Sovereign risk and cross-country heterogeneity in the transmission of monetary policy to bank lending in the euro area

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Abstract

Is the transmission of monetary policy to bank lending heterogeneous across euro area countries? This paper employs annual bank level data to test whether the bank lending channel of monetary policy was heterogeneous in the euro area over the period 2007-2016. To do so it follows a simple procedure that allows direct testing of how monetary policy affected similar banks located in different countries. Results indicate that the transmission of monetary policy to bank lending was heterogeneous across countries that were differently exposed to the sovereign debt crisis. On average, the same 1% cut in the policy rate led to a 1.6% increase in lending by banks located in non-stressed countries as opposed to a 0.4% increase for banks located in countries under severe sovereign stress. Unconventional monetary policy – as captured by the ECB shadow rate – was also unevenly transmitted to bank lending. Exposure to sovereign risk is identified as a key source of heterogeneity. Within stressed countries, banks with larger sovereign exposures reacted to monetary easing by expanding lending by less than banks with smaller exposures. As a result, monetary accommodation was smoothly transmitted to lending only by banks with limited exposure to sovereign risk. In response to the same 1% policy rate cut, the credit expansion of highly exposed stressed countries banks was instead 2.75% weaker than that of banks in non-stressed countries. These findings support existing evidence on sovereign risk having direct adverse consequences for bank lending and highlight the extent to which sovereign risk aggravated heterogeneities in the transmission on monetary policy to the real economy via the banking system during the euro area debt crisis.

Keywords: Bank lending channel, monetary policy transmission, cross-country heterogeneity, sovereign risk, financial structures, banking integration.

JEL classification: E52,E58,E42,F33

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Introduction

An important measure of the effectiveness of monetary policy is the extent to which it is transmitted to the real economy via the banking system in the form of loans to households and non-financial corporations (NFCs). That such transmission is homogeneous across countries is a challenging requirement in the euro area, where the single monetary authority – the European Central Bank (ECB) – conducts policy for 19 member countries with different financial structures and only partially integrated banking systems. As a result, the single monetary policy may affect bank lending differently in different countries, i.e. monetary transmission to bank lending may at times be heterogeneous. Still, a modicum of heterogeneity was tolerated by policy makers as inherent to the workings of a monetary union (ECB, 2012; Ehrmann et al., 2002).

During the sovereign debt crisis, however, heterogeneity in financial conditions increased markedly in the euro area, posing a major challenge for the smooth transmission of the single monetary policy (ECB, 2012). Financial fragmentation materialised along national banking systems. Highly exposed to the suffering of their own sovereign,[1] banks located in stressed countries faced higher funding costs than banks located in non-stressed countries (Durré et al., 2014).[2] Fragmentation quickly fed through retail credit markets, with household and corporate borrowing costs rising sharply in stressed countries (Gilchrist and Mojon, 2018). As a result, policy makers became increasingly concerned that "[the ECB] faced severe impairments to the transmission of monetary policy across the euro area, with marked heterogeneity from country to country" (Draghi, 2014).

The ECB responded with a series of conventional and unconventional accommodative measures in the attempt to restore the integrity of monetary transmission in the euro area (see figure 1c). Yet, bank lending remained heterogeneous across countries. Between 2010 and 2017 bank corporate credit in stressed countries fell deeper and carried a higher (real) interest rate than in non-stressed countries (figures 1a and 1b)[3]. The large cross-country dispersion in lending growth, higher than that in real output growth (figure 1d), further underscores the macroeconomic relevance of heterogeneity in bank lending across the euro area. Years after the end of the crisis, heterogeneity remains subject of interest among academics and policy-makers (Ciccarelli et al., 2013; Cœuré, 2017), raising questions that go at the heart of the functioning of the European Monetary Union.

Using a panel of more than 2500 banks from all euro area countries covering 2007-2016, this paper investigates whether the transmission of monetary policy to bank lending was heterogeneous across countries that were differently exposed to the sovereign debt crisis. Results indicate that monetary transmission was weaker for banks located in stressed countries as compared to banks based in non-stressed countries. For the baseline specification, the same 1% cut in the policy rate led to a 1.6% increase in lending by non-stressed countries banks as opposed to a 0.4% increase by stressed countries banks. Unconventional monetary policy – as measured by Wu and Xia (2016)'s shadow rate – also appears to be unevenly transmitted across countries.

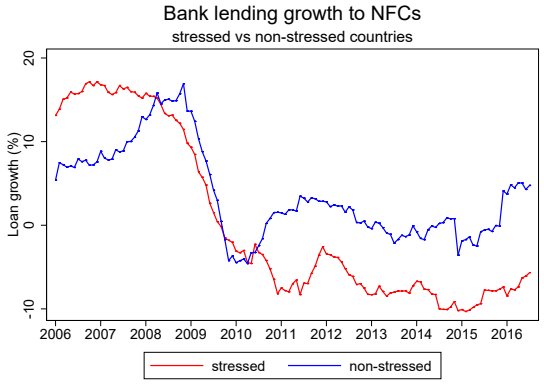
Exposure to sovereign risk is identified as an important source of heterogeneity in monetary transmission across the euro area. Within stressed countries, banks with greater sovereign exposures reacted to monetary easing by expanding their lending by less than banks with smaller exposures. Particularly, the same 1% policy rate cut was associated to a 3.7% increase in lending by banks with low (ex-ante) sovereign exposures (25^{th} percentile) as opposed to a 1.1% increase in lending by banks with high (ex-ante) sovereign exposures (75^{th} percentile). Heterogeneity in monetary transmission to lending appears then to reflect different bank behaviours arising from different exposures to sovereign default risk across stressed and non-stressed countries.Indeed, Monetary easing was homogeneously transmitted to bank lending across the euro area only for low (ex-ante) levels of sovereign exposures.

[1] With domestic government bonds making up the lion share of their fixed income portfolio, stressed countries banks saw their balance sheets rapidly deteriorating as the value of their bond holdings plummeted. Soon stressed sovereign and domestic banks became "joined at the hip" (Mody and Sandri, 2012).

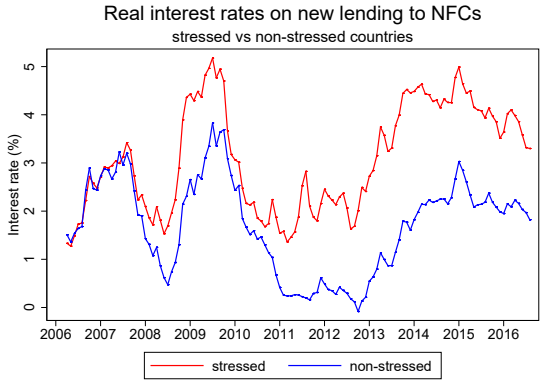
[2] As in Altavilla et al. (2017), "stressed countries" — i.e. subject to high sovereign stress — are countries whose 10-year sovereign yield exceeded 6% for at least one quarter for the period 2007-2016. Consequently, throughout the paper stressed countries are Cyprus, Greece, Ireland, Italy, Latvia, Lithuania, Portugal, Slovenia and Spain, while non-stressed countries are Austria, Belgium, Estonia, Finland, France, Germany, Luxembourg, Malta, the Netherlands and Slovakia. This categorisation is equivalent to that of "peripheral" and "core" countries as found in Lane (2012) and De Grauwe (2013).

[3] On average, the growth of bank corporate lending and its (real) price were, respectively, 7.46% slower and 0.57% higher in stressed countries. Prior to 2008 bank lending growth was actually faster for stressed countries banks, reflecting the overheating in the banking sector linked to the build-up of housing bubbles in Spain and Ireland.

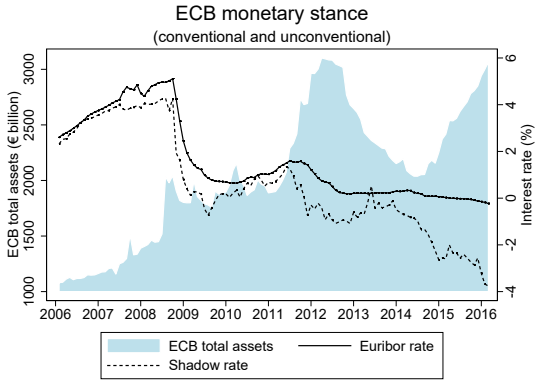
Figure 1: Heterogeneity in bank lending across the euro area



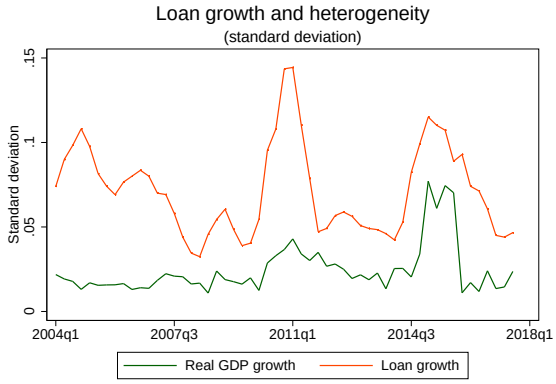
(a) Growth rate of loans (adjusted for securitisation) to euro area non-financial corporations, stressed and non-stressed countries, year-on-year growth, monthly frequency, percentage points. Source: ECB (2017).



(b) Average interest rates on lending for new business for non-financial corporations, stressed and non-stressed countries. New business is defined as any new agreement between a non-financial corporation and a bank. Inflation-adjusted, monthly frequency, percentage points. Source: ECB (2017).



(c) LHS: Eurosystem total assets, monthly average, EUR billion; RHS: 3-months Euribor rate and ECB's shadow rate, monthly average, percentage points. Sources: ECB (2017),Jing Cynthia Wu's webpage.



(d) Cross-country standard deviation of year-on-year loan growth rate of loans (adjusted for securitisation) by euro area main financial institutions to domestic non-financial corporations and cross-country standard deviation of real GDP growth, year-on-year. Source: ECB (2017) and Eurostat (2017).

In response to the same 1% policy rate cut, the credit expansion of highly exposed stressed countries banks was instead 2.75% weaker than that of banks located in non-stressed countries. These findings are consistent with the evidence that sovereign risk weighs down on bank lending and impairs the transmission of monetary policy (Altavilla et al., 2016, 2017; Bofondi et al., 2018; De Marco, 2017; Peydro et al., 2017; Popov and Van Horen, 2015).

The contribution of this paper is twofold. First, it sheds light on how sovereign risk impeded the smooth transmission of monetary policy to bank lending by rendering it markedly heterogeneous across the euro area between 2007 and 2016. Second, this paper improves the identification of the bank lending channel (Altunbas et al., 2009; Gambacorta, 2005; Gambacorta and Marques-Ibanez, 2011; Gambacorta and Shin, 2016; Kashyap and Stein, 1995) by restricting the analysis to banks that are simultaneously small, illiquid and under-capitalised. The key advantage of this procedure is that, by selecting a homogeneous group of banks with a criterion orthogonal to the specific characteristics of any national banking system, it is possible to test for cross-country heterogeneity in monetary transmission by looking at how monetary policy affects similar banks located in different countries.

The remainder of the paper is organized as follows. The first section reviews the related literature, while the empirical analysis is reported in the second section, alongside a discussion on sample, identification and econometric model. The third section presents the main results and the fourth section concludes.

1 Related literature

Smooth transmission of monetary policy in a currency union requires synchronized business cycles and similar economic structures across member states (De Santis and Surico, 2013; ECB, 2012). While euro area economies are increasingly synchronized as well as economically and financially harmonised (Baele et al., 2004; De Grauwe and Mongelli, 2005; De Haan et al., 2008; ECB, 2017), banking integration is still incomplete (Bouvatier and Delatte, 2015; Lucotte, 2015) and this may cause some differentiation in how monetary policy is transmitted to bank lending across countries. This hypothesis was originally put forth by Cecchetti (1999) and Kashyap and Stein (2000) who argued that differences in structures of financial intermediation, legal systems, corporate finance practices and capital market development within the EMU may give rise to asymmetries in the way monetary policy is transmitted to bank loans across member countries.[4] These studies were based on the bank lending channel view of monetary policy (Bernanke and Blinder, 1988; Bernanke and Gertler, 1995; Bernanke, 2007; Disyatat, 2011; Kashyap and Stein, 1995) whereby monetary policy is predicted to have a stronger influence on lending by easing the financial constraint of banks that are most exposed to asymmetric information problems in the market for uninsured non-deposit funding.[5]

Monetary integration prompted interest in the study of bank lending channels in the euro area and the extent of cross-country heterogeneity therein. Amongst country-specific studies, Gambacorta (2005), Hernando and Martínez-Pagés (2001) and Loupias et al. (2002) detected a bank lending channel working only for illiquid banks in Italy, Spain and France, respectively. EU-wide studies revealed instead a less coherent picture, with positive evidence of a bank lending channel at work only in Italy, France and Germany (De Bondt, 1999) and Spain (Altunbas et al., 2002). By estimating the bank lending channels for France, Germany, Italy and Spain, Ehrmann et al. (2002) documented that the impact of monetary policy on bank credit was homogenous across countries both prior and after the introduction of the euro. In a later exercise, De Santis and Surico (2013) found the opposite result, i.e. a bank lending channel stronger in Germany and Italy and weaker in Spain and France. De Santis (2015) also showed that between 1999 and 2011 monetary policy easing supported relatively more credit provisions by small French banks and illiquid German banks with respect to Spanish and Italian banks.

The sovereign debt crisis and the attendant response by the ECB reignited interest in bank lending and monetary policy transmission in the context of sovereign stress and heterogeneous financial conditions across countries. The adverse link between sovereign risk and bank lending emanates from the fact that sovereign risk may disproportionately raise the external finance costs of more exposed banks, forcing them to cut on lending. At the same time, large capital losses from sovereign debt re-pricing may push exposed banks close to the minimum regulatory capital ratio, inducing them to de-leverage. These arguments are formalised, for instance, by Gennaioli et al. (2014) who proposed a model where sovereign defaults impair domestic banks' balance sheets and thus reduce bank lending, the more so the larger a bank's exposure to sovereign debt. On the empirical side, Albertazzi et al. (2014) and Zoli (2013) found that sovereign risk had a negative impact on bank lending in Italy as it damaged banks' balance sheets and increased their funding costs. As a result, Italian banks cut their credit by more than foreign competitors. Similarly, using the Italian credit registry Bofondi et al. (2018) showed that domestic banks cut loan supply, increased interest rates and lowered the probability of accepting new applications by more than foreign banks. The authors argued that the credit crunch was mainly the consequence of the country-specific rise in sovereign risk and the generalised increase in Italian banks' cost of funding. Using the same data, Peydro et al. (2017) find that during the sovereign debt crisis under-capitalised Italian banks responded to monetary easing by buying securities rather than increasing credit supply. Importantly, this was not due to lack of good loan applications, but rather to different access to liquidity and risk-bearing capacity. Among euro area-wide studies, Popov and Van Horen (2015) reported that banks with larger sovereign exposures had lower participation to the syndicated loan market and

[4]The typical counterargument was that even if financial structures differed substantially across countries, economic and financial convergence in the euro area would imply that any difference in the transmission mechanism will eventually disappear over time (Ciccarelli and Rebucci, 2002; Dornbusch et al., 1998)

[5]Empirical studies used balance sheet data and focused on a subset of banks that are presumably exposed to information problems on wholesale funding markets. For instance, small banks may have difficulty accessing external funds given their simple capital structure (Kashyap and Stein, 1995), illiquid banks usually face higher costs to offset deposit losses (Gambacorta, 2005; Jiménez et al., 2014; Kashyap and Stein, 1995, 2000; Kishan and Opiela, 2000), while poorly capitalized banks are believed to face an external finance premium since they are perceived to be riskier (Gambacorta and Shin, 2016; Jiménez et al., 2014, 2012; Peek and Rosengren, 2005). For all these reasons, small, illiquid and poorly capitalized banks are likely to be more exposed to information problems, hence more sensitive to policy impulses and the ideal conduit of the bank lending channel.

raised their lending rates by more than banks with lower exposures. Similarly, Altavilla et al. (2017) revealed that stressed countries banks with larger exposures to domestic sovereign debt cut lending by more than banks with minor exposures when sovereign stress increased, while expanded lending by more when sovereign stress decreased.

A number of studies further assessed how sovereign risk impaired the smooth transmission of monetary policy to bank lending across countries. For instance, Ciccarelli et al. (2013) estimated a VAR model over the period 2002-2011 for 12 euro area countries and found the response of bank lending to monetary policy to be stronger in sovereign stressed countries, highlighting substantial heterogeneity across countries. A similar result is found by Cantero-Saiz et al. (2014) who reported that between 1999 and 2012 banks located in countries subject to sovereign stress reduced bank lending by more during policy tightening than do banks in lower sovereign risk countries. However, they find no similar evidence when monetary policy becomes accommodating. Finally, using a global VAR model for all euro area economies between 2007 and 2015, Burriel and Galesi (2018) showed that the euro area-wide response of new credit operations to unconventional monetary policy is insignificant, and suggested this may reflect a large degree of heterogeneity across countries.

2 Empirical analysis

Through the bank lending channel, expansionary monetary policy can support lending by easing banks' access to external finance. Yet, the channel may be heterogeneous across countries. This paper seeks to answer to the following questions: i) Was monetary policy transmission to bank lending heterogeneous across stressed and non-stressed euro area countries? ii) Has sovereign exposure across banks in different countries amplified heterogeneity during the sovereign debt crisis?

2.1 Data

Balance sheet and income statement data on euro area banks are extracted from Fitchconnect.[6] The original sample covers commercial, savings and cooperative banks from all 19 euro area member countries for the period 2006-2016. Information on bank specialisation, public listing, role in the banking group and identity of the parent institution are recovered from Orbis Bank Focus.[7] The final sample contains 2629 banks, (85%) of the original sample.[8] Following Gambacorta (2005) and Ehrmann et al. (2002) all nonsense observations (e.g. negative entries) are removed for total assets, loans, and capital and liquidity ratios.[9] Second, the analysis is restricted to unconsolidated accounts to keep the cross-section dimension as large as possible. Third, loan growth, total assets, capital and liquidity ratios are winsorised at 99% to minimise the incidence of outliers. The final sample is a balanced panel counting 2544 banks adding up to a total of 25440 bank-year observations over the period of interest. The representativeness of the sample is documented in table 1. On average, bank loan data covers 16% of corresponding national lending aggregates or 26% of the euro area loan market when shares are weighted by nominal GDP. Breaking down by country group, loan data cover, respectively, 16% and 31% of stressed and non-stressed countries' national aggregates. Macroeconomic data — real GDP growth, HCIP inflation and an index of house prices – are collected from Eurostat, while data on interest rates — Euribor, Eonia and sovereign debt yields — are collected from the ECB Statistical Data Warehouse.[10]

[6] Fitchconnect is a commercial database provided by Fitch Solutions, a provider of credit market data.

[7] Orbis Bank Focus (previously Bankscope) contains information on over 40,000 public and private banks around the world. The database is compiled by Bureau Van Dijk.

[8] The matching between Fitchconnect and Orbis Bank focus is made in two steps. First, banks that shared unique identifiers in both databases (the ESCB Monetary and Financial Institutions identifier, the Legal Entity Identifier and the Ticker code) were directly matched: this procedure led to two thirds of all matches. The remaining unmatched banks were "fuzzy merged" using the Stata ado file reclink2 program written by Micheal Blasnik, a bigram string comparator that calculates the fraction of consecutive character matches between two strings. As in Chodorow-Reich (2014), banks are fuzzy merged using country and consolidation identifiers along with a bigram string comparator score of the bank name as reported in each database. To ensure accuracy, all matches were manually reviewed.

[9] This step removes 3650 observations.

[10] Variables are described in details in table 9, appendix B.

Table 1: Sample description and representativeness

For each country the table reports the number of banks and the total value of loans as percentage of total aggregate data reported in the Balance Sheet Indicator statistics of the ECB. Values are time-averaged over 2007-2016.

Stressed countries	N° of banks	Loans as % of aggregate	Non-stressed countries	N° of banks	Loans as % of aggregate
Cyprus	14	15	Austria	195	17
Greece	9	3	Belgium	26	6
Ireland	21	10	Estonia	2	0,04
Italy	583	24	Finland	38	5
Latvia	8	7	France	212	16
Lithuania	2	21	Germany	1101	55
Portugal	107	15	Luxembourg	79	23
Slovenia	10	27	Malta	9	11
Spain	96	8	Netherlands	15	7
			Slovakia	17	34
Total N° of banks	850			1694	
Average		14			17
Weighted average		16			31
All countries, average		16			
All countries, weighted average		26			

2.2 Identification

The first identification task is isolating the effect of monetary policy on bank lending — the bank lending channel. Requiring some banks to be more sensitive to monetary policy at the margin, the bank lending channel is usually tested by focusing on banks that are either small, illiquid or under-capitalised (Altunbas et al., 2009; Gambacorta, 2005; Gambacorta and Marques-Ibanez, 2011; Jiménez et al., 2014, 2012). However, single balance sheet measures may fail to gauge banks' sensitivity to monetary policy across different banking systems. First, some banks are small but liquid, or big but under-capitalized. If that occurs systematically in some country, individual balance sheet measures cannot identify the bank lending channel and cross-country comparisons are impossible.[11] Second, individual balance sheet measures may not be suitable proxies for banks' financial constraint. For instance, large banks in upper tiers of banking groups serve as liquidity providers to small banks in lower tiers, potentially neutralizing the latter's liquidity constraint (Ashcraft, 2006, 2008; Ehrmann et al., 2002). Furthermore, banks engaged in relationship lending — typically small banks (Ongena and Smith, 2000) — have an incentive to grant credit to firms regardless of short-term liquidity and monetary conditions, with a view to share in firms' future surplus by extracting long-run relationship rents (Petersen and Rajan, 1995).[12] Size may hence be unsuited to evaluate the effect of monetary policy across banks.[13] Capital can also be an ambiguous indicator. Under Basel II and Basel III risk-based capital requirements, after a monetary expansion banks close to the capital regulatory floor may be less able to increase lending — thus lowering capital-assets ratios — unless provided with additional capital. Additional liquidity may instead be allocated to assets free from capital requirements, such as government bonds. Accordingly, no differential effect of policy on lending would be captured via bank capital (Van den Heuvel, 2002).

[11] For instance, in Italy small banks are often liquid and highly capitalised. Banks of small size rooted in the territory are good at drawing resources from local deposit markets and are thus particularly liquid (Gambacorta, 2005). By the same token, German banks tend to have low capital, but this is usually compensated by the low riskiness of their asset structure (Ehrmann et al., 2002).

[12] For example, the lender may backload interest payments over time, so to subsidize the firm in bad times and extracting rents in good times (Petersen and Rajan, 1995).

[13] Government guarantees and national deposit insurance also cover banks irrespective of their size. Accordingly, deposit accounts at small banks should not be considered riskier than deposits accounts at big banks (Ehrmann et al., 2002).

Table 2: Bank lending channel selection criterion

Bank's characteristic	Threshold	Average number of banks	Other banks
Small	Total assets $\leq 95^{th}$ pct	2415	124
Under-capitalised	Capital regulatory distance $\leq 25^{th}$ pct	436	2108
Illiquid	Liquidity ratio $\leq 75^{th}$ pct	1859	685
BLC banks	Small, illiquid and under-capitalised	468	2076

Disentangling loan supply from loan demand is another important identification challenge. Demand for and supply of credit jointly determine bank lending decisions and are both affected by monetary, economic and financial conditions. Moreover, sovereign stress affects not only banks but also firms and households in stressed countries, which in turn are more likely to reduce investment and consumption than their counterparts in non-stressed countries (Altavilla et al., 2017). If this leads to systematically lower credit demand in stressed countries, it becomes hard to determine if heterogeneity in monetary transmission to credit stems from demand or supply. To overcome these issues, the bank lending channel literature typically assumes all banks face a homogeneous domestic loan demand, implying it is unrelated to bank characteristics. However, if monetary policy easing leads to a disproportionate increase in credit demand by customers of,say, small banks, it becomes impossible to identify the bank lending channel with bank size. Recent research has isolated loan supply by using loan-level data from national credit registries on a country-by-country basis (Bofondi et al., 2018; Iyer et al., 2014; Jiménez et al., 2014, 2012; Khwaja and Mian, 2008; Peydro et al., 2017). However, comparable euro area-wide loan level data are not available.[14]

To overcome these issues and allow for cross-country comparisons, this research employs a single criterion that is more stringent than those implied by previous studies. The logic is as follows: If through the bank lending channel monetary policy has any differential effect, then it should definitely be observed for banks that are simultaneously small, illiquid and under-capitalized. If no effect is detected for these banks, then it is very unlikely there is an active bank lending channel of monetary policy for the period considered. This criterion is equivalent to a necessary condition for the existence of a bank lending channel and, as such, revives previous work on the bank lending channel that focused on banks that were simultaneously small and illiquid (Kashyap and Stein, 2000) or small and under-capitalised (Kishan and Opiela, 2000).

Defining the criterion involves two steps. First, three thresholds are defined to classify banks as small, illiquid or under-capitalized. Following Kashyap and Stein (1995), banks are considered small if they lay in the bottom 95% of the distribution of total assets for all countries, and illiquid if their liquidity ratio is smaller than 20%.[15] Similarly, banks are marked as under-capitalized when the distance between their Tier 1 capital ratio from the regulatory floor is in the bottom quartile of the distribution of distances for all countries, as in Borio and Gambacorta (2017) and Gambacorta and Shin (2016).[16]

[14] An exception are data on syndicated loans. However, the syndicate loan market covers only 10% of total euro area lending (Altavilla et al., 2017). Moreover, the syndicated loan market involves mostly large and well established banks which are least indicated for tests of the bank lending channel that instead focus instead on financially constrained intermediaries.

[15] The liquidity threshold corresponds to the 75^{th} percentile of the distribution of banks by liquidity ratio. The size threshold corresponds to a cut-off around €14 billion, as of 2016. For comparison, the ECB bank size group classification used for supervisory and prudential statistics considers a bank small if, in any given year, its consolidated assets are less than 0.005% of total consolidated assets of EU banks; medium-sized if its assets are between 0.005% and 0.5% of total consolidated assets of EU banks; and large if its assets are greater than 0.5% of total consolidated assets of EU banks. For 2016 these cut-offs correspond to €2.1 billion and €215 billion, respectively. Hence, the small category used in this paper is slightly larger than that used by the ECB. If anything this should work against the test by making estimates more conservative.

[16] The regulatory floor corresponds to the minimum requirements for risk-weighted capital ratios for Basel I: Tier 1/RWA $> 4\%$ (Borio and Gambacorta, 2017). In the sample, the bank at the 25^{th} percentile of the distribution of regulatory distance has a Tier 1 ratio of 11% and a capital ratio (equity capital/total assets) of 7.7%. To maximise the sample size, the Tier 1 ratio-based cut-off is replaced with the equivalent capital ratio cut-off (i.e. the 25^{th} percentile of the distribution of capital assets ratio) whenever

Table 2 and figures 6,7 and 8 sum up the procedure by reporting the cut-offs for the distribution of banks by size, capitalisation and liquidity for stressed and non-stressed countries. Second, an indicator variable is defined that takes value 1 for all banks that are simultaneously small, under-capitalised and illiquid, and zero otherwise. That is:

$$BLC\ banks_i = \begin{cases} 1 & \textit{if a bank is small \& illiquid \& undercapitalised} \\ 0 & \textit{otherwise} \end{cases}$$

where *i* indicates the bank. This procedure selects a sub-sample of 468 banks (BLC banks henceforth) corresponding to the 18% of the original sample. All tests of the bank lending channel will hinge upon comparing the lending response of these banks vis-à-vis the other banks.

This approach has three advantages and one main drawback. First, it allows doing away with all suitability issues inherent to the choice of any particular measure of bank sensitivity to monetary policy. Second, by selecting a homogeneous sub-set of banks through a criterion orthogonal to the specific characteristics of any national banking system, this approach allows to test how monetary policy affects lending decisions by similar euro area banks located in different countries. Third, it makes the assumption about homogeneity of loan demand more likely to hold. Indeed, it is unlikely that credit demand faced by banks that are simultaneously small, illiquid and under-capitalised is systematically more sensitive to monetary policy than that faced by all other banks. Nonetheless, significant differences may still exist in how domestic credit demand responds to monetary policy across stressed and non-stressed countries. However, such concern is attenuated by evidence from the ECB Bank Lending Survey indicating the absence of divergence (and, if anything, a close co-movement) between credit demand in stressed and non-stressed countries (see figure 3).[17] At any rate, section 3.1 formally checks that results are robust to credit demand.

The potential drawback of this approach is selection bias. Relying on ad hoc thresholds, the criterion may prove too strict for some banking system and too lax for others by construction. That is, it may select few banks in big, well capitalised and liquid banking systems, and many in small, undercapitalised and illiquid systems. As a consequence, the sub-sample would be skewed towards some country group, thereby misrepresenting the original sample. In fact, it turns out that non-stressed countries banks are over-represented in the sub-sample – German (Italian) banks are particularly over (under)-represented – but the extent of misrepresentation is minimal (table 7). In particular, the relative shares of stressed and non-stressed countries banks in the sub-sample (23,5% and 76,5%, respectively) are very close to that of the full sample (33,4% and 66,6%, respectively). Robustness of main results to this type of selection bias is tested in section 3.

2.3 Econometric model

Model (1) adapts standard estimating models of the bank lending channel to test for heterogeneity in monetary transmission to lending between stressed and non-stressed countries:

$$\Delta \ln \textit{(Loans)}_{it} = \alpha_i + \Delta MP_t(\beta_1 + \beta_2 BLC\ banks_i + \beta_3 BLC\ banks_i \times \textit{Stressed}_i) + \gamma_1 X_{it-1} + \gamma_2 Y_{it} + \epsilon_{it} \quad (1)$$

where *i* indicates banks and *t* years. The dependent variable, $\Delta \ln(Loans)$, is the annual growth rate of bank loans and is regressed on a measure of monetary policy, ΔMP, – in first differences to avoid spurious correlation – alongside two interaction terms and two vectors containing lagged bank level controls and contemporaneous macroeconomic variables, respectively (X and Y).

The main explanatory variable is monetary policy. From 2009 onwards the ECB embarked in a major program of unconventional monetary policy measures. As the policy rate approached the zero lower bound, unconventional policies were implemented to support the interest rate tool. As a result, the policy rate under-represents the full scope of monetary policy action during and after the sovereign debt crisis. Multiple indicators are therefore employed to account for both conventional and unconventional policy across specifications. First, the annual change in money market rates — the 3-months Euribor and the Eonia interbank rates — capture the conventional interest rate policy. Highly correlated with

observations on the former are missing. Results are unchanged if this step is not implemented.

[17] The time-series pairwise correlation between credit demand in stressed and non-stressed countries reported in 3 is 0.45 and is statistically significant at the 0.01 significance level.

the ECB's main refinancing rate, these are benchmark interest rates for bank funding and have been widely used to test the bank lending channel (Altunbas et al., 2009; Jiménez et al., 2014). Second, since monetary policy is likely to be endogenous,[18] Taylor residuals are employed in the attempt to identify pure monetary policy shocks (De Santis and Surico, 2013; Peydro et al., 2017).[19] Third, Wu and Xia (2016)'s shadow rate for the EMU is used to proxy for unconventional monetary policies. The shadow rate is taken as a summary indicator for all unconventional policies implemented by the ECB, including Long Term Refinancing Operations (LTROs), Targeted Long Term Refinancing Operations (TLROs),the Asset Purchase Program (APP), as well as negative interest rate and forward guidance policies.[20]

The interaction terms test for the bank lending channel and cross-country heterogeneity in monetary transmission to lending. The first term interacts monetary policy with the indicator selecting the BLC banks sub-sample,*BLC banks*, as defined in section 2.2. The second interaction term compounds the first interaction with a dummy (*Stressed*) that takes value 1 if the bank is located in a country subject to sovereign stress and 0 otherwise.[21] X is a vector of bank-level control variables controlling for balance sheet characteristics, including the natural log of total assets, liquidity ratio (cash, interbank liquidity and securities over total assets), capital ratio (equity capital over total assets), efficiency (return on equity) and bank risk (natural log of Z scores as used in Beck et al. (2013)). All variables are normalized with respect to their own average across all banks. So transformed, they are entered with one lag to attenuate endogeneity concerns and because lending decisions conditional upon bank-specific features usually take place with a lag (Gambacorta, 2005).[22] Y is a vector of country level control variables including real GDP growth, HCIP inflation, a house price index and sovereign spread.[23] Bank fixed effects, α_i, are added to absorb bank-specific time-invariant unobservable heterogeneity.

Two testable hypotheses fall out of model (2) and depend on sign and statistical significance of β_1 and β_2. First, the bank lending channel predicts a negative sign on β_2: An interest rate cut should have a larger expansionary effect on lending by banks that are simultaneously small, illiquid and undercapitalised, everything else held constant. Second, a statistically significant estimate for β_3 would imply the bank lending channel to be stronger for banks located in a country-group with respect to banks located in the other group. In turn, this would point to the presence of heterogeneity in monetary transmission to lending.

3 Results

This section presents the results of the tests based on model (1) which is estimated with fixed effects, standard errors clustered at the country level.[24] The main findings are reported in table 3. Looking at the first column, monetary policy has the expected sign and magnitude. A 1% interest rate cut leads to a 1% increase in bank lending growth. Estimates of bank and country level control variables are also in line with standard results (Ehrmann et al., 2002; Gambacorta, 2005).

[18]For instance, the ECB may cut interest rates owing to deteriorating economic conditions, while at the same time banks may lend less because there are fewer and riskier lending opportunities due to deteriorating economic conditions. In this case, the relationship between monetary policy and lending would be biased because the deterioration of economic conditions drives them both.

[19]Following De Santis and Surico (2011) and Peydro et al. (2017), Taylor residuals are obtained by regressing the nominal interest rate (Euribor rate) on present and future realisations of credit growth, real GDP growth and inflation rate at the EMU-level. Details of the estimation are reported in appendix C).

[20]Building a nonlinear term structure model to analyse an economy operating near the zero lower bound (ZLB) for interest rates, Wu and Xia (2016) construct a shadow rate that incorporates the macroeconomic effects of unconventional monetary policy at the ZLB. As in Peydro et al. (2017), this paper uses the shadow rates implied by Wu and Xia (2016)'s model for Europe. Shadow rates data for Europe were downloaded from https://sites.google.com/site/jingcynthiawu/home/wu-xia-shadow-rates.

[21]Refer to footnote 2 for the definition of stressed and non-stressed countries.

[22]The ln(total assets) variable makes exception in that it is normalized not only with respect to the average over the whole sample period but also with respect to each single period. This aims at removing undesired trends in size, due to the fact that size is measured in nominal terms (Gambacorta, 2005).

[23]A widely used measure of sovereign risk, sovereign spread is defined as the difference between the German and the country's 10-year government bond yield, annual averages (Albertazzi et al., 2014)

[24]The Breusch-Pagan / Cook-Weisberg test revealed the presence of heteroskedasticity (Chi squared statistics is 47.39 and p-value is 0.0000) and the analysis of residual revealed higher heteroskedasticity across countries than across banks. In any case, results are robust to clustering at the bank level instead.

Table 3: Main results

Dep.Variable: Δ ln Loans	(1) MP=Euribor	(2) MP=Euribor	(3) MP=Euribor	(4) MP=Eonia	(5) MP=Taylor	(6) MP=Shadow rate
Δ MP	-1.013***	-1.063***		-0.870***	-3.251***	-0.487***
	(0.215)	(0.217)		(0.276)	(0.575)	(0.130)
Δ MP $\times$ BLC banks	-0.174	-0.532**	-0.417*	-0.486**	-2.350*	-0.347*
	(0.177)	(0.215)	(0.219)	(0.237)	(1.269)	(0.185)
Δ MP $\times$ BLC banks $\times$ Stressed		1.203***	0.937***	1.000***	11.27***	0.717**
		(0.317)	(0.324)	(0.360)	(2.477)	(0.285)
ln (Total assets$_{-1}$)	-0.136***	-0.134***	-0.213***	-0.137***	-0.150***	-0.154***
	(0.0136)	(0.0136)	(0.0211)	(0.0144)	(0.0127)	(0.0124)
Capital ratio$_{-1}$	-0.00346	-0.00378	-0.0107	-0.00393	-0.00466	-0.00525
	(0.0187)	(0.0187)	(0.0192)	(0.0187)	(0.0189)	(0.0188)
Liquidity ratio$_{-1}$	-0.00352	-0.00366	0.00253	-0.00268	-0.00575	-0.000451
	(0.0234)	(0.0234)	(0.0230)	(0.0235)	(0.0230)	(0.0237)
ln (Z scores$_{-1}$)	0.0271	0.0283	0.00789	0.0252	0.0217	0.0181
	(0.0228)	(0.0228)	(0.0231)	(0.0228)	(0.0228)	(0.0228)
ROE$_{-1}$	0.0364	0.0365	0.0713***	0.0410	0.0451*	0.0522**
	(0.0247)	(0.0247)	(0.0265)	(0.0250)	(0.0247)	(0.0252)
Real GDP growth	0.430***	0.450***	-0.118	0.368***	-0.00153	0.278***
	(0.0786)	(0.0798)	(0.176)	(0.0928)	(0.0401)	(0.0621)
Inflation	0.605***	0.625***	1.171***	0.457***	0.329***	0.357***
	(0.144)	(0.144)	(0.410)	(0.142)	(0.122)	(0.122)
Sovereign spread	-1.169***	-1.174***	-2.086***	-1.125***	-1.488***	-1.152***
	(0.171)	(0.171)	(0.260)	(0.173)	(0.198)	(0.174)
House index	0.00145***	0.00147***	0.000899***	0.00153***	0.00142***	0.00149***
	(0.000185)	(0.000186)	(0.000218)	(0.000185)	(0.000184)	(0.000184)
Observations	12,401	12,401	12,401	12,401	12,401	12,401
R-squared	0.381	0.382	0.393	0.380	0.383	0.380
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	No	Yes	No	No	No

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

In particular, bank lending is cyclical, as higher real GDP growth, inflation and the house price index are associated with higher bank lending, while domestic sovereign risk is negatively correlated to lending growth. Additionally, smaller banks have higher lending rates, while bank capitalisation, efficiency, risk and liquidity are not significantly related to the flow of loans. Moreover, there appears to be no evidence of a bank lending channel, as the coefficient on the first interaction term (β_2) is not statistically different from zero at conventional levels.

The second column of table 3 adds the second interaction term thereby allowing the bank lending channel to vary between banks located in stressed and non-stressed countries. The coefficient (β_3) is positive and statistically significant and the bank lending channel coefficient (β_2) now turns negative and statistically significant. This finding indicates that the transmission of monetary policy to bank lending is weaker for banks in stressed countries as compared to banks in non-stressed countries.[25] The effect is economically significant: the same 1% cut in the policy rate leads to a 1.6% increase in lending by banks located in non-stressed countries as opposed to a 0.4% increase for banks located in stressed countries. These results contrast with evidence by Ciccarelli et al. (2013) and Cantero-Saiz et al. (2014), while accord to the findings of De Santis and Surico (2013) and De Santis (2015), albeit their evidence is based on country-by-country regressions for the largest four countries in the euro area (Germany, France, Italy and Spain).

[25] A Wald test performed on the joint significance of the beta coefficients rejects the hypothesis that coefficients are equal to zero. The p-value is 0.0005 and the F statistic is 12.79.

The same results are found when year fixed effects are added (third column of table 3) and when monetary policy is measured by the Eonia or by Taylor residuals (fourth and fifth columns of table 3), suggesting the effect is not driven by year-specific shocks nor by the choice or potential endogeneity of the monetary policy indicator.

Next, unconventional monetary policy is considered by replacing the shadow rate as monetary policy indicator. Results in column 6 of table 3 are in line with previous findings, though the coefficients are smaller. A 1% drop in the shadow rate increases lending growth by 0.8% for non-stressed countries banks as opposed to a 0.1% for banks located in stressed countries.

The robustness of the main results is verified with a series of checks reported in table 4. First, bank level variables may suffer of endogeneity. For instance, lending growth may be correlated to its past realisations. If so, failure to account for such persistence would introduce omitted variable bias into the estimation. Similarly, causality may reversely run from the dependent variable (lending growth) to bank level independent variables (total assets, capital and liquidity ratios), as changes in current and future lending could in fact be driving changes in other balance sheet characteristics rather than the other way around. To tackle both issues, model (1) is re-estimated with the Generalised Method of Moments (GMM) estimator (Arellano and Bond, 1991; Blundell and Bond, 1998)[26] in the attempt to mitigate endogeneity concerns while avoiding the dynamic panel bias inherent to the introduction of a lagged dependent variable.[27] System GMM estimates are reported in column 1 of table 4. Lagged lending growth is not statistically significant, alleviating concerns about omitted variable bias in other specifications.[28] The main results are left qualitatively unchanged, though coefficients are now larger. The same 1% drop in the Euribor rate leads to a 4.5% increase in lending by banks located in non-stressed countries as opposed to a 2.6% increase for banks located in stressed countries.

Second, the finding on heterogeneity may be driven by particular countries in particular years. To make sure this is not the case, the model is re-estimated with country $\times$ year fixed effects. Estimates in column 2 of table 4 remain qualitatively and quantitatively in line with baseline estimates.

Third, as discussed in section 2.2, the BLC sub-sample may suffer of selection bias owing to the over-representation of banks located in non-stressed countries. To mitigate this concern, the model is re-estimated with OLS and an additional dummy for BLC banks together with its interaction with the stressed countries indicator and monetary policy. The rationale is that if selection bias was truly skewing the results, these variables should absorb most of the effect and drastically reduce the size and statistical significance of β_1 and β_2. Column 3 of table 4 reveals this is not the case. Albeit quantitatively smaller, point estimates for the two coefficients are statistically significant and consistent with previous results.

Fourth, banks that belong to a banking group are usually safer than standalone banks, regardless of the health of their unconsolidated balance sheet (Ashcraft, 2006, 2008).[29] Hence, it is possible that the selection criterion considers a bank to be small (under-capitalised/illiquid) when it is in fact a subsidiary of a very large (well capitalised/liquid) banking group, thus casting doubts on the bank lending channel test.[30] A similar confounding factor is bank specialisation. As stressed by De Santis and Surico (2013), specialisation is an important source of cross-bank variation and has an impact on how banks react to monetary policy shocks. The issue here is that if banks with a particular specialisation were systematically more sensitive to monetary policy and if such type of bank was prevalent in a particular country group, heterogeneity in the transmission of monetary policy would be driven by specialisation.[31]

[26] The system version of the estimator is used as it tends to outperform difference GMM in terms of both consistency and efficiency (Blundell and Bond, 1998). System GMM mitigates endogeneity issues by instrumenting suspected endogenous variables (lagged lending growth, total assets, capital and liquidity ratios, bank risk and ROE) with their lags or differenced lags. Exogenous variables (monetary policy and other macroeconomic variables) are instrumented by themselves.

[27] Lagged values of the dependent variable are mathematically correlated with bank fixed effects.

[28] Fungáčová et al. (2014) found the same results using similar data and argued that the annual frequency may not be a meaningful time-frame to evaluate lending persistence.

[29] Campello (2002) and Ashcraft (2006) documented that banks affiliated with multi-bank holding companies are more likely to receive capital injections through access the parent has on public markets. Banks affiliated with multi-bank holding also tend to have better access to federal funds and funding markets, implying they find it easier to smooth monetary and financial shocks on their balance sheets.

[30] However, as noted by Kashyap and Stein (1995), any misclassification will merely have the effect of making estimates of the bank lending channel more conservative.

[31] As reported by De Santis and Surico (2013), in Orbis Bank Focus commercial banks are defined as mainly active in retail banking (households and SMEs), wholesale banking (large firms) and private banking. Savings banks are similarly engaged in retail banking but belong to a banking group usually characterised by a decentralised distribution network which provides local

Table 4: Robustness

Dep.Variable: $\Delta \ln$ (Loans)	(1) GMM	(2) Country × Year	(3) Selection bias	(4) Special. & group	(5) Special. & group	(6) Placebo
Δ MP	-2.473***		-1.768**	-2.299***		-1.049*
	(0.320)		(0.691)	(0.464)		(0.525)
Δ MP × BLC banks	-2.071***	-0.326**	-0.393*	-0.709***	-0.634***	0.314
	(0.388)	(0.138)	(0.219)	(0.177)	(0.116)	(0.503)
Δ MP × BLC banks × Stressed	1.894***	0.476**	0.586**	1.293***	1.211***	-1.124
	(0.535)	(0.198)	(0.255)	(0.227)	(0.340)	(1.476)
$\ln$ (Total assets$_{-1}$)	0.00474	-0.215***	-0.00601	-0.00661	-0.00655	-0.135***
	(0.0214)	(0.0451)	(0.00373)	(0.00669)	(0.00632)	(0.0173)
Capital ratio$_{-1}$	-0.00352	-0.00865	0.00302	0.00469	0.00472	-0.00346
	(0.0926)	(0.0228)	(0.00643)	(0.00529)	(0.00529)	(0.0235)
Liquidity ratio$_{-1}$	-0.00769	-0.0109	0.0241	0.00996	0.00809	-0.00347
	(0.0347)	(0.0229)	(0.0206)	(0.0123)	(0.0106)	(0.0211)
$\ln$ (Z scores$_{-1}$)	0.111	-0.00945	-1.31e-05	-0.000519	-0.000555	0.0273
	(0.117)	(0.0442)	(0.00176)	(0.00229)	(0.00213)	(0.0297)
ROE$_{-1}$	-0.114	0.0522	0.0512***	0.0789***	0.0799***	0.0364
	(0.102)	(0.0525)	(0.0176)	(0.0161)	(0.0182)	(0.0325)
Real GDP growth	1.028***		0.573***	0.802***	0.337	0.430**
	(0.112)		(0.188)	(0.154)	(0.340)	(0.166)
Inflation	0.931***		0.983***	1.143***	1.166***	0.605**
	(0.302)		(0.219)	(0.178)	(0.387)	(0.225)
Sovereign spread	-0.533		-1.253**	-1.181**	-1.340**	-1.169***
	(0.375)		(0.491)	(0.503)	(0.479)	(0.338)
House index	0.00270***		0.00122**	0.00168***	0.00144***	0.00145*
	(0.000703)		(0.000421)	(0.000350)	(0.000388)	(0.000699)
$\Delta \ln$ Loans$_{-1}$	0.0125					
	(0.0235)					
BLC banks			0.00868**			
			(0.00331)			
Stressed			0.0107			
			(0.00765)			
Δ MP × Stressed			0.614			
			(0.449)			
BLC banks × Stressed			-0.0104			
			(0.00610)			
Constant			-0.0961**			
			(0.0412)			
Observations	7,575	12,386	12,544	9,024	9,015	12,401
R-squared		0.440	0.049	0.078	0.094	0.381
Bank FE	Yes	Yes	No	No	No	Yes
Country × Year FE	No	Yes	No	No	No	No
Special. × Group FE	No	No	No	Yes	No	No
Special. × Group × Year FE	No	No	No	No	Yes	No
AB test for AR(1), p-value	0.000					
AB test for AR(2), p-value	0.297					
Hansen test, p-value, p-value	0.209					
Number of instruments	32					

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

outreach. Finally, cooperative banks have a cooperative ownership structure and are also engaged in retail banking.

In addition, these issues are likely to be intertwined: for example, saving banks in Germany and cooperative banks in France are often subsidiaries of larger banking groups. To address these concerns, model (1) is re-estimated adding Group×Specialisation and Group×Specialisation×year fixed effects. "Group" is a categorical variable that contains information on whether a bank is independent, single location, a local branch, a controlled subsidiary, or the group head.[32] "Specialisation" is a categorical variable indicating whether the bank is a commercial, savings or cooperative institution. Once again, results remain broadly unchanged (columns 4 and 5 of table 4).

Finally, a placebo regression provides a general test of the validity of the BLC selection criterion by focusing on a subset of banks that, according to the bank lending channel theory, should be least sensitive to monetary policy. Specifically, in column 6 the indicator variable BLC now selects banks that are simultaneously large, liquid and well capitalised (the thresholds are the opposite of those defined in section 2.2). If the BLC criterion is valid, one would expect β_2 and β_3 to be statistically insignificant, in line with the notion that these banks are less sensitive to monetary policy changes since they face negligible information issues on funding markets and can freely access liquidity when needed (Kashyap and Stein, 1995). Estimates reported in column 6 of table 4 confirm this is the case. While the effect of monetary policy for all banks (β_1) remains negative and significant, estimates for β_2 and β_3 are statistically insignificant.[33]

3.1 Sovereign stress as source of heterogeneity

Results presented so far indicate that the transmission of monetary policy to lending was weaker for banks located in countries subject to severe sovereign stress. One possible interpretation is that sovereign stress impaired the transmission of monetary policy across the euro area by restricting lending supply more in stressed countries than in non-stressed countries. This may be because sovereign risk impairs the balance sheet and disproportionately raises borrowing costs of banks located in countries under sovereign stress and with large domestic sovereign exposures, forcing them to cut on lending. Another interpretation focuses instead on credit demand. At times of sovereign stress, firms and households in stressed countries are more likely to reduce investment and consumption, and hence to demand less credit than their counterparts in non-stressed countries. In this case, heterogeneity would reflect a weaker response of credit demand to monetary policy in stressed countries. Although, as discussed in section 2.2, there is little evidence consistent with this interpretation, this section tests whether heterogeneity in monetary transmission can be directly linked to the adverse effect of sovereign risk on bank loan supply. A second model is estimated:

$$\Delta \ln (Loans)_{it} = \alpha_i + \Delta MP_t(\beta_1 + \beta_2 BLC\ banks_i + \beta_3 BLC\ banks_i \times Stressed_i + \beta_4 BLC\ banks_i \times Stressed_i \times Sov\ exposure_{it-1}) + \gamma_1 X_{it-1} + \gamma_2 Y_{it} + \epsilon_{it} \quad (2)$$

where, as before, *i* indicates banks and *t* years. Model (2) augments model (1) with one interaction term designed to capture how heterogeneity in monetary transmission to lending varies with banks' sovereign exposure, defined as the ratio of government debt securities to total assets as in Altavilla et al. (2017).[34] The logic is the following. If sovereign stress really constrains the response of bank lending to monetary policy in stressed countries, this response should be weaker for banks with larger (ex-ante) sovereign exposures. Conversely, if subdued credit demand is driving the weaker lending response to monetary policy in stressed countries, one should not observe significant differential effects

[32] Specifically, the categories are defined as: branch location, i.e. a secondary location over which headquarters have legal responsibility; controlled subsidiary, i.e. a bank that is controlled by another entity; global ultimate owner (GUO), i.e. a bank which is the ultimate owner of a corporate group; independent, that is a company which is not a GUO but which could be GUO; and single location, i.e. a bank which has no ownership links to any other bank (that is, is neither a shareholder nor a subsidiary).

[33] A Wald test performed on the joint significance of the beta coefficients cannot reject the hypothesis that coefficients are equal to zero. The p-value is 0.6072 and the F statistic is 0.51.

[34] Breakdown between domestic and non-domestic government securities holdings is not available, hence the variable "Sovereign exposure" lumps domestic government bonds together with non-domestic bonds. However, as noted by Altavilla et al. (2017), from 2010 onwards the extent of "home bias" in government bond holdings for both banks in stressed and non-stressed countries is considerable. As of January 2015, on average banks in stressed countries had five time more domestic sovereign exposure than non-domestic sovereign exposure, while banks in non-stressed countries had almost twice as much domestic sovereign exposure than non-domestic exposure. Similarly, Battistini et al. (2014) emphasise the extent of home bias in sovereign portfolios by euro area banks from 2008 to 2013. It thus appears reasonable to treat much of the sovereign bond holding as domestic. As all other bank level variables, the sovereign exposure variable is normalised with respect to its own mean.

across banks with different sovereign exposures.[35] The test thus rests on the size and statistical significance of β_4. A positive sign would indicate that the effect of monetary policy on lending for stressed countries banks weakens with sovereign exposure. In turn, this would imply that heterogeneity in monetary transmission to bank lending between stressed and non-stressed countries in the euro area is exacerbated by exposure to sovereign risk.

Table 5 presents the result of this test, reporting estimates related to conventional monetary policy (Euribor rate) in columns 1 to 3 and estimates related to unconventional policy (Shadow rate) in columns 4 to 6. For this exercise, the estimating sample is reduced to the period 2010-2015 in order to focus on the sovereign debt crisis and its aftermath. Findings are consistent with hypothesis 4. The coefficient of interest (β_4) is positive and statistically significant across specifications and measures of monetary policy, indicating that in stressed countries the effect of monetary policy on bank lending abates with sovereign exposure. Figure 2a provides a graphical illustration of this finding by plotting the estimated marginal effect of monetary policy on bank lending growth for stressed countries banks as a function of their sovereign exposure. In stressed countries, the same 1% policy rate cut is associated to a 3.7% increase in lending by banks with low (ex-ante) sovereign exposures (1st quartile, i.e. a share of government debt holding equal to 0.6% of total assets) as opposed to a 1.1% increase in lending by banks with high (ex-ante) sovereign exposures (3rd quartile, i.e. 10% of total assets). The effect becomes nihil and even turns negative for higher exposures to sovereign debt, suggesting that extremely exposed banks actively reduced credit in the face of monetary policy easing.

The implications of sovereign exposure on heterogeneity can be seen in figure 2b, which plots the estimated degree of heterogeneity (corresponding to coefficient β_3) as a function of sovereign exposure. For banks with low (ex-ante) levels of sovereign exposure, the same 1% policy rate cut is evenly transmitted to lending across banks in stressed and non-stressed countries. Specifically, the bank lending channel of monetary policy of non-stressed countries banks is not significantly different than that of stressed countries banks for sovereign exposures smaller than 3% of total assets.[36] As sovereign exposure increases, however, heterogeneity in monetary transmission gradually builds up. In response to the same 1% policy rate cut, the credit expansion of stressed countries banks with high sovereign exposures (10% of total assets) is 2.75% weaker than that of non-stressed countries bank.

The finding that cross-country heterogeneity in monetary transmission to lending increases with sovereign exposure can be explained by two complementary considerations. On the one hand, during the euro area debt crisis sovereign default risk was disproportionally higher for government bonds issued by stressed countries. Insofar the largest share of banks' sovereign debt portfolios was typically domestic, debt re-pricing and balance sheet impairment would have been more severe for banks based in stressed-countries for any given level of domestic sovereign exposure. On the other hand, home bias was particularly pronounced for the sovereign debt portfolios of banks located in stressed countries (Altavilla et al., 2017; Battistini et al., 2014). Heterogeneity can then be attributed to the skewed distribution of sovereign bond holdings by banks across countries depicted in figure 2c. Between 2007 and 2016, on average 95% of banks in non-stressed countries had sovereign exposures lower than 10% of total assets, as opposed to 35% of stressed countries banks. Conversely, 65% of stressed countries banks had sovereign exposures over 10% of total assets, as opposed to only 5% of non-stressed countries banks. The combination of these dynamics — higher sovereign risk and greater home bias in sovereign exposure for banks in stressed countries — likely explains heterogeneity in monetary transmission to bank lending across the euro area.

[35] Crucially, this test depends on the assumption that banks with larger sovereign exposures in stressed countries do not systematically face customers whose loan demand is more sensitive to sovereign stress and/or less sensitive to monetary policy. If this identifying assumption fails to hold, supply and demand effects remain indistinguishable.

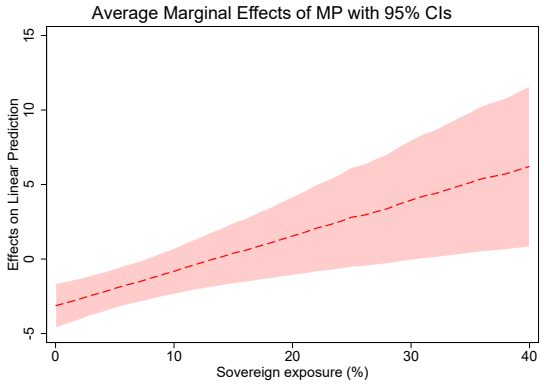
[36] More precisely, the marginal effect is not significantly different from 0 until sovereign exposure reaches 3% of total assets.

Table 5: Sovereign risk

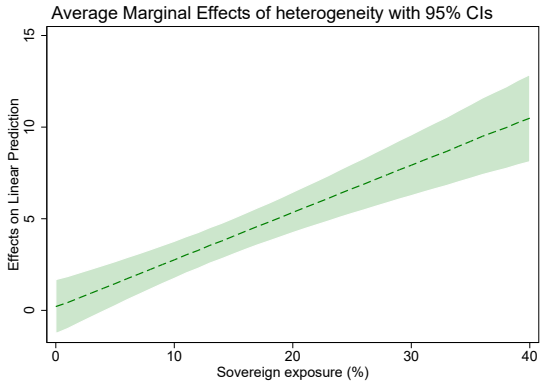
	(1)	(2)	(3)	(4)	(5)	(6)
Δ ln (Loans)	MP=Euribor	MP=Euribor	MP=Euribor	MP=Shadow	MP=Shadow	MP=Shadow
Δ MP	-1.650***			-1.263***		
	(0.450)			(0.186)		
Δ MP $\times$ BLC banks	-2.250***	-2.255***	-1.645***	-0.759**	-0.860**	-0.649***
	(0.358)	(0.297)	(0.421)	(0.323)	(0.336)	(0.115)
Δ MP $\times$ BLC banks $\times$ Stressed	2.157***	2.427***	1.088	1.294**	1.438**	1.286**
	(0.554)	(0.507)	(0.847)	(0.530)	(0.616)	(0.525)
Δ MP $\times$ BLC banks $\times$ Stressed	2.888***	2.647***	2.556***	0.779***	0.829***	0.868***
$\times$ Sov. Exposure$_{-1}$	(0.470)	(0.561)	(0.531)	(0.217)	(0.215)	(0.176)
ln (Total assets$_{-1}$)	-0.256***	-0.278***	-0.316***	-0.321***	-0.281***	-0.317***
	(0.0417)	(0.0578)	(0.0503)	(0.0405)	(0.0588)	(0.0511)
Capital ratio$_{-1}$	0.0499**	0.0510**	0.0539***	0.0538**	0.0514**	0.0548***
	(0.0220)	(0.0199)	(0.0165)	(0.0204)	(0.0201)	(0.0171)
Liquidity ratio$_{-1}$	0.00531	0.00198	0.000518	-0.000117	0.00186	0.000352
	(0.0196)	(0.0211)	(0.0222)	(0.0217)	(0.0206)	(0.0218)
ln (Z score$_{-1}$)	-0.102	-0.111	-0.156**	-0.141**	-0.112	-0.157**
	(0.0643)	(0.0666)	(0.0624)	(0.0584)	(0.0669)	(0.0628)
ROE$_{-1}$	0.153**	0.169**	0.233***	0.212***	0.170**	0.235***
	(0.0622)	(0.0711)	(0.0689)	(0.0586)	(0.0705)	(0.0691)
Sov. exposure$_{-1}$	0.0269***	0.0244***	0.0241***	0.0208***	0.0249***	0.0245***
	(0.00396)	(0.00397)	(0.00309)	(0.00472)	(0.00397)	(0.00317)
Real GDP growth	-0.464	-1.078*		-0.874	-1.063*	
	(0.589)	(0.536)		(0.549)	(0.535)	
Inflation	0.385	0.762		0.0990	0.827	
	(0.380)	(0.688)		(0.467)	(0.724)	
Sovereign spread	-1.900***	-2.295***		-2.206***	-2.298***	
	(0.572)	(0.657)		(0.543)	(0.663)	
House index	0.00198***	0.00142*		0.00152**	0.00134*	
	(0.000652)	(0.000705)		(0.000598)	(0.000720)	
Observations	7,155	7,155	7,141	7,155	7,155	7,141
R-squared	0.493	0.500	0.538	0.495	0.499	0.538
Bank FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	No	Yes	No	No	Yes	No
Country $\times$ Year FE	No	No	Yes	No	No	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

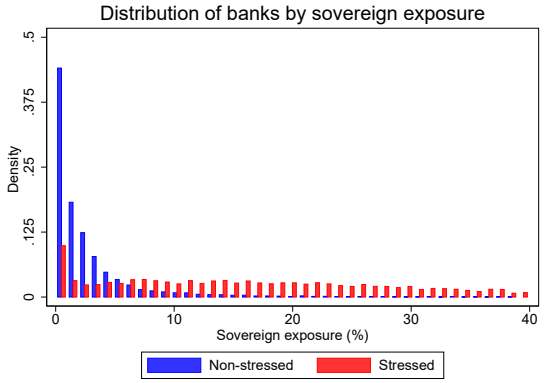
Figure 2: Sovereign risk and heterogeneity



(a) Estimated marginal effect of monetary policy on lending growth for BLC banks in stressed countries as a function of sovereign exposure. Author's calculation based on estimates of model 2(table 5, column 1).



(b) Estimates of β_3 as a function of sovereign exposure. Author's calculation based on estimates of model 2(table 5, column 1).



(c) Source: Fitchconnect (2017).

These results are consistent with evidence on the adverse effect of sovereign risk on bank lending and monetary transmission (Altavilla et al., 2016, 2017; Bofondi et al., 2018; De Marco, 2017; Peydro et al., 2017; Popov and Van Horen, 2015), and establish a direct link between sovereign risk and heterogeneity in monetary transmission to bank lending across countries.

A sceptic may still contend that there may be nothing special about government debt. The effect may instead come from differences in banks' holdings of liquid securities more generally. It is indeed possible that banks with different degrees of liquidity respond differently to monetary policy, especially in periods of financial turmoil (Gambacorta and Marques-Ibanez, 2011; Kashyap and Stein, 2000). While the effect of banks' liquidity ratios is already controlled for in all previous estimations, robustness to this specific concern is specifically checked by replacing sovereign exposure with the ratio of other securities to total assets in model (2). If the effect observed for sovereign exposure is a particular case of a general liquidity effect, then one should observe the same result by conditioning on the share of securities other than government bonds. Estimates reported in table 6 indicate that this is not the case. Across specification, the sign on the triple interaction coefficient is mostly negative, suggesting that, if anything, stressed countries banks responded to monetary easing by expanding lending by more the higher their holdings of securities other than government bonds. This finding is however less robust and economically significant than that presented in table 6. Overall, there is no evidence that heterogeneity in monetary transmission across countries is greater the larger the share of securities other than government bonds held by banks, confirming sovereign exposure to be a key source of heterogeneity.

Table 6: Other securities

VARIABLES	(1) MP=Euribor	(2) MP=Euribor	(3) MP=Euribor	(4) MP=Shadow	(5) MP=Shadow	(6) MP=Shadow
Δ MP	-1.270**			-1.407***		
	(0.495)			(0.187)		
Δ MP $\times$ BLC banks	-2.248***	-2.277***	-1.663***	-0.656**	-0.790**	-0.621***
	(0.368)	(0.320)	(0.420)	(0.300)	(0.320)	(0.129)
Δ MP $\times$ BLC banks $\times$ Stressed	0.993	1.281	1.124	-2.414	-2.219	-1.126
	(1.111)	(0.821)	(0.774)	(2.310)	(2.301)	(1.874)
Δ MP $\times$ BLC banks $\times$ Stressed	-1.450*	-1.511**	-0.277	-3.939*	-3.984*	-2.817*
$\times$ Other securities$_{-1}$	(0.746)	(0.573)	(0.644)	(1.876)	(1.900)	(1.474)
ln (Total assets$_{-1}$)	-0.226***	-0.268***	-0.301***	-0.299***	-0.272***	-0.305***
	(0.0572)	(0.0711)	(0.0670)	(0.0506)	(0.0710)	(0.0669)
Capital ratio$_{-1}$	0.0328*	0.0332**	0.0382***	0.0352**	0.0344**	0.0397***
	(0.0167)	(0.0150)	(0.0125)	(0.0156)	(0.0153)	(0.0128)
Liquidity ratio$_{-1}$	-0.00849	-0.0112	-0.0135	-0.0119	-0.0108	-0.0131
	(0.0208)	(0.0215)	(0.0214)	(0.0221)	(0.0213)	(0.0211)
ln (Z score$_{-1}$)	-0.0963*	-0.110**	-0.151***	-0.130***	-0.114**	-0.155***
	(0.0503)	(0.0508)	(0.0467)	(0.0423)	(0.0510)	(0.0466)
ROE$_{-1}$	0.144**	0.172**	0.232***	0.199***	0.175***	0.235***
	(0.0537)	(0.0601)	(0.0589)	(0.0481)	(0.0593)	(0.0585)
Other securities$_{-1}$	0.0306***	0.0321***	0.0281***	0.0329***	0.0319***	0.0280***
	(0.00364)	(0.00364)	(0.00309)	(0.00386)	(0.00363)	(0.00315)
Real GDP growth	-0.589	-1.024*		-0.894	-1.023*	
	(0.666)	(0.516)		(0.578)	(0.512)	
Inflation	0.0691	0.643		-0.0939	0.715	
	(0.379)	(0.680)		(0.395)	(0.721)	
Sovereign spread	-2.142***	-2.452***		-2.361***	-2.452***	
	(0.643)	(0.682)		(0.584)	(0.689)	
House index	0.00155***	0.00104*		0.00123***	0.000955*	
	(0.000412)	(0.000501)		(0.000383)	(0.000515)	
Observations	7,227	7,227	7,213	7,227	7,227	7,213
R-squared	0.494	0.503	0.539	0.501	0.503	0.539
Bank FE	Yes	Yes	Yes	Yes	Yes	No
Year FE	No	Yes	No	No	Yes	No
Country $\times$ Year FE	No	No	Yes	No	No	Yes

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Conclusion

This paper documented that between 2007 and 2016 monetary transmission to bank lending was heterogeneous across the euro area, with conventional and unconventional monetary policy having a weaker effect on bank lending in countries under sovereign stress vis-à-vis non-stressed countries. In line with previous studies, sovereign risk is singled out as a crucial source of heterogeneity. The effect of monetary policy on bank lending is weaker the greater the sovereign exposure of banks in stressed countries.

These results have direct implications for policy. Significant heterogeneity in the transmission of the single monetary policy to bank lending poses significant challenges to monetary policy makers since it implies that policy feeds through the real economies of different euro area members with a varying degree of intensity and efficacy (Cœuré, 2017; ECB, 2012; Guiso et al., 2000). In this respect, two types of policy measures may be helpful. First, insofar sovereign risk exacerbates heterogeneity, reducing home bias in sovereign exposure is urgent and indispensable, all the more so given banks' holdings of domestic government bonds are now even higher than in 2011 (Altavilla et al., 2016). In this respect, bank regulation may create incentives to reduce excessive exposures to specific sovereigns, for instance by introducing "sovereign concentration charges" whereby banks holding exposures to any euro area sovereign issuer in excess of a threshold would be required to hold additional capital (Bénassy-Quéré et al., 2018; Véron, 2017). Second, completing the Banking Union would hasten the harmonisation of standards, regulations and procedures across euro area banking systems, thus reducing heterogeneities in monetary transmission emanating from differences in financial structures across countries.

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Appendix A Figures

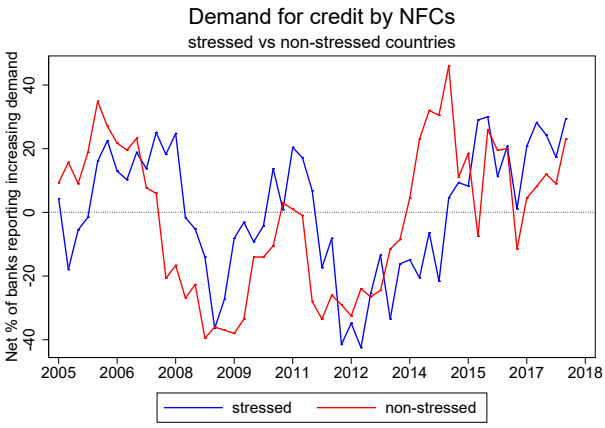

Figure 3: Demand for credit by NFCs, stressed vs non-stressed countries
Difference between the share of surveyed banks that reported an increase in credit demand by NFCs over the past three months minus the share of surveyed banks that reported a reduction in credit demand by NFCs over the past three months. Source: Bank Lending Survey, ECB (2017).

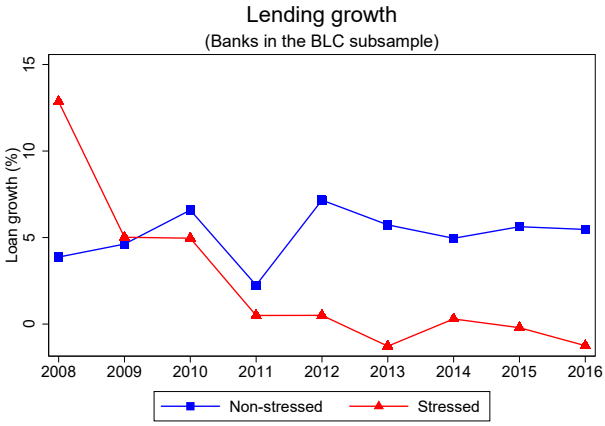

Figure 4: Lending growth in the cross section
Annual lending growth by BLC-banks across stressed and non-stressed countries. Source: Fitchconnect (2017).

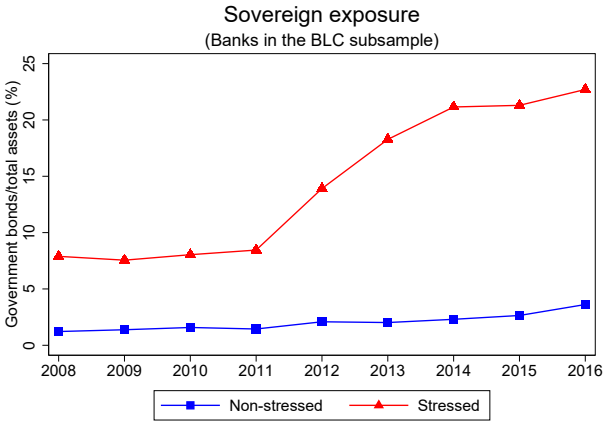

Figure 5: Government securities on banks' balance sheets
Annual share of government securities as % of total assets held by BLC banks across stressed and non-stressed countries. Source: Fitchconnect (2017).

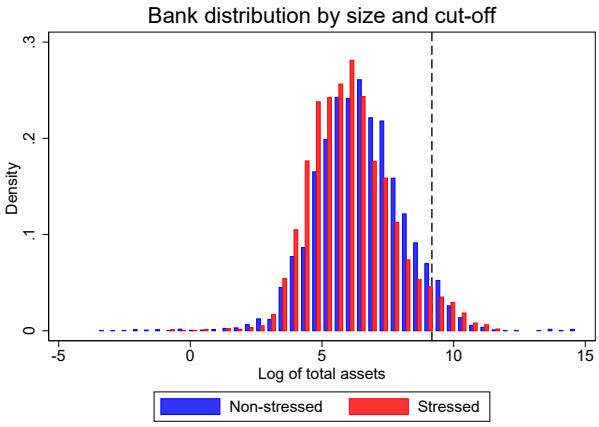

Figure 6: Distribution of banks by size across stressed and non-stressed countries and relative cut-off as defined in section 2.2. Source: Fitchconnect (2017)

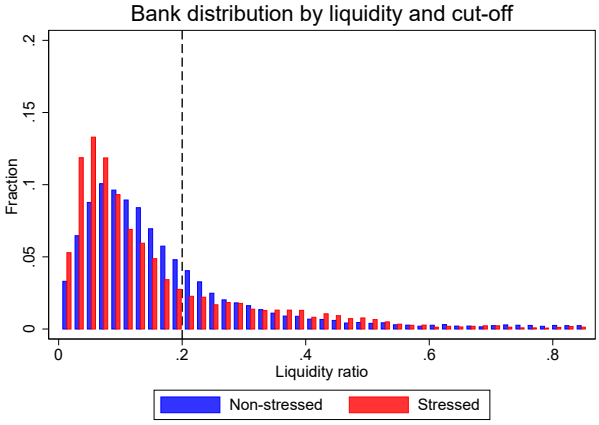

Figure 7: Distribution of banks by liquidity ratio across stressed and non-stressed countries and relative cut-off as defined in section 2.2. Source: Fitchconnect (2017)

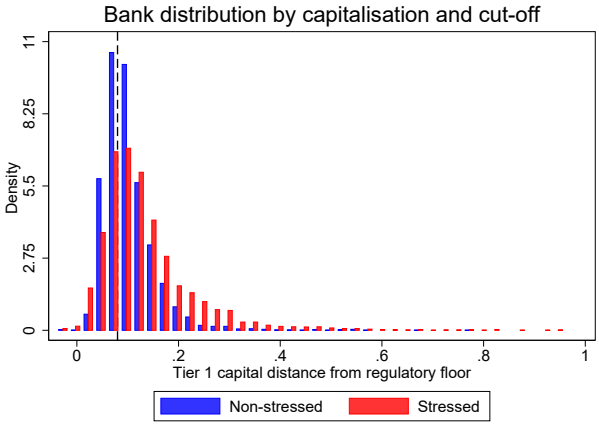

Figure 8: Distribution of banks by Tier 1 capital ratio across stressed and non-stressed countries and relative cut-off as defined in section 2.2. Source: Fitchconnect (2017)

Appendix B Tables

Table 7: Selection bias – comparing BLC banks with full sample

	BLC banks		Full sample		Comparison
Countries	(1) Number of banks, BLC subsample	(2) Share of BLC subsample (%)	(3) Number of banks, full sample	(4) Share of full sample (%)	(5) Over/under representation (=2-3)
Stressed countries	*110*	*23,5*	*850*	*33,4*	*-9,9*
Cyprus	4	0,9	14	0,6	0,3
Greece	0	0,0	9	0,4	-0,4
Ireland	2	0,4	21	0,8	-0,4
Italy	75	16,0	583	22,9	-6,9
Latvia	1	0,2	8	0,3	-0,1
Lithuania	2	0,4	2	0,1	0,3
Portugal	4	0,9	107	4,2	-3,4
Slovenia	4	0,9	10	0,4	0,5
Spain	18	3,8	96	3,8	0,1
Non-stressed countries	*358*	*76,5*	*1694*	*66,6*	*9,9*
Austria	35	7,5	195	7,7	-0,2
Belgium	6	1,3	26	1,0	0,3
Estonia	0	0,0	2	0,1	-0,1
Finland	1	0,2	38	1,5	-1,3
France	52	11,1	212	8,3	2,8
Germany	231	49,4	1101	43,3	6,1
Luxembourg	29	6,2	79	3,1	3,1
Malta	0	0,0	9	0,4	-0,4
Netherlands	1	0,2	15	0,6	-0,4
Slovakia	3	0,6	17	0,7	0,0
Total	**468**	**100**	**2544**	**100**	**100**

Table 8: Descriptive statistics

Descriptive statistics (mean values, 2007-2016)	All countries			Stressed countries			Non-stressed countries		
	All banks	BLC banks	Other banks	All banks	BLC banks	Other banks	All banks	BLC banks	Other banks
Total assets	1,973	919	2,048	1,748	743	1,852	2,075	1,056	2,133
Equity/assets	0.1	0.07	0.1	0.11	0.08	0.12	0.09	0.06	0.09
Loans/assets	0.59	0.66	0.58	0.63	0.71	0.62	0.57	0.62	0.57
NPL/loans	0.08	0.07	0.08	0.11	0.1	0.11	0.04	0.05	0.04
Liquidity ratio	0.69	0.03	0.75	1.01	0.03	1.12	0.52	0.02	0.55
Loans growth	0.04	0.06	0.04	0.03	0.037	0.035	0.04	0.051	0.04
Securities/assets	0.23	0.21	0.23	0.2	0.16	0.2	0.25	0.24	0.25
Government securities/assets	0.08	0.07	0.08	0.18	0.12	0.19	0.03	0.02	0.03

Table 9: Variables description

Variable	Definition	Source
Euribor rate	Euro Interbank Offered Rate rate, 3 months	ECB (2017)
Eonia rate	Euro OverNight Index Average	ECB (2017)
Shadow rate	Wu and Xia (2017) estimated shadow rate for Europe	Jing Cynthia Wu personal website
Real GDP growth	Gross domestic product at market prices, chained linked volume, annual growth	Eurostat (2017)
Inflation	Harmonised index of consumer prices, overall index, annual rate of change	Eurostat (2017)
Sovereign spread	Spread between domestic 10-year government bond yield and 10-year German Bund yield	ECB (2017)
House index	Residential property price index statistics, new and existing dwellings	ECB (2017)
Loans	Gross loans	Fitchconnect (2017)
Total assets	Log of total banking assets	Fitchconnect (2017)
Liquidity ratio	Liquidity ratio	Fitchconnect (2017)
Capital ratio	Equity capital/total assets	Fitchconnect (2017)
Z scores	$\frac{ROA_{it}+(Equity_{it}/\,Total\ assets_{it})}{\sigma(ROA_{it})}$	Fitchconnect (2017), Beck et al. (2013)
Tier 1 ratio	Tier 1 Risk-weighted capital ratio	Fitchconnect (2017)
Sovereign exposure	Government securities/total assets	Fitchconnect (2017)

Appendix C Taylor residuals

To obtain Taylor residuals, the following model is estimated with OLS (De Santis and Surico, 2013; Peydro et al., 2017):

$$i_t = \alpha + \beta_1 i_{t-1} + \beta_2 Y_t + \beta_3 Y_{t+1} + \epsilon_t$$

Where t stands for years,the sample period being 2007-2016. The short-term interest rate (Euribor rate) is regressed on its past realizations as well as on present and future (forecast) measures of credit growth, real GDP growth and inflation at the euro area level. OLS estimation provides residuals, defined as the difference between the dependent variable and its least square prediction. Residuals are intended to pick up all the variability of the interest rate which is not explained by independent variables and are taken as a measure of exogenous monetary policy shocks.