2.261***	2.311***	2.450***
		(0.979)	(0.452)	(0.828)	(0.677)	(0.452)	(0.670)	(0.414)	(0.574)
	N	39,789,655	39,606,210	39,789,655	29,708,250	39,129,239	28,984,523	39,129,239	28,984,523
	R-squared	0.0676	0.472	0.152	0.516	0.695	0.760	0.719	0.783
Non-Stressed Countries									
	$NPL_{b,t-1}$	2.997*	-0.989	-1.695	-0.127	-0.0171	-0.131	-	-
		(1.570)	(0.959)	(1.313)	(1.533)	(0.956)	(1.724)		
	$BQ_{f,t-1}$	-0.645***	-0.441***	-0.608***	-	-0.428***	-	-0.469***	-
		(0.184)	(0.0958)	(0.170)		(0.0829)		(0.0882)	
	$NPL_{b,t-1}$ x $BQ_{f,t-1}$	3.392**	1.644**	2.502***	4.238***	1.141	1.287	1.705**	2.473**
		(1.562)	(0.814)	(0.917)	(1.315)	(0.758)	(1.239)	(0.678)	(1.107)
	N	6,290,285	6,222,399	6,290,285	2,854,088	6,183,626	2,796,595	6,183,626	2,796,595
	R-squared	0.221	0.697	0.296	0.636	0.840	0.869	0.845	0.875
Fixed effects									
	Country*Time (ct)	Y	Y	Y	Y	Y	Y	Y	Y
	Bank (b)	-	Y	Y	Y	-	-	-	-
	Firm (f)	-	Y	-	-	-	-	-	-
	Bank*Firm (bf)	-	-	-	-	Y	Y	Y	Y
	Firm*Time (ft)	-	-	-	Y	-	Y	-	Y
	Sector*Time (st)	-	-	Y	-	Y	-	Y	-
	Bank*Time (bt)	-	-	-	-	-	-	Y	Y

Note: The dependent variable is the (log-)credit granted (drawn and undrawn) by bank "b" to firm "f" operating in sector "s" at time "t". NPL is the share of non-performing exposure to total exposure. BQ is the borrower quality and indicates for each borrower the ratio between exposures in arrears and total exposures. Data are at semi-annual for the period 2012H1 – 2017H2. Standard errors clustered at bank level in parentheses: * p<0.1, ** p<0.05, *** p<0.01.

Table 4: The role of Banking Supervision

	Stressed Countries		Non-Stressed Countries	
	(1)	(2)	(3)	(4)
	ct bt st bf	ct bt ft bf	ct bt st bf	ct bt ft bf
$BQ_{f,t-1}$	-0.346***	-	-0.238***	-
	(0.0718)		(0.0594)	
$NPL_{b,t-1}$ x $BQ_{f,t-1}$	1.830***	2.000***	1.341***	2.454**
	(0.362)	(0.471)	(0.466)	(0.970)
$BQ_{f,t-1}$ x $Sup_{b,t-1}$	-0.675***	-0.528***	-0.342**	0.0204
	(0.135)	(0.169)	(0.148)	(0.156)
$NPL_{b,t-1}$ x $BQ_{f,t-1}$ x $Sup_{b,t-1}$	1.524**	1.647*	-0.530	0.141
	(0.636)	(0.853)	(0.927)	(1.426)
N	39,129,239	28,984,523	6,183,626	2,796,595
R-squared	0.719	0.783	0.845	0.875
Fixed effects				
Country*Time (ct)	Y	Y	Y	Y
Bank*Firm (bf)	Y	Y	Y	Y
Firm*Time (ft)	-	Y	-	Y
Sector*Time (st)	Y	-	Y	-
Bank*Time (bt)	Y	Y	Y	Y

Note: The dependent variable is the (log-)credit granted (drawn and undrawn) by bank "b" to firm "f" operating in sector "s" at time "t". Data are at semi-annual covering an unbalanced sample of banks (971 for stressed countries and 916 for non-stressed countries) for the period 2012H1 – 2017H2. Standard errors clustered at bank level in parentheses: * p<0.1, ** p<0.05, *** p<0.01.

Table 5: Robustness

	Baseline		Robustness 2 (#SIx2)		Robustness 3 (6banks)	
	ct bt st bf	**ct bt ft bf**	**ct bt st bf**	**ct bt ft bf**	**ct bt st bf**	**ct bt ft bf**
Stressed Countries						
BQ x Sup	-0.675***	-0.528***	-0.678***	-0.280*	-0.467***	-0.653**
	(0.135)	(0.169)	(0.144)	(0.167)	(0.111)	(0.263)
NPL x BQ x Sup	1.524**	1.647*	1.327*	0.613	1.194	2.717
	(0.636)	(0.853)	(0.695)	(0.928)	(0.775)	(1.813)
N	39,129,239	28,984,523	26,054,982	16,498,109	4,132,517	1,405,138
R-squared	0.719	0.783	0.718	0.794	0.785	0.869
Non-Stressed Countries						
BQ x Sup	-0.342**	0.0204	-0.372**	0.0577	0.0682	-0.00243
	(0.148)	(0.156)	(0.156)	(0.197)	(0.134)	(0.275)
NPL x BQ x Sup	-0.530	0.141	-0.640	0.0796	-4.190*	0.553
	(0.927)	(1.426)	(1.121)	(1.508)	(2.140)	(2.667)
N	6,183,626	2,796,595	5,590,480	2,235,451	1,755,450	216,734
R-squared	0.845	0.875	0.847	0.878	0.858	0.878
Non-Euro Area Countries						
BQ x Sup	-0.201	-0.154	-0.242	0.361	-0.242	0.361
	(0.121)	(0.196)	(0.137)	(0.250)	(0.137)	(0.250)
NPL x BQ x Sup	0.0582	0.185	0.0721	0.781	0.0721	0.781
	(0.182)	(0.334)	(0.199)	(0.470)	(0.199)	(0.470)
N	2,378,536	1,152,117	1,430,393	349,429	1,430,393	349,429
R-squared	0.778	0.777	0.817	0.826	0.817	0.826
Fixed effects						
Country*Time (ct)	Y	Y	Y	Y	Y	Y
Bank*Firm (bf)	Y	Y	Y	Y	Y	Y
Firm*Time (ft)	-	Y	-	Y	-	Y
Sector*Time (st)	Y	-	Y	-	Y	-
Bank*Time (bt)	Y	Y	Y	Y	Y	Y

Note: The dependent variable is the (log-)credit granted (drawn and undrawn) by bank "b" to firm "f" operating in sector "s" at time "t". Data are at semi-annual covering an unbalanced sample of banks (971 for stressed countries and 916 for non-stressed countries) for the period 2012H1 – 2017H2. Standard errors clustered at bank level in parentheses: * p<0.1, ** p<0.05, *** p<0.01.

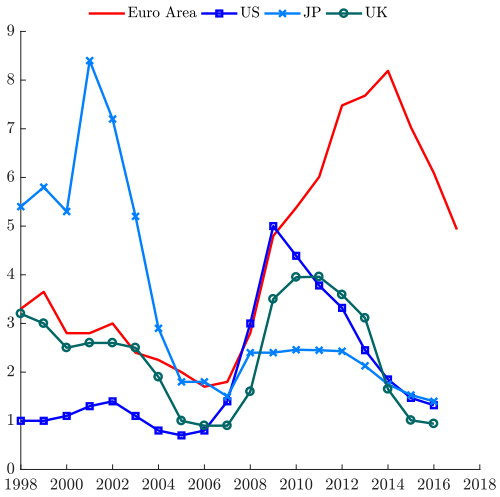
Table 6: Interaction between bank supervision and monetary policy

	Stressed Countries		Non-stressed Countries	
	(1)	(2)	(3)	(4)
	ct bt st bf	ct bt ft bf	ct bt st bf	ct bt ft bf
$BQ_{f,t-1}$	-0.360***		-0.239***	
	(0.0697)		(0.0592)	
$NPL_{b,t-1}$ x $BQ_{f,t-1}$	1.907***	2.092***	1.372***	2.285**
	(0.353)	(0.474)	(0.439)	(0.989)
$BQ_{f,t-1}$ x $Sup_{b,t-1}$	-0.642***	-0.464***	-0.318**	-0.00542
	(0.132)	(0.160)	(0.144)	(0.158)
$BQ_{f,t-1}$ x MP_{t-1}	-0.0172***		-0.0124***	
	(0.00661)		(0.00453)	
$NPL_{b,t-1}$ x $BQ_{f,t-1}$ x $Sup_{b,t-1}$	1.208*	0.997	-1.297	0.0862
	(0.624)	(0.859)	(0.864)	(1.561)
$NPL_{b,t-1}$ x $BQ_{f,t-1}$ x $Shock_{t-1}^{MP}$	0.0729*	0.102**	0.0186	-0.251*
	(0.0398)	(0.0470)	(0.0288)	(0.134)
$BQ_{f,t-1}$ x $Sup_{b,t-1}$ x $Shock_{t-1}^{MP}$	0.0246*	0.0353*	0.0204***	-0.0312**
	(0.0127)	(0.0205)	(0.00737)	(0.0143)
$NPL_{b,t-1}$ $BQ_{f,t-1}$ x $Sup_{b,t-1}$ x $Shock_{t-1}^{MP}$	-0.162**	-0.332***	-0.261**	0.181
	(0.0694)	(0.0893)	(0.103)	(0.174)
N	39129239	28984523	6183626	2796595
R-squared	0.719	0.783	0.845	0.875
Fixed effects				
Country*Time (ct)	Y	Y	Y	Y
Bank*Firm (bf)	Y	Y	Y	Y
Firm*Time (ft)	-	Y	-	Y
Sector*Time (st)	Y	-	Y	-
Bank*Time (bt)	Y	Y	Y	Y

Note: The dependent variable is the (log-)credit granted (drawn and undrawn) by bank "b" to firm "f" operating in sector "s" at time "t". Data are at semi-annual covering an unbalanced sample of banks (971 for stressed countries and 916 for non-stressed countries) for the period 2012H1 – 2017H2. Standard errors clustered at bank level in parentheses: * p<0.1, ** p<0.05, *** p<0.01.

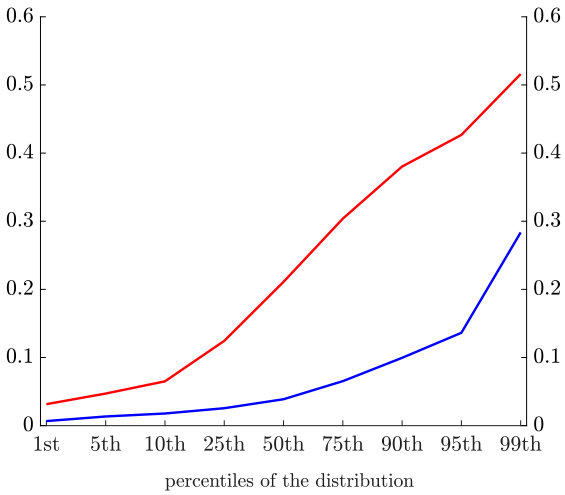
Figure 1: Bank NPL and Borrower Exposure

(A) Bank Non-Performing Loan ratios in selected jurisdictions (% of gross loans)



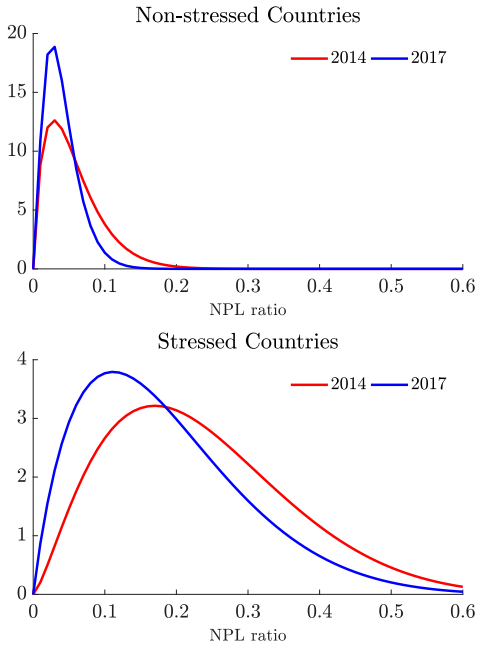
Source: data are available online on Federal Reserve Economic Data (FRED). Note: the chart shows the evolution over time of the non-performing loans ratio gross of impairments and provisions in selected jurisdictions.

(B) Bank Non-Performing Loan ratios in the euro area (% of gross loans)



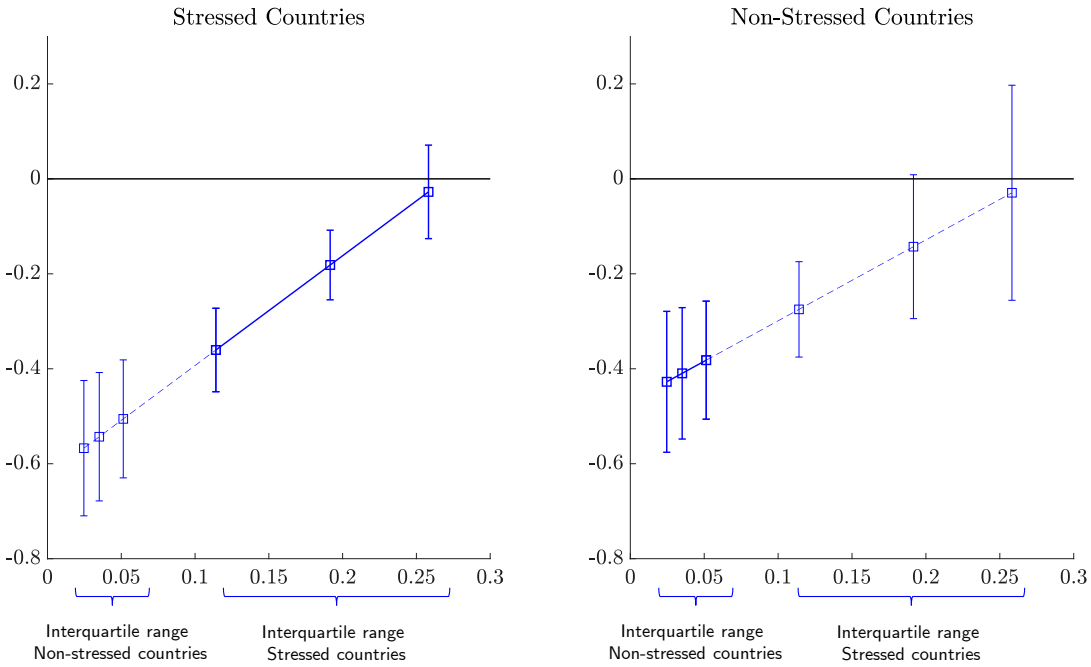
Note: Stressed countries are IT, ES, PT; Non-stressed countries are AT, BE, DE, LT, SK, FR. Pooling data at country, time, and bank level. NPL ratio gross of impairments and provisions on the x-axis.

Figure 2: NPL ratio by year (share of total exposure)



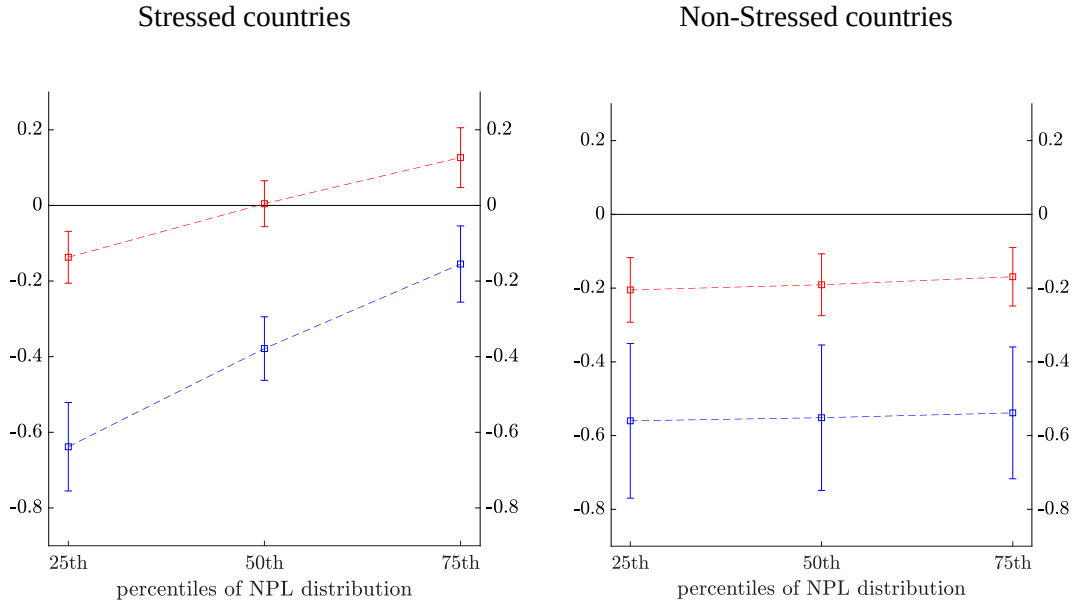
Note: Stressed countries are IT, ES, PT; Non-stressed countries are AT, BE, DE, LT, SK, FR. Pooling data at country, time, bank level. NPL ratio on x-axis.

Figure 3: Effect of a decrease in borrower quality on lending for different perc. of NPL



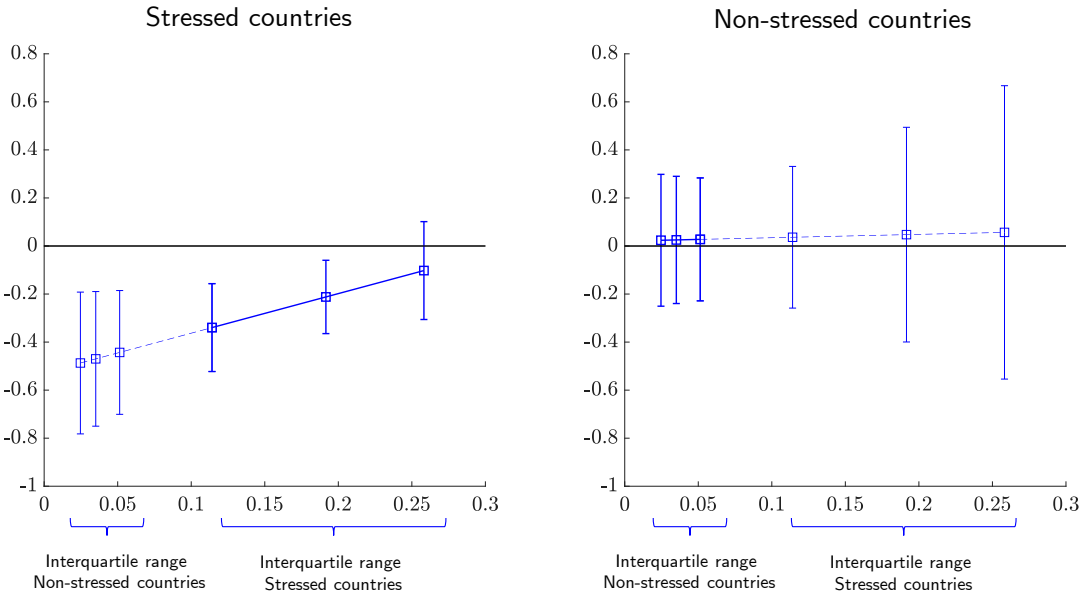
Notes: The chart reports the marginal effect of a deterioration in borrower quality (from 0 to 1), controlling for Country x time, Bank x time, Bank x firm, and, Sector x time fixed effects (i.e. based on the coefficients in column 9 of Table 2). The boxplots report, for each percentile of NPL, the 90% confidence interval of the estimates.

Figure 4: Effect of a decrease in borrower quality on lending for different percentiles of NPL



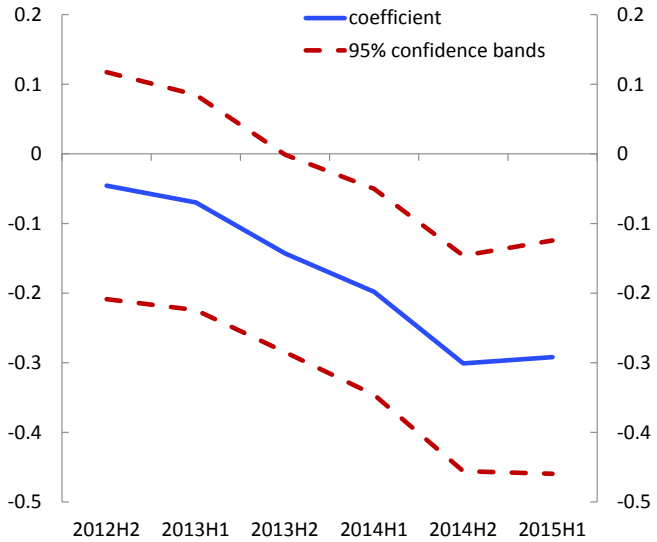
Notes: The chart reports the effect of a deterioration in borrower quality for different percentiles of the bank's NPL ratio, based on the coefficients in column 9 of Table 6. The boxplots report, for each percentile of NPL, the 90% confidence interval of the estimates.

Figure 5: Effect of a decrease in borrower quality on lending: Difference between Centralized and Local Supervision



Notes: Effect of a deterioration in borrower quality (from 0 to 1), controlling for Country x time, Bank*time, Bank*firm, and Firm*time fixed effects.

Figure 6: Robustness on the timing of banking supervision

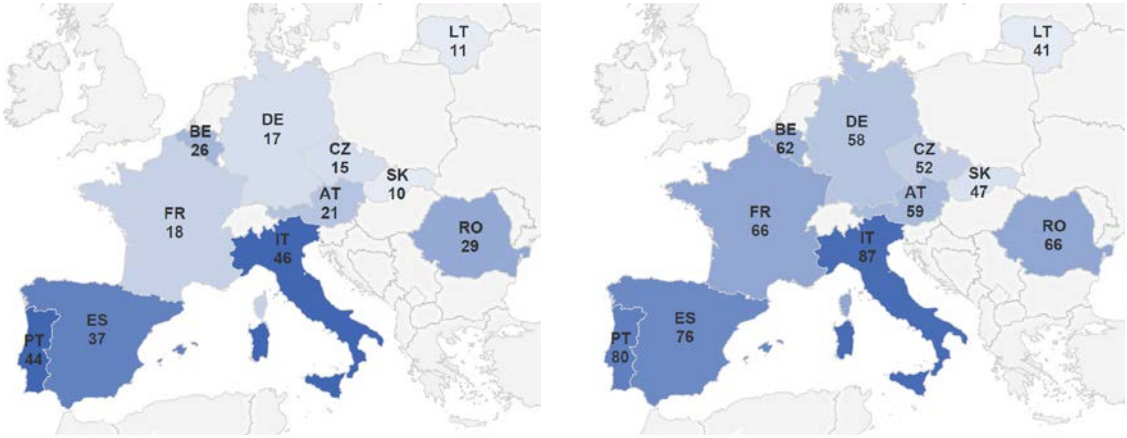


Notes: Difference in the effect of a deterioration in borrower quality (from 0 to 1) between locally and centrally supervised banks, based on different dates for the effective start of bank supervision. The specifications control for Country x time, Bank*time, Bank*firm, and Firm*time fixed effects.

Appendix

Figure A1: Share of firms with multiple lending relationships

(% of total borrowers) (% of total credit)



Notes: the chart reports the share of non-financial corporations with multiple lending relationships in each country as a share of the total number of borrowers (left panel) and of total lending (right panel).

Table A1: Risk taking: NPL (excluding borrower's sector) and borrower quality

		(1) ct	(2) ct b f	(3) ct b st	(4) ct b ft	(5) ct st bf	(6) ct ft bf	(7) ct bt st bf	(8) ct bt ft bf
Stressed Countries									
	NPL	0.410*	-0.186	0.0142	0.211	-0.765**	-0.622*	2.587***	2.913***
		(0.244)	(0.295)	(0.316)	(0.327)	(0.317)	(0.372)	(0.481)	(0.461)
	BQ	-0.390*	-0.464***	-0.623***	-	-0.577***	-	-0.601***	-
		(0.206)	(0.0773)	(0.192)		(0.0785)		(0.0790)	
	NPL x BQ	1.858**	1.861***	2.962***	1.998***	1.972***	2.129***	2.138***	2.249***
		(0.930)	(0.432)	(0.799)	(0.647)	(0.425)	(0.638)	(0.393)	(0.544)
	N	39,741,738	39,558,624	39,741,737	29,652,538	39,075,905	28,921,876	39,075,904	28,921,876
	R-squared	0.0676	0.473	0.151	0.516	0.696	0.761	0.719	0.783
Non-Stressed Countries									
	NPL	2.919*	-0.529	-0.415	0.636	-0.381	-0.438	-2.891**	-2.599
		(1.551)	(0.769)	(0.902)	(1.336)	(0.770)	(1.421)	(1.310)	(1.996)
	BQ	-0.505**	-0.481***	-0.584***	-	-0.425***		-0.473***	-
		(0.200)	(0.0983)	(0.167)		(0.0777)		(0.0857)	
	NPL x BQ	2.269	2.337***	2.243**	4.039***	1.175*	1.760*	1.855***	2.949***
		(1.955)	(0.752)	(1.099)	(1.253)	(0.638)	(0.966)	(0.648)	(0.867)
	N	6,289,069	6,221,060	6,289,067	2,863,021	6,181,960	2,805,059	6,181,957	2,805,056
	R-squared	0.222	0.697	0.296	0.636	0.841	0.870	0.845	0.876
Fixed effects									
	Country*Time (ct)	Y	Y	Y	Y	Y	Y	Y	Y
	Bank (b)	-	Y	Y	Y	-	-	-	-
	Firm (f)	-	Y	-	-	-	-	-	-
	Bank*Firm (bf)	-	-	-	-	Y	Y	Y	Y
	Firm*Time (ft)	-	-	-	Y	-	Y	-	Y
	Sector*Time (st)	-	-	Y	-	Y	-	Y	-
	Bank*Time (bt)	-	-	-	-	-	-	Y	Y

Note: The dependent variable is the (log-)credit granted (drawn and undrawn) by bank "b" to firm "f" operating in sector "s" at time "t". NPL a measure of non-performing loan ratio which, for each borrower, excludes the corresponding sector of economic activity. BQ is borrower quality and indicates for each borrower the ratio between exposures in arrears and total exposures. Data are at semi-annual for the period 2012H1 – 2017H2. Standard errors clustered at bank level in parentheses: * p<0.1, ** p<0.05, *** p<0.01.