Received 26 March 2019
Revised 13 June 2019
Accepted 6 July 2019

How did regulation and market discipline influence banking distress in Europe?

Lessons from the global financial crisis

Vitor Branco Oliveira
Banco de Portugal, Lisbon, Portugal, and

Clara Raposo
Lisbon School of Economics and Management, University of Lisbon, Lisbon, Portugal

Abstract

Purpose – This paper aims to examine the relationship between regulation, market discipline and banking distress.

Design/methodology/approach – To address the empirical question put forward above, a multivariate logit model is applied to an international sample of 586 banks from 21 European countries in the period between 2000 and 2012. To give robustness to the results, different variables have been used to test the role played by market discipline and regulation as well as an alternative methodology known as duration/survival analysis.

Findings – It can be found that market discipline is a good indicator in signalling banking distress, that is, market discipline has penalized more banks with a higher likelihood of being in distress. Nonetheless, as broadly acknowledged, market discipline was not sufficient per se to avoid banking distress in Europe. With regard to regulation, this paper evidences that the adoption of other regulatory measures beyond the simple transposition of changes occurred in the EU Directives such as borrower-based measures and limits on pre-emptive exposures' concentration, have contributed toward reducing the probability of distress of EU banks, showing that the introduction of this kind of measures was necessary and relevant. In addition, in this paper, it can be found that the NPL ratio, size, capital (including the well-known regulatory capital ratio, as well as the novel leverage ratio which discards the risk weights present in the former one) and liquidity are good indicators of banking distress which lead us to conclude that the new regulatory framework known as Basel III is on the right path to mitigate the probability that a new banking crisis similar to the last one takes place again.

Research limitations/implications – The first limitation regards the period of time chosen, that is, from 2000 to 2012, empirically neglecting, to some extent the important regulatory changes occurred after the aforementioned period. Nonetheless, as mentioned in the Data and Methodology section, the period ends in 2012 because it is difficult to flag a reasonable number of banks' bailouts afterwards, to properly run the type of model used in this paper. The second limitation is the fact that the possible changes in the risk management and risk assessment by institutions and in the behaviour of investors, acknowledge as weak and inappropriate before the on-set of the global financial crisis, albeit very relevant, are not in the scope of this paper.

JEL classification – G21, G28

The authors acknowledge helpful comments and suggestions from Kevin Davis, Raquel Gaspar and Samuel Lopes. The views expressed in this article are those of the author, Vitor Oliveira, and do not necessarily reflect those of the Banco de Portugal or the Eurosystem. Clara Raposo gratefully acknowledges financial support from FCT – Fundação para a Ciencia e Tecnologia (Portugal), national funding through research grant (UID/SOC/04521/2013).

Studies in Economics and Finance
Vol. 37 No. 1, 2020
pp. 160-198

1086-7376
DOI 10.1108/SEF-03-2019-0123

Practical implications – Despite the welcomed changes performed by regulators so far, some aspects are not complete yet and new areas deserve more empirical work and attention by the regulators and supervisors. Some of them stem directly from the results obtained from this paper such as the enhancement and a close monitoring of the current Pillar 3 framework the increase of the adoption of more targeted tools, in a more preemptive way, to counter the build-up of risks and the implementation of the leverage ratio.

Originality/value – In the aftermath of the financial crisis, the identification of leading indicators signalling emerging risks to the banking system has become a major priority to central banks and supervisory authorities. As a consequence, several studies have formulated the aim of analysing predictive characteristics of a set of macroeconomic variables, such as GDP Growth, Credit-to-GDP, Inflation, M2-to-GDP, among others. Other studies take a different perspective and complement the analysis with bank-specific risk indicators. Nonetheless the aforementioned studies do not consider the relationship between regulation and market discipline and banking distress. This is the gap the authors wanted to fill, and this assessment is the main contribution of this paper.

Keywords Regulation, Risk, Banks, Market discipline, Banking distress, Early-warning indicators, Banking problems

Paper type Research paper

1. Introduction

The 2008 financial crisis brought to light the consequences that a global banking crisis can have in the real economy. The contagion effects were certainly a reason for the worst recession the world faced since 1929's Great Depression in the USA. According to the IMF, the financial crisis in the USA has resulted in banks' asset losses that reached $4tn[1].

In many countries, mainly in Europe, the capital injected in banks by governments contributed to a sovereign debt crisis (Jahn and Kick, 2012). The link from banking to debt crises is based, essentially, on two factors. First, costly bank bailouts shift credit risk from bank balance sheets to national fiscal accounts. Second, policymakers may want to introduce a fiscal stimulus to strengthen domestic demand (Babecký *et al.*, 2012).

In the aftermath of the global financial crisis, there was a broad acknowledgment that the aforementioned costs resulted partly from weaknesses in the regulatory framework and the failure of supervisors in countering the build-up of vulnerabilities and excessive risk-taking in the global financial sector. The effective market discipline of the stakeholders was also pointed out as being weak, stemming mainly from the structure of the liabilities that characterizes banks as well as the investment in complex products, namely, securitized assets, whose investors were not able to assess their risk, not even rating agencies. In panic situations, as the one prompted by the US subprime, investors have sell off these type of assets spilling over to other investors, which include financial institutions (Breitenfellner and Wagner, 2010).

In this vein, a major priority to central banks and supervisory authorities was the identification of leading indicators signalling emerging risks to the banking system. As a consequence, several studies have emerged with the aim of analysing the predictive characteristics of a set of macroeconomic variables, such as GDP Growth, Credit-to-GDP, Inflation, M2-to-GDP, among others (Demirgüç-Kunt and Detragiache, 1998; Demirgüç-Kunt and Detragiache, 2005; Jahn and Kick, 2012; Babecký *et al.*, 2012 and Drehmann and Juselius, 2013). Martin and Schaeck (2007), Poghosyan and Čihak (2011) and Betz *et al.* (2014) take a different perspective and complement the analysis with bank-specific risk indicators.

Nonetheless there are some questions that were left unanswered:

Q1. All regulators and supervisors have behaved in the same manner?

Q2. Market discipline did not work?

Q3. There are some lessons that we can draw from the actions taken by some authorities that can be used as a benchmark?

These are the questions we want to answer with this paper summing in one main question "How did regulation and market discipline influence banking distress in Europe?"

Even though, some studies have tried to tackle the relationship between banks' risk and regulation/supervision (Klomp and De Haan, 2012; Vazquez and Federico, 2015) and market discipline (Nier and Baumann, 2006), these studies use databases and indicators that reflect whether laws and regulations are in place but not to what extent they are implemented in practice. With regard to market discipline, they commonly rely on measures for market discipline that do not reflect actions taken by the market as the ratio between subordinated debt and total liabilities (Nier and Baumann, 2006). Additionally, they seldom analyse the relationship in the context of banking probability of default and neglect, to some extent, the combined effect of supervision and market discipline, an aspect taken into account in this paper.

It is worth mentioning that as a consequence of the identified weaknesses in regulation/supervision, put forward, among others, in the "Larosière Report" (Larosière *et al.*, 2009), the Basel Committee on Banking Supervision started to work to improve regulation and supervision level that was in force at that time, culminating in the Basel III Regulatory Framework (Basel Committee on Banking Supervision – "Basel III: a global regulatory framework for more resilient banks and banking systems", 2010), encompassing the Directive/2013/36/EU (2013) (CRDIV), Regulation (EU) no 575/2013 of the European Parliament and of the Council of 26 June 2013 (CRR) and the Directive/2014/59/EU (2014) (as known as Banking Recovery and Resolution Directive – BRRD), as well as in the widespread adoption of stress tests as a tool to assess the resilience of the banking sector.

The main novelties of the new regulatory framework comprise:

- the enhancement of quality and quantity of capital through the build-up of capital buffers and increased scrutiny of the quality of instruments that should be included in common-equity Tier 1 and Tier 1 capital;
- the reduction of the procyclicality of leverage with the imposition of an countercyclical capital tool known as countercyclical capital buffer;
- the adoption of a leverage ratio to complement the risk weight capital ratios;
- the adoption of liquidity requirements such as the liquidity coverage ratio and the stable funding ratio;
- the improvement of the regulation regarding large and interconnected institutions, with the emergence of a specific capital buffer targeted to global systemically institutions and domestic systemically institutions;
- the enlargement of the regulatory perimeter to other financial institutions than banks;
- the importance given to systemic risk which has been neglected until this moment at the expense of idiosyncratic risks and the mandate given to countries to constitute macro-prudential authorities responsible for the surveillance of this type of risk and policy measures to address it; and
- the development of resolution frameworks through which investors would bear more risk and taxpayer support would be minimized.

On top of this, the European Union adopted in 2016 the International Financial Reporting Standard 9 (known as IFRS 9) which entered into force in January 2018, replacing the International Accounting Standard 39 (IAS 39). The main change was the inclusion of provisional information in the calculation of credit impairment losses and the shift from an incurred credit loss model towards an expected credit loss model. The consequences of this change to financial stability are discussed in detail in the report published by the European Systemic Risk Board, in 2017, entitled "Financial Stability Implications of IFRS 9" (ESRB, 2017).

The aforementioned changes have translated into many challenges to regulators, supervisors and financial institutions. Regarding the regulators and supervisors, they had to hire more experts to intensify the supervision and the development of models to calibrate some of the new instruments at disposal. From the institutions side, they had, on the one hand, to issue significant amounts of capital and/or reduce and sell assets in adverse conditions characterized by the risk aversion of potential investors in the aftermath of the global financial crisis. On the other hand, they had to adapt to the increase in regulation, augmenting their working teams with expertise and an investment in information technologies to keep track of these new regulatory requirements. Notwithstanding, as acknowledged by several institutions such as the International Monetary Fund, the European Central Bank and the European Banking Authority in their periodic reports, there is evidence that these new challenges have been offset by the increase in the resilience of the financial systems, i.e. banks with higher capital and liquidity buffers, by the decline in procyclicality of bank credit since the crisis and by the emergence of systemic risk as a new relevant concern, beyond banks' idiosyncratic risks, with the subsequent build-up of a toolkit to mitigate this type of risk[2].

In this vein, we take the opportunity to empirically analyse, whether the new regulation framework, characterized by stringent capital and liquidity requirements, as well as with the incentive that was given to market discipline (with the introduction of the Banking Recovery and Resolution Directive), is on the right path to address the more prominent risks that led to banking distress during the last financial crisis in Europe. The possible changes in the risk management, the risk assessment by institutions and the changes in the behaviour of investors, acknowledged as weak and inappropriate before the onset of the global financial crisis (Breitenfellner and Wagner, 2010), although very relevant, are not in the scope of this paper.

With an international sample of 586 banks from 21 European countries for the period between 2000 and 2012 (5,318 bank-year observations), we find that market discipline is a good indicator of signalling banking distress, that is, market discipline has penalized more the banks with higher likelihood of being in distress. With regard to regulation, this paper evidences that the adoption of other regulatory measures beyond the simple transposition of changes occurred in the EU Directives such as borrower-based measures, mainly loan-to-value and debt service-to-income caps and limits on exposures concentration in a pre-emptive way, have contributed to reduce the probability of distress of EU banks, showing that the introduction of this kind of measures was necessary and relevant[3].

In addition, in this paper, we find that the non-performing loans' ratio, size, capital (including the well-known regulatory capital ratio, as well as the novel leverage ratio, which discards the risk weights present in the former one) and liquidity are good indicators of banking distress, which lead us to conclude that the new regulatory framework known as Basel III is on the right path to mitigate the probability that a new banking crisis similar to the last one takes place again, although no regulatory framework can reduce the probability of a crisis to zero.

Nevertheless, some action taken after the crisis, with the intention of rescuing the financial system, have left their footprint in the aftermath of the global financial crisis. This lasting low-interest-rate environment stemming from an accommodative monetary policy adopted by the European Central Bank may prompt a search for yield behaviour by the economic agents, which in turn, might foster investment in complex products with higher yields but also higher risk, a behaviour that, according to Breitenfellner and Wagner (2010), underpinned the global financial crisis. Additionally, the flight-to-quality behaviour carried out by banks characterized by large investments in government bonds as a consequence, on the one hand of the rescue operations the banks have beneted, and, on the other hand, from the new liquidity requirements, has increased their exposition to interest rate risk as found by Arnould *et al.* (2017). This aspect gains importance if we project the impact that the end of this loosening monetary policy could have on the banking system. This can have an even more negative impact in the case in which correlations between bonds and equity start to become positive, thus reducing the opportunities to diversify (Arnould *et al.*, 2017). Thus the change of the regulatory treatment of sovereign debt, advocated by Kahlert and Wagner (2017), discussed further in this paper, gains additional relevance.

In this vein, despite the welcomed changes performed by regulators so far, some aspects are not complete and yet and new areas deserve more empirical work and attention by the regulators and supervisors. Some of these stem directly from the results obtained from this paper such as the enhancement and close monitoring of the current Pillar 3 framework, the increase of the adoption of more targeted tools, in a more pre-emptive way, to counter the build-up of risks and the implementation of the leverage ratio. Other issues that shall also be addressed by the regulators are the inclusion, in the legal regulatory framework, of the last post-crisis reforms to complete Basel III, proposed by the Basel Committee on Banking Supervision, mainly the constraints that should be given to the use of internal rating models by banks; the revision of the regulatory treatment given to the great majority of the sovereign debt securities in terms of risk weights and limits to concentration according to their market fundamentals (Kahlert and Wagner, 2017); and the new areas such as fintech and cyber security whose risks deserve additional attention by the regulators and supervisors.

Finally, as advocated by Breitenfellner and Wagner (2010), tighter regulation is not the sole answer to mitigate that a turmoil like the global financial crisis does not repeat. It shall be accompanied by an appropriate risk management and risk assessment by financial institutions instead of short-term profitability. The introduction of the Resolution framework might incentivize this type of behaviour by institutions' shareholders.

The remainder of the paper is organized as follows: Section 2 presents a literature review. The hypotheses to be tested are presented in Section 3. Section 4 introduces the data set including descriptive statistics about the behaviour of different types of banks, banks that were bailed out by the government and the others, as well as the characteristics of the jurisdictions included in the sample and the empirical approach that was followed. Section 5 reports the results and robustness tests and the main conclusions and policy actions, as well as additional concerns, are put forward in Section 6.

2. Literature review

In the past 20 years, the role played by supervision, regulation and markets in disciplining banks have been under intense discussion. One stream of the literature argues that banks' capital structure and risk-taking are heavily determined by regulators and supervisors rather than by markets (Rajan and Zingales, 1995; Berger *et al.*, 1995; Santos, 2001 and Calomiris and Wilson, 2004). The influence of regulation and supervision is based on the

need to limit the incentives for excessive risk-taking of explicit creditor insurance schemes, such as deposit insurance systems and state implicit subsidies for too-big-to-fail institutions, among other market failures, by setting minimum capital ratio requirements.

Another strand of the literature advocates that the attributes that affect banks' capital structure and target ratios are not that different from those influencing non-financial firms' capital (Flannery, 1994; Flannery and Rangan, 2008; Gropp and Heider, 2010; Allen *et al.*, 2011 and De Jonghe and Öztekin, 2015). This view claims that banks are, to some extent, subject to market discipline, and more room should be given to market to discipline banks as a supplement tool to supervision/regulation.

Market discipline can be beneficial in several ways. First, the market could provide information to supervisors about the probability of default of banks, which could help supervisors to efficiently allocate resources. Second the market could discipline banks directly by including some covenants on debt issues (Ashcraft, 2008). Third, this type of discipline may reduce moral hazard incentives which governmental guarantees create for banks. Finally, market discipline could improve efficiency, creating pressure on less-efficient banks (Martinez Peria and Schmukler, 2001).

Regarding the role played by regulation and supervision during the last financial crisis, it was concluded that regulatory and supervisory financial authorities can and must do much better in the future to reduce the likelihood of events like these happening again (Larosière *et al.*, 2009).

Since then, some action has been taken by the regulators which culminated in the new Basel III Regulatory Framework, encompassing the Directive 2013/36/EU of The European Parliament and of The Council of 26 June 2013 (CRDIV), the Regulation (EU) No 575/2013 of The European Parliament and of The Council of 26 June 2013 (CRR) and the Directive 2014/59/EU of The European Parliament and of the Council of 15 May 2014 (as known as Banking Recovery and Resolution Directive – BRRD), as well as in the widespread adoption of stress tests as a tool to assess the resilience of the banking sector and the adoption of IFRS 9 in 2016.

Among others, the main changes brought by these regulatory documents comprise the requirement of a set of capital buffers (CRD IV), a new capital requirement known as "leverage ratio" besides the regulatory capital ratio, two liquidity requirements (CRR) and a new framework to cope with bank failures in a way that avoids financial instability and minimizes cost for tax payers, whereby shareholders and some credit holders will be called to bear the first losses (fraction of total losses absorbed by equity) and second losses (excess of the total losses not absorbed by equity that shall be absorbed by creditors).

The main capital buffers introduced were the capital conservation buffer, the counter-cyclical capital buffer and the buffers that should be assigned to systemically important institutions, either at global or domestic levels.

The rationale behind the introduction of a capital conservation buffer is the build-up of adequate buffers above the minimum that can be drawn down in periods of stress in a way that it is unlikely to breach the minimum capital requirements. The build-up of this buffer mitigates the distributions in the form of dividends, share buy-backs and generous compensation payments even though banks' financial condition and the outlook for the sector were deteriorating as those that occurred before the materialization of the financial crisis (BCBS, 2010).

The counter-cyclical capital buffer aims at requiring the build-up of a capital buffer during periods of excessive credit growth whose objective is twofold. First this capital buffer is seen as sufficient to absorb credit losses stemming from the credit growth as the crisis arrives, thus dampening the potential cut-back on credit granted to the economy.

Second the building up of these defences in periods when credit has grown should have the additional benefit of helping to moderate excess credit growth (BCBS, 2010).

The capital buffers related to global or domestic systemic important institutions aim at mitigating the negative externalities created by systemically important institutions and the moral hazard that characterizes these types of institutions which might amplify risk-taking, reduce market discipline, create competitive distortions and further increase the probability of distress in the future (BCBS (2012).

The leverage ratio as envisaged in CRR, introduced in 2014, is computed as the ratio of Tier-1 capital [as defined in Article 61 of Regulation (EU) No 575/2013] to total exposure. The importance of this variable, which will be noticed by the results obtained in this paper, is twofold. First, using the total assets in the denominator, instead of risk-weighted assets (RWAs), we account for the different adoption of standard approach or internal ratings model across banks which have distinct impacts on capital ratios[4]. Second, as internal models reflect past realizations of default rates (PD) and losses (LGD), in "good times", in particular, after a period of reduced volatility, the estimated losses and, consequently, capital requirements tend to be low (BCBS, 2014), which highlights pro-cyclical effects of RWA which is partly mitigated by the fact that regulation imposes a "Through-the-Cycle" methodology instead of a "Point-in-Time". Nonetheless this ratio should be complemented by the regulatory capital ratio, because the lack of sensitivity to the riskiness of individual assets might hamper the alignment between capital surcharges and asset risk. If the leverage ratio was the only constraint, banks could be incentivized to invest in assets with higher risk, as they will not have to comply with capital add-ons (Brei and Gambacorta, 2016)[5].

The liquidity requirements introduced were the liquidity coverage ratio and the net stable ratio. The former ratio is computed as the liquid assets over liquidity outflows less the liquidity inflows under stress conditions and over a period of 30 days. The ratio shall be equal or greater than 100 per cent as from 1 January 2018 and aims at promoting resilience to potential liquidity disruptions over a 30-day horizon (BCBS (2010). The latter ratio aims at ensuring that institutions' long-term obligations are adequately net with a diversity of stable funding instruments under both normal and stressed conditions.

The changes concerning the internal risk models, namely, those related with the calculation of the minimum capital requirements for market risk, are also relevant mainly owing to the consequences that they might have had in the computation of the minimum capital requirements. These changes includes the introduction of a stress Value-at-Risk (VaR) measure for a confidence level of 99 per cent, in 2010, and the subsequent withdrawal of this measure, in 2013, and its replacement by a single stressed shortfall for a confidence level of 97.5 per cent.

A relevant research study was carried out by Kinateder (2016) with the aim at analysing the impact that these changes might have in minimum capital requirements. Using Cantelli's inequality to compute theoretical minimum capital requirements violations levels, the author found that, under normal tails, the minimum capital requirements violation levels, under the 2013 version of Basel III, are only slightly higher than those under Basel II. Notwithstanding, this difference is higher for risk models equipped with normal innovations and lower for heavy-tailed ones. Moreover, he concluded that, under the 2010 version of the Basel III, the minimum capital requirements' violation levels during stress periods are adequate when using a risk model even with poorly distributional specifications, but are too conservative under the baseline scenario which may discourage banks from developing accurate market risk models.

Finally, market discipline can be defined as the process by which informed market investors gather and monitors firm's activities and prospects (Flannery and Sorescu, 1996) as well as their risk. The importance of market discipline is acknowledged by the supervisors and regulators since Basel II (BCBS, 2006). It should be mentioned that Basel II introduced a third Pillar called "Market Discipline" whose aim is to encourage market discipline by introducing the disclose of a broader range of information to allow market participants to assess key pieces of information regarding capital, risk exposures, risk assessment procedures and capital adequacy of the institution (BCBS, 2006).

3. Hypotheses development

Taking into account the literature review and the main purpose of this paper, we formulate the following hypotheses:

H1. Regarding regulation, we hypothesize that regulatory authorities that applied regulatory measures targeted to some sectors and in a pre-emptive way such as capital requirements targeted to some sectors, reserves requirements, concentration limits and loan-to-value caps, which were beyond the ones prescribed in the European Directives that result from the reforms of Basel II (such as the inclusion of operational and market risk in the capital requirements and/or the imposition of a common equity Tier 1) reduce the probability of default of their banks.

H2. Taking into account the results obtained by Flannery and Sorescu (1996), Gropp and Vesala (2004), Ashcraft (2008), Flannery and Rangan (2008), Distinguin *et al.* (2013) and Hoang *et al.* (2014) we hypothesize that market discipline is a good predictive indicator of banking distress.

H3. Finally to assess if the new regulation framework is on the right path to mitigate future financial crises similar to the last one, we hypothesize that the more prominent risks in banking are credit risk (evidenced by high NPL ratios), capital (risk of being undercapitalized) size (linked to moral hazard), risk embedded in the calibration of the models used to calculated RWAs (mitigated by the introduction of the "leverage ratio") and liquidity risk.

A detailed overview of the explanatory variables, sources and countries, as well as expected signs of the effects of bank-specific indicators and of macro-economic variables on a bank's probability of bailout and/or going bankrupt – supported by theoretical arguments and literature review – are given in Tables I to III.

4. Data and methodology

The data set for this chapter includes banks under the scope of regulators in 21 European countries, which adds up to 586 banks, for the period 2000-2012, summing 5318 bank-year observations. The time horizon starts in 2000 because the structural change that occurred between the end of the 1990s and 2000s in the vast majority of the countries considered in this sample – the adoption of the euro as a common currency and the consequent loss of their monetary policy – which had relevant consequences for the banking system, in particular, the low-interest-rate environment that, afterwards, led to excessive credit growth and the build-up of a relevant level of private and public indebtedness. The period ends in 2012 because it is difficult to flag a reasonable number of banks' bailouts afterwards, to properly run the type of model used in this paper. As shown in Figure 1, the sample covers a high percentage of European banking system assets reaching, in 2012, a share of 90 per cent. We

Variables	Description	Source
Panel A		
Dependent variable	Dummy variable that takes the value of 1 if the bank was liquidated, dissolved or bailed-out by the government and 0 otherwise	Bankscope/European Competition Report (2011)/Moody's periodic reports/ Laeven and Valencia (2010)
Prudential – bank level		
LEVERAGE RATIO (LR)	Ratio of Tier 1 Capital (as defined in Articles 38 and 40 of Directive 2000/12/EC until 2006 and in Article 12 of Directive 2006/49/EC from 2007 onwards) to assets	Bankscope
CAPITAL RATIO (CR)	The Ratio of Total Capital (as defined in article 40 of Directive 2000/12/EC until 2006 and in Article 57 of Directive 2006/48/EC from 2007 onwards) to Risk Weighted Assets (as defined in Article 43 of Directive 2000/12/EC until 2006 and in Articles 76 to 115 of Directive 2006/48/EC from 2007 onwards)	Bankscope
Other bank level variables		
ASSETS	The sum of following items: "cash and advances in other credit institutions", "claims on other credit institutions", "total loans and receivables", "financial assets classified at fair value through profit or loss", "financial assets classified as available for sale", "financial assets classified as held for trading", "financial assets classified as held to maturity" and "other assets", net of their impairment	Bankscope
COST TO INCOME	Ratio of fixed costs (computed as total staff costs plus general administrative costs plus amortization and depreciation costs) to total gross profit (computed as net interest margin plus income from capital instruments plus income from services and commissions plus results from financial operations plus other operating profit and loss)	Bankscope
CUSTOMER DEPOSITS	Total deposits from non-financial clients	Bankscope
EQUITY	The sum of the following items: "capital", "reserves" and "net income"	Bankscope
LOANS	Total gross loans net of impairments	Bankscope
LIQUIDITY RATIO	Ratio of liquid assets (securities and cash on demand) to deposits and short term funding	Bankscope
NET INCOME	The sum of the following items: "interest margin" (+), "gross income" (+), "staff costs" (−), "general administrative costs" (−), "amortization and depreciation costs" (−), "impairment losses and other net value adjustments" (−) and "taxes" (−)	Bankscope
NON-PERFORMING LOANS RATIO (NPL/TL)	Ratio of non-performing loans ("impaired loans") to total loans	Bankscope
		Bankscope

(*continued*)

Table I.
Bank-specific indicators – description and sources

Variables	Description	Source
RETURN ON ASSETS (ROA)	Ratio of NET INCOME to the average of ASSETS (over the past two years)	
Too-big-to-fail (TBTF)	Controls for the too-big-to-fail argument being a dummy variable that takes the value of 1 if the bank has an average assets throughout the period equal or higher than percentile 75th and 0 otherwise	Bankscope
Banks' controls (BC)	Dummy variables that controls for mergers, listed/unlisted banks and banks' business models	Bankscope
MARKET DISCIPLINE	Ratio of "other interest expenses" over "other liabilities"	Bankscope
Panel B		
Macroeconomic variables		
COUNTRY YTM	Yield to maturity of the country's sovereign bonds. In the case of Estonia, due to lack of data availability, we use the YTM from Latvia, given the perceived similarities in terms of country level risk	ECB
CREDIT TO PRIVATE SECTOR/GDP (CPS/GDP)	"Credit to the Private Sector" as a percentage of GDP	World Bank
FISCAL SURPLUS/GDP	"Government Surplus" as a percentage of GDP	World Bank
GDP GROWTH	Rate of Real GDP Growth	World Bank
GDP PER CAPITA	GDP per capital	World Bank
INFLATION	Inflation Rate	World Bank
REGULATION (REG)	Based on the measures collected by Cerutti *et al.* (2017), this variable is a dummy variable that assumes the value of one if the number of measures applied with a tightening nature surpasses the ones with a loosening nature throughout the period 2000-2008 that is, at the inception of the financial crisis, and 0 otherwise. The variable is based on a survey that comprises a wide range of measures such as sector specific capital buffers, limits on banks' exposures to specific borrowers or sectors, interbank exposures limits and loan-to-value (LTV) caps	Cerutti *et al.* (2017)

Note: This table presents the definitions and sources of the main variables used in this study

Table I.

can observe also that the higher number of bankruptcies and bailouts occurred in 2008, 2009 and 2012.

We opted for not cleaning the sample from outliers, as the occurrence of a banking distress is by nature an extreme event; thus, it is hardly surprising that these types of banks are outliers. Notwithstanding, we have cleaned the database of some inconsistencies, for instance, the presence of negative interest expenses.

As described in Table I, all data were collected from Bankscope, World Bank and European Central Bank databases, as well as from two surveys.

To address the empirical question and to test the hypotheses presented in Section 3, we apply a multivariate logit model to the data described above, as commonly used in the literature in early-warning models (Porath, 2004; Martin and Schaeck, 2007; Poghosyan and Čihak, 2011; Cole and White, 2012; Kick and Koetter, 2007; Arena, 2008; DeYoung and Torna, 2013; Davis and Karim, 2008; Duca and Peltonen, 2013; Sarlin and Peltonen, 2013; Betz *et al.*, 2014).

The dependent variable in equation (5.2) (Y_{it}) stands for a dummy variable that takes value of one if the bank was bailed out by the government or went bankrupt in time period t, and zero otherwise. The data regarding the banks that have been bailed out are provided by the report published by the European Commission Competition in 2011 and, by Moody's periodic reports, identified augmented by several detailed searches on individual banks in global newspapers such as *The Wall Street Journal*, *The Financial Times*, *The Economist* and Reuters newswires and the study developed by Laeven and Valencia (2010).

We estimate the probability of distress as a function of lagged explanatory variables $X_{(i,t-1)}$. Therefore we assume that $F(\beta' X_{(i,t-1)})$ is the cumulative probability distribution evaluated at $\beta' X_{(i,t-1)}$, where β is a vector of coefficients to be estimated, and the likelihood function of the model is:

$$\text{LogL} = \sum_{t=1}^{T}\sum_{i=1}^{N}\{Y_{it} log[F(\beta' X_{(i,t-1)}] + (1 - Y_{it}) log[1 - F(\beta' X_{(i,t-1)}]\} \tag{4.1}$$

The explanatory variables are bank-specific indicators, country's macroeconomic variables and the variables used to represent the role played by regulation and market discipline – the core variables of interest of this paper.

This model is broadly consistent with the one that maximizes the policymaker's utility (Betz *et al.*, 2014), as it combines macroeconomic indicators with bank-specific ones (including accounting and prudential indicators). In addition to address the potential correlation of the observations for individual banks, we drop the standard assumption that errors are independent within each bank and use a variance covariance matrix that is clustered by banks[6].

Therefore we estimate, in the first place, a baseline model that comprises only bank-specific indicators and macroeconomic ones. Next we proceed to adding each of the variables we want to test, namely, market discipline and regulation. In this vein, to assess the relationship between regulation and banking distress, we use the database developed by Cerutti *et al.* (2017). Cerutti *et al.* (2017) have gathered the regulatory measures undertaken by a reasonable number of countries. These measures comprise, among others, capital

Table II.
Countries included in the sample

Countries						
Austria(AT)	Belgium(BE)	Czech Republic (CZ)	Denmark (DK)	Estonia (EE)	Finland (FI)	France (FR)
Germany (DE)	Greece (GR)	Hungary (HU)	Ireland (IE)	Italy (IT)	Luxembourg (LU)	The Netherlands (NL)
Poland (PL)	Portugal (PT)	Slovakia (SK)	Slovenia (SI)	Spain (ES)	Sweden (SE)	United Kingdom (UK)

Note: This table presents the countries included in the sample

Variables	Expected sign	Rationale
Prudential – bank level		
LR	–	It is expected that a bank with a higher Leverage Ratio has a lower probability of being in distress since it has more capital to absorb unexpected losses. This expectation is aligned with the results obtained by Grill *et al.* (2015)
CR	–	It is expected that a bank with a higher capital ratio has a lower probability of being in distress. This expectation is consistent with results obtained by Martin and Schaeck (2007) and Betz *et al.* (2014). The relationship remains positive and statistical significant using total capital ratio or the TIER 1 ratio as shown by Porath (2004), Jordan *et al.* (2010)
Other bank-level variables		
TBTF	+	On the one hand, according to the "too big to fail" argument, it is expected that a larger bank size increases the probability of a bank being in distress. Banks perceived as too big to fail would be encouraged to increase risk because they would expect a bail-out by governments (in a form of "moral hazard"). Cole and White (2012) confirms this result. On the other hand, in terms of failure, according to Arena (2008), bank size reduces the probability of a bank defaulting because larger banks are better able to diversify their loan portfolios, which might introduce some uncertainty in our expectations
COST TO INCOME	+	A higher cost-to-income ratio means that the bank's overhead costs absorb a larger part of its gross profit, decreasing its profitability. Therefore, it is expected that a higher cost-to-income increases the probability of a bail-out or bankruptcy. According to Poghosyan and Čihak (2011) and Betz *et al.* (2014), the cost-to-income ratio increase that probability, but the result was not statistically significant
LIQUIDITY RATIO	–	It is expected that banks that hold more liquid assets proportionally to their short-term funding liabilities suffer less fire sales costs when entry into distress and have to sell the assets to comply with their debtors. However Poghosyan and Čihak (2011) did not find a statistically significant relationship between this indicator and the likelihood of being in distress
NPL/TL	+	A higher NPL/TL ratio is related to more potential losses to the bank through an increase of impairment flow, as well as through a lower interest margin. It is expected that a higher NPL ratio increases the probability of a bank being unhealthy. This expectation is consistent with Martin and Schaeck (2007)
ROA	–	It is expected that a bank with higher profitability has a lower probability of being in distress. This expectation is consistent with the results obtained by Martin and Schaeck (2007), Kick and Koetter (2007), Poghosyan and Čihak (2011) and Betz *et al.* (2014)
MARKET DISCIPLINE	+	Taking into account the results obtained by Flannery and Sorescu (1996), Gropp and Vesala (2004), Distinguin *et al.* (2006), Flannery and Rangan (2008), Ashcraft (2008) and Hoang *et al.* (2014) we hypothesized that market discipline measured by the costs paid by the banks to wholesale funding is a good predictive indicator to banking distress
Macroeconomic variables and indexes		
COUNTRY YTM	+	As a proxy of the government's creditworthiness and taking into consideration the weight of this type of securities in the banks' balance sheets, it is expected that a higher country YTM increases the probability of a bank being in distress
CREDIT TO PRIVATE	+	As in Martin and Schaeck (2007), Demirgüç-Kunt and Detragiache (1998), Demirgüç-Kunt and Detragiache (2005), Babecký *et al.* (2012), Drehmann and

(*continued*)

Table III.
Expected effects of each variable on the probability a bank being in distress (bail out or bankruptcy)

Variables	Expected sign	Rationale
SECTOR/GDP (CPS/GDP)		Juselius (2013) and Betz *et al.* (2014), it is expected that a higher credit to private sector/GDP ratio increases the probability of a banking crisis
FISCAL SURPLUS/GDP	–	Despite the evidence in Martin and Schaeck (2007), Demirgüç-Kunt and Detragiache (1998) and Demirgüç-Kunt and Detragiache (2005), that this variable was not statistically significant, it is expected that a higher FISCAL SURPLUS/GDP ratio (as a proxy of the government's health) decreases the probability of bank distress
GDP GROWTH	+/?	Taking into consideration the results obtained by Martin and Schaeck (2007), Demirgüç-Kunt and Detragiache (1998), Demirgüç-Kunt and Detragiache (2005) and Babecký *et al.* (2012), it is expected that GDP growth decreases the probability of a banking crisis. However, more recent events have questioned the pro-cyclicality of bank behaviour, which could induce more risk taking in periods of economic growth, thus contributing to a higher potential of bank distress
GDP PER CAPITA	–	Taking into account results by Martin and Schaeck (2007), Demirgüç-Kunt and Detragiache (2005) and Babecký *et al.* (2012), it is expected that a higher GDP per Capita decreases the probability of bank failure
INFLATION	+	Following Martin and Schaeck (2007), Demirgüç-Kunt and Detragiache (1998), Demirgüç-Kunt and Detragiache (2005) and Babecký *et al.* (2012), it is expected that inflation increases the probability of a banking crisis
REG	–	We hypothesize a negative relationship between the imposition of prudential instruments with a tightening nature and banking distress

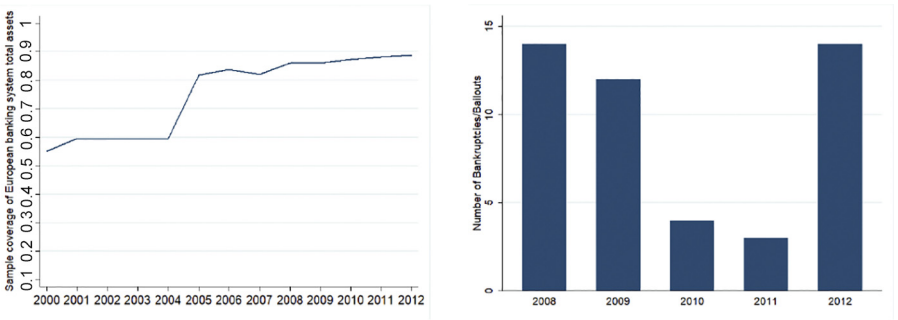
Notes: This table presents the effects of each variable on the probability of a bank's bailed out or became bankrupted, where ROA is the return on assets ratio and is computed as the quotient between the NET INCOME and the average of ASSETS (over the last two years); TBTF which controls for the too-big-to-fail argument being a dummy variable that takes the value 1 if the bank has an average assets throughout the period equal or higher than percentile 75th and 0 otherwise; LIQUIDITY RATIO is the ratio of liquid assets (securities and cash on demand) to deposits and short term funding; COST TO INCOME is the ratio of fixed costs (computed as total staff costs plus general administrative costs plus amortization and depreciation costs) to total gross profit (computed as net interest margin plus income from capital instruments plus income from services and commissions plus results from financial operations plus other operating profit and loss); CR is the ratio of total capital (as defined in article 40 of Directive 2000/12/EC until 2006 and in Article 57 of Directive 2006/48/EC from 2007 onwards) to risk-weighted assets (as defined in Article 43 of Directive 2000/12/EC until 2006 and in Articles 76 to 115 of Directive 2006/48/EC from 2007 onwards); NPL/TL is the ratio between non-performing loans (computed as impaired loans) to total gross loans; LR is the leverage ratio computed as the quotient between Tier 1 capital (as defined in Articles 38 and 40 of Directive 2000/12/EC until 2006 and in Article 12 of Directive 2006/49/EC from 2007 onwards) and assets; MARKET DISCIPLINE is computed as the ratio between "other interest expenses" and "other liabilities"; GDP GROWTH is the rate of real GDP's growth; INFLATION is the inflation rate; GDP per CAPITA is the GDP per capita; FISCAL SURPLUS/GDP is the ratio of government surplus in percent of GDP;CREDIT TO PRIVATE SECTOR/GDP is the ratio of credit to private sector in percent of GDP; COUNTRY YTM is the yield to maturity of country's treasury bonds and REG is a dummy variable that assumes the value of one if the number of measures applied with a tightening nature surpasses the ones with a loosening nature throughout the period 2000-2008 that is, at the inception of the financial crisis, and 0 otherwise

Table III.

requirements targeted to some sectors, reserves requirements, concentration limits and loan-to-value caps, totalling nine measures. To test the effect of this regulatory action undertaken by the jurisdictions, we build up a dummy variable that takes the value of one if the number of measures applied with a tightening nature surpasses the ones with a loosening nature throughout the period 2000-2008 (until the inception of the financial crisis), i.e. during the period between 2000 and 2008 the regulatory authority of each country had a tight policy stance, and 0 otherwise. We do not use the measures identified in the survey developed by Barth *et al.* (2013) for two reasons. First indexes for supervisory and regulatory powers reflect the framework in place and not the actions taken by the supervisors/regulators. Second the surveys were carried out with a space of three years, and as such, we only would have data for 2003, 2007 and 2011.

With the aim of gauging the role played by market discipline, we use the ratio of "other interest expenses" over "other liabilities" to assess how markets have been aware of banks' risk during the crisis and in line with the measures used by Sironi (2003), Flannery and Sorescu (1996), Gropp and Vesala (2004), Ashcraft (2008), Distinguin *et al.* (2013) and Hoang *et al.* (2014). We did not select other type of measures such as the ratio between subordinated debt-to-liabilities or the proportion of the wholesale funding, as used by Nier and Baumann (2006), because of the same aforementioned reason regarding regulation indexes. Using these types of measures, we are assessing the potential role of market discipline but not if market discipline has been aware of banks' weaknesses, demanding an additional *risk premia* reflected in the interest expenses paid.

It is worth mentioning that, contrary to what have been done by Poghosyan and Čihak (2011) and Hadad *et al.* (2011), which have used the interest rates paid to the total liabilities or to depositors, we opt for excluding the interest expenses paid to retail depositors and the retail deposits themselves to assess market discipline. In fact, market discipline by depositors is undermined by deposit schemes. If depositors know that their funds are safe and liquid they will not have an incentive to withdraw their deposits or demand higher interest rates (Martinez Peria and Schmukler (2001). According to some studies, depositors may exert some discipline in only some special circumstances such as in the wake of a financial crisis (Martinez Peria and Schmukler, 2001) and when deposit guarantee schemes are not credible (Martinez Peria and Schmukler, 2001; Hadad *et al.*, 2011). Additionally, we consider that to perform market monitoring the creditors of financial institutions have to consider themselves at risk



(a) **(b)**

Figure 1.
Sample coverage and number of banks' bankruptcies/bailouts

Notes: (a) This figure depicts the sample coverage of European banking system's total assets; (b) this figure presents the number of banks' bankruptcies and bailouts by year

(Nieto, 2012) which is not the case of depositors in particular in countries with a credible deposit insurance scheme (Hadad *et al.*, 2011) as well as with powerful supervisory authorities (Hosono and Tsuru, 2005) which is the case with countries that compose the sample used in this paper.

To clear some doubts that could arise for collinearity between some variables such as the capital ratio and leverage ratio, we can observe through Table V that these kinds of issues are rather limited.

For each model we have computed Type I and Type II errors (as also performed by Cole and Gunther, 1998; Martin and Schaeck, 2007; Poghosyan and Čihak, 2011; Cole and White, 2012; and Betz *et al.*, 2014).

Type I error represents the proportion of missed banks, with problems relative to the total number of distressed banks, and it is computed as the ratio between false negatives (when the model predicts that the bank is solvent and the event of failure is observed) and true positives (when the model predicts that the bank is distressed and the event is observed) plus false negatives (when the model predicts that the bank is solvent and the event of failure is observed). Type II error represents the proportion of false alarms relative to the number of non-distressed banks and is computed as the ratio between false positives (when the model predicts that the bank is in distress and the event is not observed) and the sum of false positives with true negatives (when the model predicts that the bank is not in distress and the event is not observed). Given the probability of each error's type, the policymaker should choose a threshold such that her loss is minimized. The loss of the policymaker consists of Type I and Type II errors, weighted according to her relative preferences between missing a distressed bank and having false alarms. It is clear that missing banking problems – giving rise to spillovers of a bank failure – gains more importance than costs of having false alarms.

To assess the discriminatory power of our logit model presented in Table VII, we also estimate the area under the receiver operating characteristics curve (AUC), which can be found in Figure 6[7].

It is worth mentioning that the coefficients of the logit model presented in Table VII measure the direction of the impact but cannot be given an economic interpretation. A common approach to derive economic impact of the explanatory variables is to compute the marginal or partial effect on the conditional mean of the dependent variable of a change in one of the regressors. This method replaces each explanatory variable with its sample average.

We have carried out several robustness checks. First we have replace the variable REG which stands to regulation and stems from the survey carried out by Cerutti *et al.* (2017) by another database gathered by Budnik and Kleibl (2018). Second acknowledging for the potentially short view of the markets, we tested the signal ability of the market discipline with a lag of two periods instead of one. Third we replace countries' specific variables by the interaction of country and year dummies to mitigate some omitted bias concerning in particular countries' legal and regulatory frameworks or the level of competition. Finally, we perform the analysis using an alternative model such as a parametric duration model, taking the previous studies by Whalen (1991) and Martin and Schaeck (2007) as a starting point.

According to that model, the instantaneous probability of a bank being bailed out by the government or going bankrupt given survival up to time t is modelled as a function of a subset of bank ratios and macroeconomic control variables (X), as follows:

$$\lambda(t;X) = \lim_{x \downarrow 0} \frac{P(t \leq T < t + hT \geq t, X)}{h} \tag{4.2}$$

Where T is the length of time the bank remains in the sample until becoming bankrupt or being bailed out by the government, X is a vector of explanatory variables and is the probability of leaving the initial sate in the interval $[t, t+h]$ given survival until time t. $\lambda(t; X)$ stands for the instantaneous rate of leaving per unit of time. From the equation above it follows that, for small h:

$$P(t \leq T < t + hT \geq t, X) \approx \lambda(t;X)h$$

Therefore our duration model measures the time until a bank without financial problems is bailed out or enters a bankruptcy/liquidation process, and it is based on the exponential distribution. We draw upon the same data set used for the logit model. The number of observations is, however, smaller in the duration model, as banks that experience distress exit the data set in the year in which the problems are observed. A bank's duration corresponds to the number of years it remains in the data set. Thus, the minimum duration is one year if the bank experiences a bailout or bankruptcy event in the first period, and the maximum duration is 12 years if problems occur in 2012 or beyond this date.

4.1 Descriptive statistics

Table IV presents descriptive statistics, and how they have evolved throughout the period considered, for the financial and prudential ratios and for the macroeconomic variables used in this paper. Figures 2 and 3 depict the behaviour of the banks that were bailed out by the government or failed ("unhealthy banks") versus the banks that did not receive any state aid ("healthy banks"), in terms of asset value, return-on-assets and other bank-specific variables.

Table VI summarizes, by country, the number of banks that were bailed out by the government or failed ("unhealthy banks") and the banks that did not receive any state aid ("healthy banks").

As noticeable in Table VI, there are countries that have experienced some banking bailouts or liquidations and some that have not. Therefore these differences deserve a more granular analysis as we present in Figures 4 and 5 with the expectation of drawing some lessons from the countries that have not engaged in bailouts. In this regard, the countries that do not have any register of a banking bailout throughout the period between 2000 and 2012 are designated as "non-banking crisis" countries, whereas the other group is named as "banking crisis" countries. Exception is made for Denmark, which was considered as "non-banking crisis", given the reduced materiality of the bailout in terms of the banking system assets (please see Table VI).

4.2 Data – descriptive statistics

Table IV reveals that the total assets of an average bank, in this sample, reached €70bn. We notice that the total assets of the largest bank reach €2bn, while the total assets of the smallest bank reach €3m. The average net income, return-on-assets, liquidity ratio and cost-to-income ratio in the sample are €207bn, 0.01, 1 and 0.67, respectively.

Regarding prudential/regulatory ratios, we can observe that the average capital ratio (0.14) is well above the minimum requirement. The average non-performing loans ratio and leverage ratio reached 0.05 and 0.05, respectively.

Table IV.
Descriptive statistics of variables

Bank-specific variables	2000	2012	Total	Bank-specific variables	2000	2012	Total	Macroeconomic variables	2000	2012	Total
ASSETS (millions euros)				ROA				GDP growth			
–No of observations	273	438	5,318	–No of observations	273	438	5,318	–No of observations	273	438	5,318
–Mean	50,183	92,353	70,040	–Mean	0.01	0.00	0.01	–Mean	0.04	−0.01	0.01
–SD	114,512	273,719	208,162	–SD	0.02	0.02	0.02	–SD	0.01	0.02	0.03
–Min	93	4	3	–Min	−0.01	−0.25	−0.38	–Min	0.03	−0.07	−0.15
–Max	927,918	2,012,329	2,202,423	–Max	0.35	0.06	0.35	–Max	0.10	0.05	0.11
EQUITY (millions euros)				COST-TO-INCOME				INFLATION			
–No of observations	273	438	5,318	–No of observations	273	438	5,318	–No of observations	273	438	5,318
–Mean	2,367	4,894	3,271	–Mean	0.63	0.73	0.67	–Mean	0.03	0.01	0.02
–SD	5,560	15,251	9,757	–SD	0.18	0.53	0.36	–SD	0.02	0.01	0.01
–Min	8	−2,316	−2,316	–Min	0.00	0.00	0.00	–Min	0.01	−0.01	−0.04
–Max	54,096	192,625	192,625	–Max	2.11	7.67	9.48	–Max	0.10	0.03	0.11
NET INC (millions euros)				LIQUIDITY RATIO				GDP PER CAPITA			
–No of observations	273	438	5,318	–No of observations	246	431	5,089	–No of observations	273	438	5,318
–Mean	359	−61	207	–Mean	0	1	1	–Mean	114	110	112
–SD	1,266	1,636	1,225	–SD	1	7	48	–SD	21	27	23
–Min	−1,648	−21,239	−21,239	–Min	0	0	0	–Min	47	65	46
–Max	13,513	9,938	25,439	–Max	10	141	3,405	–Max	250	264	265
LOANS (millions euros)				CR				FISCAL SURPLUS/GDP			
–No of observations	273	438	5,318	–No of observations	87	212	2,079	–No of observations	273	438	5,318
–Mean	22,682	42,618	31,483	–Mean	0.12	0.17	0.14	–Mean	−0.02	−0.04	−0.03
–SD	46,514	132,832	89,957	–SD	0.03	0.28	0.13	–SD	0.02	0.03	0.04
–Min	22	0	0	–Min	0.07	−0.06	−0.06	–Min	−0.09	−0.11	−0.31
–Max	274,660	1,680,823	1,703,550	–Max	0.23	4.16	4.16	–Max	0.04	0.02	0.05
C. DEP. (millions euros)				LR				CPS/GDP			
–No of observations	273	438	5,318	–No of observations	87	212	2,079	–No of observations	273	438	5,318
–Mean	18,767	30,792	23,521	–Mean	0.06	0.08	0.07	–Mean	112	157	141
–SD	43,331	86,929	66,623	–SD	0.03	0.14	0.08	–SD	24	45	43
–Min	0	0	0	–Min	0.02	−0.04	−0.04	–Min	34	54	34
–Max	350,552	578,884	602,456	–Max	0.18	2.03	2.03	–Max	148	226	235

(*continued*)

Table IV.

Bank-specific variables	2000	2012	Total	Bank-specific variables	2000	2012	Total	Macroeconomic variables	2000	2012	Total
MARKET DISCIPLINE				NPL/TL				COUNTRY YTM			
–No of observations	246	432	5,090	–No of observations	87	212	2,079	–No of observations	273	438	5,318
–Mean	0.08	0.04	0.06	–Mean	0.02	0.11	0.05	–Mean	0.05	0.03	0.04
–SD	0.08	0.07	0.09	–SD	0.02	0.16	0.08	–SD	0.01	0.02	0.01
–Min	0.00	0.00	0.00	–Min	0.00	0.00	0.00	–Min	0.00	0.01	0.00
–Max	0.65	0.65	0.92	–Max	0.08	1.81	1.81	–Max	0.06	0.13	0.21

Notes: This table presents descriptive statistics of bank's specific indicators along the period 2000-2012. The table presents the number of observations (N), and the mean, standard deviation (SD), minimum (Min) and maximum (Max) of the following variables: ASSETS which is the sum of the following items: "cash and advances in other credit institutions", "claims on other credit institutions", "total loans and receivables", "financial assets classified at fair-value trough profit or loss", "financial assets classified as available for sale", "financial assets classified as held for trading", "financial assets classified as held to maturity" and "other assets" net of the respective impairment; EQUITY which is the sum of the following items: "capital", "reserves" and "net income"; NET INC computed as the sum of "interest margin" (+), "gross income" (+), "staff costs" (–), "general administrative costs" (–), "amortization and depreciation costs" (–), "impairment losses and other net value adjustments" (–) and "taxes" (–); LOANS computed as the gross loans minus impairments; C. DEP. which is total deposits from non-financial clients and MARKET DISCIPLINE computed as the ratio of "other interest expenses" over "other liabilities"; ROA which is the return on assets and is computed as the quotient between net income and average assets (past two years); COST TO INCOME which is the ratio of fixed costs (computed as total staff costs plus general administrative costs plus amortization and depreciation costs) to total gross profit (computed as net interest margin plus income from capital instruments plus income from services and commissions plus results from financial operations plus other operating profit and loss); LIQUIDITY RATIO is computed as the quotient between liquid assets and deposits plus short-term funding; CR is the ratio of total capital (as defined in article 40 of Directive 2000/12/EC until 2006 and in Article 57 of Directive 2006/48/EC from 2007 onwards) to risk-weighted assets (as defined in Article 43 of Directive 2000/12/EC until 2006 and in Articles 76 to 115 of Directive 2006/48/EC from 2007 onwards); NPL/TL is the ratio between non-performing loans (computed as impaired loans) to total gross loans; LR is the leverage ratio computed as the quotient between Tier 1 capital (as defined in Articles 38 and 40 of Directive 2000/12/EC until 2006 and in Article 12 of Directive 2006/49/EC from 2007 onwards) and assets; GDP GROWTH which is the rate of real GDP Growth; INFLATION which is the inflation rate; GDP per CAPITA which is the GDP per capita; FISCAL SURPLUS/GDP which is the ratio of government surplus in percent of GDP; CPS/GDP which is the ratio of credit to private sector in percent of GDP; and COUNTRY YTM which is the yield to maturity of country's treasury bonds

Table V.
Correlation matrix

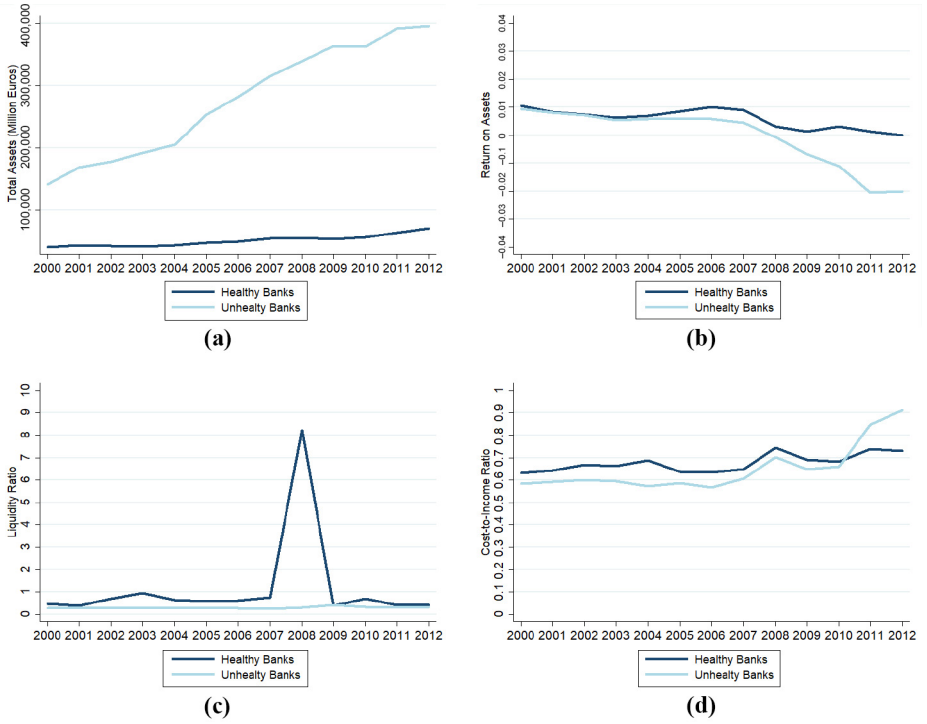
Variables	DV	ROA	CTI	LIQR	CR	NPL/TL	LR	TBTF
DV	1	–	–	–	–	–	–	–
ROA	−0.0727*	1	–	–	–	–	–	–
CTI	−0.0252	−0.4230*	1	–	–	–	–	–
LIQR	−0.0053	−0.0583*	0.0251	1	–	–	–	–
CR	−0.0674*	0.0224	0.0713*	0.1390*	1	–	–	–
NPL/TL	0.0807*	−0.4517*	0.1438*	0.0292	−0.0070	1	–	–
LR	−0.0907*	0.0836*	0.0079	0.0057	0.1274*	0.0834*	1	–
TBTF	0.3782*	−0.0728*	−0.0332*	−0.0033	−0.0991*	−0.0640*	−0.2094*	1
GDP GROWTH	−0.0084	0.1996*	−0.0626*	0.0021	−0.0057	−0.2418*	−0.0088	0.0058
INFLATION	−0.0020	0.0699*	−0.0128	0.0060	0.0071	−0.0588*	0.0205	−0.0493*
GDP/CAPITA	−0.0140	−0.0061	−0.0048	−0.0020	0.0544*	−0.1693*	−0.1335*	0.0583*
FS/GDP	−0.0780*	0.1421*	−0.0453*	−0.0152	0.0285	−0.2813*	−0.0171	−0.0523*
CPS/GDP	0.0430*	−0.1634*	0.0464*	0.0216	0.0284	0.0448*	−0.1020*	0.0441*
YTM	0.1182*	−0.0973*	−0.0160	−0.0235	−0.0867*	0.1812*	0.0005	0.0258
REG	−0.1359*	0.0745*	−0.0364*	−0.0086	−0.0117	−0.0339	−0.0534*	0.0324*
MD	−0.0409*	0.0022	0.0573*	−0.0025	−0.0079	−0.0491*	0.0196	−0.1111*

(*continued*)

Table V.

Variables	DV	ROA	CTI	LIQR	CR	NPL/TL	LR	TBTF
Variables	GDP GROWTH	INFLATION	GDP/CAPITA	FS/GDP	CPS/GDP	YTM	REG	MD
GDP GROWTH	1	–	–	–	–	–	–	–
INFLATION	0.3669*	1	–	–	–	–	–	–
GDP/CAPITA	0.0376*	−0.2268*	1	–	–	–	–	–
FS/GDP	0.4063*	−0.0446*	0.3160*	1	–	–	–	–
CPS/GDP	−0.3106*	−0.0967*	0.2983*	−0.2445*	1	–	–	–
YTM	−0.0766*	0.1477*	−0.3127*	−0.1698*	−0.1346*	1	–	–
REG	−0.0013	−0.2101*	0.0378*	0.0936*	−0.1865*	−0.2333*	1	–
MD	0.0626*	0.0185	0.0494*	0.0665*	−0.0063	−0.0035	−0.0333*	1

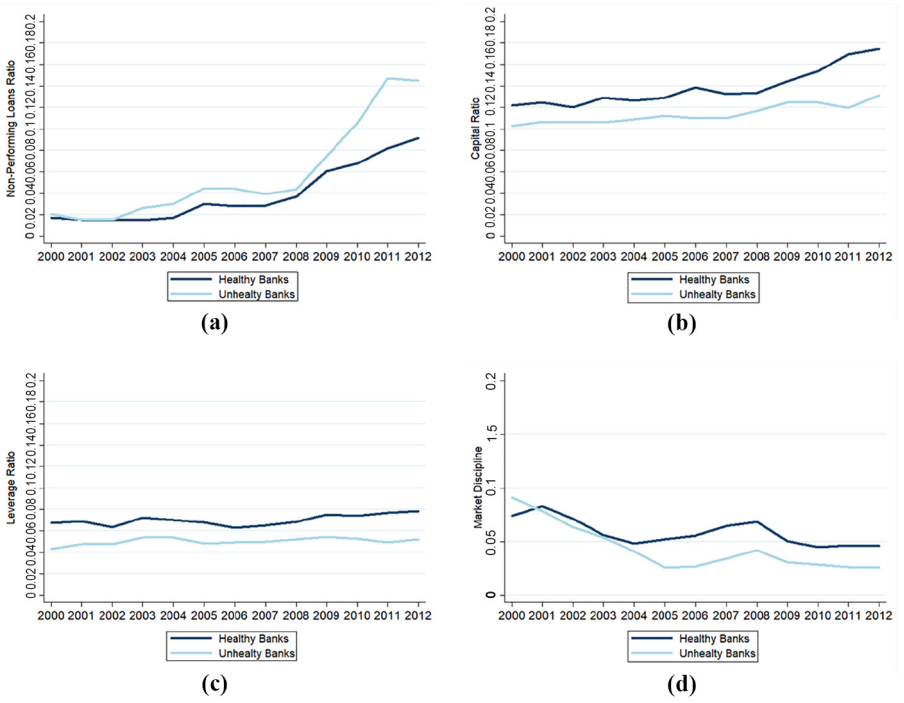
Notes: This table presents the correlation between the variables along the period 2000-2012. DV stands for dependent variable which is a dummy variable that takes the value 1 if the bank was liquidated, dissolved or bailed-out by the government and 0 otherwise; ROA which is the return on assets and is computed as the quotient between net income and average assets (past two years); COST TO INCOME (CTI) which is the ratio of fixed costs (computed as total staff costs plus general administrative costs plus amortization and depreciation costs) to total gross profit (computed as net interest margin plus income from capital instruments plus income from services and commissions plus results from financial operations plus other operating profit and loss); LIQUIDITY RATIO (LIQR) is computed as the quotient between liquid assets and deposits plus short-term funding; CR is the ratio of total capital (as defined in article 40 of Directive 2000/12/EC until 2006 and in Article 57 of Directive 2006/48/EC from 2007 onwards) to risk-weighted assets (as defined in Article 43 of Directive 2000/12/EC until 2006 and in Articles 76 to 115 of Directive 2006/48/EC from 2007 onwards); NPL/TL is the ratio between non-performing loans (computed as impaired loans) to total gross loans; LR is the leverage ratio computed as the quotient between Tier 1 capital (as defined in Articles 38 and 40 of Directive 2000/12/EC until 2006 and in Article 12 of Directive 2006/49/EC from 2007 onwards) and assets; TBTF controls for the too-big-to-fail argument being a dummy variable that takes the value of 1 if the bank has an average assets throughout the period equal or higher than percentile 75th and 0 otherwise; GDP GROWTH which is the rate of real GDP Growth; INFLATION which is the inflation rate; GDP per CAPITA (GDP/CAPITA) which is the GDP per capita; FISCAL SURPLUS/GDP (FS/GDP) which is the ratio of government surplus in percent of GDP; CREDIT TO PRIVATE SECTOR/GDP (CPS/GDP) which is the ratio of credit to private sector in percent of GDP; and COUNTRY YTM (YTM) which is the yield to maturity of country's treasury bonds; REG is a dummy variable that assumes the value of one if the number of measures applied with a tightening nature surpasses the ones with a loosening nature throughout the period 2000-2008 that is, at the inception of the financial crisis, and 0 otherwise, and is based on the data collected by Cerutti *et al.* (2017); and MARKET DISCIPLINE (MD) computed as the ratio of "other interest expenses" over "other liabilities". *Denotes significance at the 5 per cent



Notes: (a) This figure presents the historical average of assets' values, in millions of euros, for "unhealthy banks" and "healthy banks". Assets is computed as presented in Table I "Unhealthy banks" comprise banks that have faced a bailout or a bankruptcy/liquidation in the period between 2000 and 2012; "healthy banks" are composed by banks that have never been in those situations; (b) this figure presents the historical average of the return on assets ratios for "unhealthy banks" and "healthy banks". ROA is computed as shown in Table I "Unhealthy banks" comprise banks that have faced a bailout or a bankruptcy/liquidation in the period between 2000 and 2012; "healthy banks" are composed by banks that have never been in those situations; (c) this figure presents the historical average of liquidity ratio computed as shown in Table I, for "unhealthy banks" and "healthy banks"; "unhealthy banks" comprise banks that have faced a bailout or a bankruptcy/liquidation in the period between 2000 and 2012; "healthy banks" are composed by banks that have never been in those situations; (d) this figure presents the historical average of cost-to-income ratios for "unhealthy banks" and "healthy banks". Cost-to-income is computed as outlined in Table I; "unhealthy banks" comprise banks that have faced a bailout or a bankruptcy/liquidation in the period between 2000 and 2012; "healthy banks" are composed by banks that have never been in those situations

Figure 2.
Accounting indicators

As we can see through Table IV, bank performance, mainly regarding profitability and non-performing loans, was affected by the 2008 crisis. Return-on-assets decreased from 0.01 (2000) to 0 (2012), while the non-performing loans ratio increased from 0.02 to 0.11 across the same period.



Notes: (a) This figure presents the historical average of non-performing ratios for "unhealthy banks" and "healthy banks". NPL/TL is computed as the ratio of non-performing loans ("impaired loans") to total gross loans; "unhealthy banks" comprise banks that have faced a bailout or a bankruptcy/liquidation in the period between 2000 and 2012; "healthy banks" are composed by banks that have never been in those situations; (b) this figure presents the historical average capital ratio's values, for" unhealthy banks" and" healthy banks. CAPITAL RATIO is computed as shown in Table I; "Unhealthy banks" comprise banks that have faced a bailout or a bankruptcy/liquidation in the period between 2000 and 2012; "healthy banks" are composed by banks that have never been in those situations; (c) this figure presents the historical average of the leverage ratios for" unhealthy banks" and" healthy banks". LR is computed as the ratio of Tier 1 capital (as defined in Articles 38 and 40 of Directive 2000/12/EC until 2006 and in Article 12 of Directive 2006/49/EC from 2007 onwards) over total assets, for "unhealthy banks" and "healthy banks"; "unhealthy banks" comprise banks that have faced a bailout or a bankruptcy/liquidation in the period between 2000 and 2012; "healthy banks" are composed by banks that have never been in those situations; (d) this figure presents the historical average market discipline, computed as outlined in Table I; "unhealthy banks" comprise banks that have faced a bailout or a bankruptcy/liquidation in the period between 2000 and 2012; "healthy banks" are composed by banks that have never been in those situations

Figure 3.
Accounting and prudential/regulatory indicators

Countries	Healthy banks	Unhealthy banks	Unhealthy banks (% of Total banking system assets)	Total
Austria (AT)	34	3	15	37
Belgium (BE)	11	3	97	14
Czech Republic (CZ)	6	0	0	6
Denmark (DK)	36	1	1	37
Estonia (EE)	3	0	0	3
Finland (FI)	7	0	0	7
France (FR)	88	3	51	91
Germany (DE)	55	1	11	56
Greece (GR)	7	5	84	12
Hungary (HU)	9	0	0	9
Ireland (IE)	10	5	55	15
Italy (IT)	62	5	17	67
Luxembourg (LU)	9	0	0	9
The Netherlands (NL)	16	5	61	21
Poland (PL)	12	0	0	12
Portugal (PT)	12	4	63	16
Slovakia (SK)	7	0	0	7
Slovenia (SI)	11	0	0	11
Spain (ES)	50	7	29	57
Sweden (SE)	15	0	0	15
United Kingdom (UK)	81	3	29	84
Total	541	45	24	586

Table VI.
"Healthy" and "unhealthy" banks per country

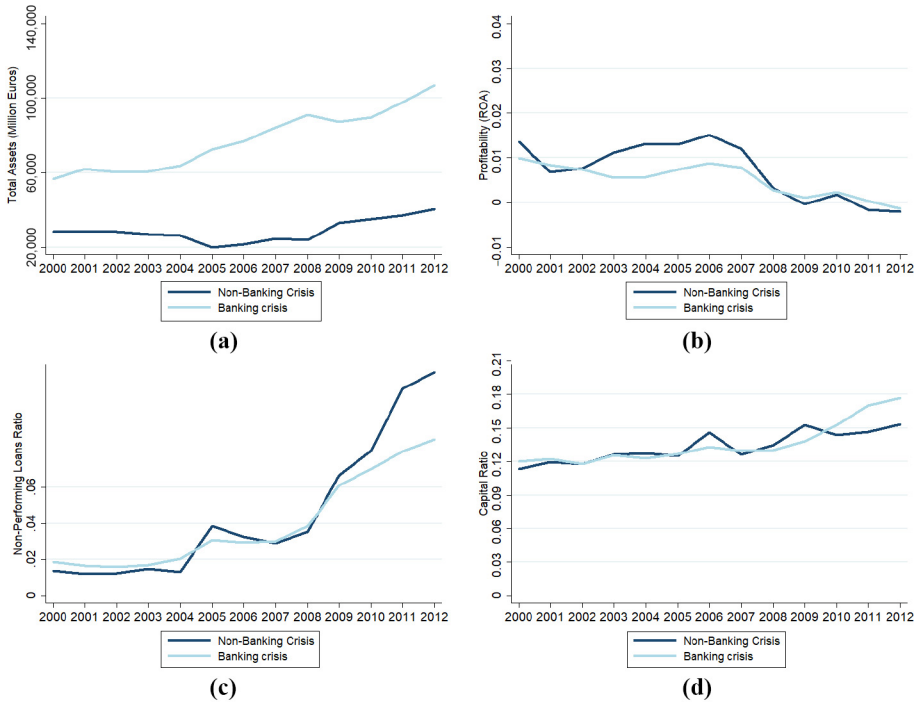
Note: This table presents the number of banks identified as "unhealthy" (i.e. having been bailed out by the Government or gone bankrupt) or "healthy" (i.e. not having experienced bail out nor bankruptcy) per country as well as the bailed out assets in percentage of the total assets of each banking system

Nevertheless, the capital ratio experienced a noticeable upward change from 0.12 (2000) to 0.17 (2012), owing to the reinforcement made by the majority of the EU regulators to strengthen banks' resilience to address the consequences of the 2008 global financial crisis.

When we turn to the macroeconomic variables, which comprise the 21 countries considered in the sample, we notice a downward trend in the majority of the variables, such as GDP growth and fiscal surplus/GDP, which decreased between 5 percentage points (p.p.) and 2 p.p. In the latter ratio we have the effect of the bailout of several banks, which has arguably lead to significant government deficits across several countries.

4.2.1 Behaviour of financial and prudential indicators of "unhealthy banks" vs "healthy banks" across the period between 2000 and 2012. This subsection describes the historical evolution of bank-specific indicators, where we can compare the behaviour of "unhealthy banks" vs "healthy banks". The "unhealthy banks" group comprises banks which faced a bailout or a bankruptcy/liquidation in the period considered in this paper, 2000-2012. Hence, the "healthy banks" sub-sample includes all other banks, those which did not go through bailout or bankruptcy/liquidation processes.

By inspection of Figures 2 and 3, we can see that the "unhealthy banks" are larger (which is consistent with the "too big to fail" issue), have lower profitability, measured by the return-on-assets ratio (more pronounced after 2008) and liquidity[8]. With respect to the cost-to-income ratio we cannot identify a significant pattern of difference between "healthy banks" and "unhealthy banks"[9].

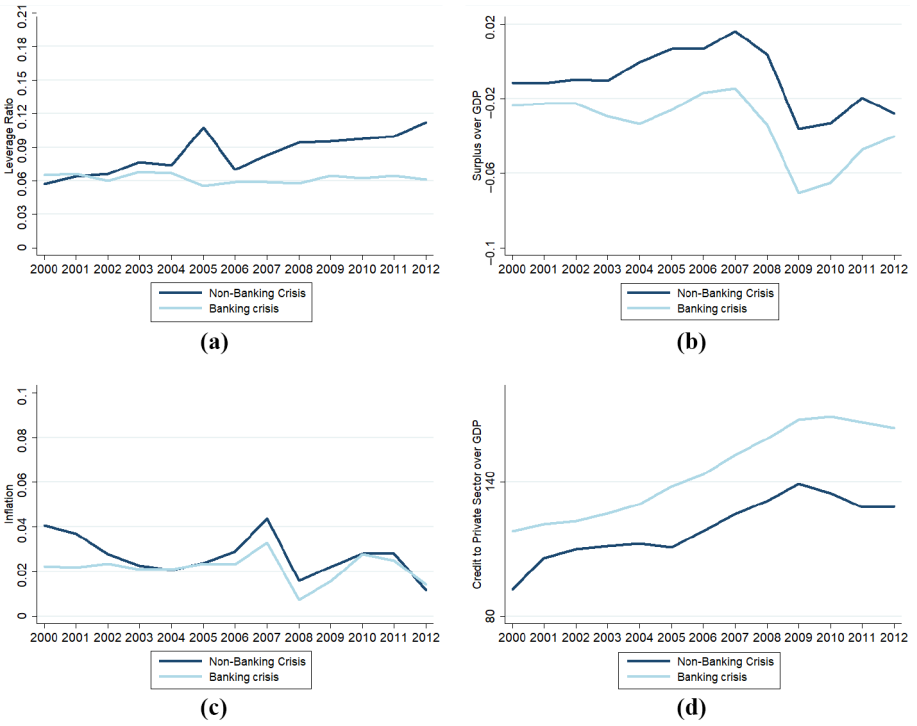


Notes: (a) This figure presents the historical average of the banking system total assets for "banking crisis" and "non-banking crisis" countries. total assets is computed as presented in Table I; "banking crisis" comprises countries that had to bail out banks in the period between 2000 and 2012; "non-banking crisis" is composed by countries that did not have to bail out banks; (b) this figure presents the historical average of the ROA for "banking crisis" and "non-banking crisis" countries. ROA is computed as presented in Table I;" banking crisis" comprises countries that had to bail out banks in the period between 2000 and 2012; "non-banking crisis" is composed by countries that did not have to bail out banks; (c) this figure presents the historical average of the NPL for "banking crisis" and "non-banking crisis" countries. NPL is computed as presented in Table I; "banking crisis" comprises countries that had to bail out banks in the period between 2000 and 2012; "non-banking crisis" is composed by countries that did not have to bail out banks; (d) this figure presents the historical average of the CR for "banking crisis" and "non-banking crisis" countries. CR is computed as presented in Table I; "banking crisis" comprises countries that had to bail out banks in the period between 2000 and 2012; "non-banking crisis" is composed by countries that did not have to bail out banks

Figure 4.
Countries' banking system indicators

Regarding the prudential or regulatory ratios, we can notice that the "healthy banks" have higher capital ratios and leverage ratios, and a lower non-performing loans ratio.

Nonetheless it should be mentioned that these descriptive data on bank behaviour across the period used the average in differencing the two types of banks, a measure with



Notes: (a) This figure presents the historical average of the LR for "banking crisis" and "non-banking crisis" countries. LR is computed as presented in Table I; "banking crisis" comprises countries that had to bail out banks in the period between 2000 and 2012; "non-banking crisis" is composed by countries that did not have to bail out banks; (b) this figure presents the historical average of the surplus over GDP for "banking crisis" and "non-banking crisis" countries. Surplus over GDP is computed as presented in Table I; "banking crisis" comprises countries that had to bail out banks in the period between 2000 and 2012; "non-banking crisis" is composed by countries that did not have to bail out banks; (c) This figure presents the historical average of the inflation for "banking crisis" and "non-banking crisis" countries. Inflation is computed as presented in Table I; "banking crisis" comprises countries that had to bail out banks in the period between 2000 and 2012; "non-banking crisis" is composed by countries that did not have to bail out banks; (d) this figure presents the historical average of the credit to private sector over GDP for "banking crisis" and "non-banking crisis" countries. Credit to private sector over GDP is computed as presented in Table I; "banking crisis" comprises countries that had to bail out banks in the period between 2000 and 2012; "non-banking crisis" is composed by countries that did not have to bail out banks

Figure 5.
Countries' banking system and macroeconomic indicators

some acknowledgeable caveats. Therefore this analysis will be subject to econometric models.

4.2.2 Behaviour of "banking crisis" vs "non-banking crisis" countries across the period between 2000 and 2012. This subsection tries to answer the following question: Are there lessons to be drawn from those countries that did not have to withstand banking distress during the period 2000 to 2012? The answer is yes. To this end, Figures 4 and 5 seem to evidence that countries that have not experienced banking distress are characterized by banking systems that are more capitalized, with less non-performing loans, and smaller and more profitable banks. Additionally, the economy of "non-banking crisis" countries has been less leveraged on credit to the private sector.

That said, it should be mentioned, again, that this type of analysis is heavily underpinned on average which in some cases may not result on an accurate picture of the whole differences between these two groups of countries.

5. Results

5.1 Main results

This section provides evidence for the empirical question discussed in Section 3. In terms of accounting indicators, the outcomes present in Table VII (regression 1) show that there are some bank-specific risk indicators that provide good signals for the probability of banks experiencing problems. These indicators are liquidity ratio, leverage ratio, non-performing loans ratio and the bank identified as too-big-to fail (TBTF variable). While the first two decreases the probability of distress the latter ones increase that probability.

Consistent with our expectations, banks that hold more liquid assets can address their short-term debt obligation in a period of stress, as these types of assets normally comprise less fire sales costs than other less-liquid assets such as loans and immovable properties. Despite using a proxy for the liquidity instruments brought by Basel III accord, this result supports the recent introduction of two liquidity requirements in the regulatory framework such as the liquidity coverage ratio and the net stable funding ratio described in detail in Section 2. Notwithstanding the economic impact on the probability of distress shows up as residual. The marginal effect varies between −0.05 and −0.08, i.e. an increase of 1 percentage point in the liquidity ratio, as defined in Table I, reduces the probability of distress in 5 and 8 basis points.

Interestingly the capital ratio decreases the probability of distress but loses significance in the presence of leverage ratio, pointing to the assumption raised in Section 2. Banks, under the possibility brought by Basel II accord, maximize their regulatory capital ratios, optimizing their RWAs rather than increasing their capital. As such, to the same amount of capital, banks can raise their regulatory capital ratios, decreasing their RWAs by engaging in the well-known "model risk" related to the computation of the RWAs. As risk weights rely on risks estimation, there is a possibility that the assumptions underlying banks' risk models are not satisfied in the real world[10]. More generally, models are simplifications of the real world, and the ways in which they are simplified may lead to miscalibration (Danielsson, 2008). The leverage ratio addresses this type of risk, imposing a ratio between capital and total assets irrespective of the risk-weighted ascribed to each type of assets. This measure mitigates "model risk".

In this vein, the leverage ratio shows up as significant in decreasing banks' likelihood of distress, whereas the capital ratio is not significant. This result highlights the importance of the introduction of such a ratio supplementing the already used capital ratio. The statistical significance of the leverage ratio is complemented by its economic impact. According to the

Table VII.
Likelihood of bank failure – logit regression results

Variables	(1)	(2)	(3)	(4)
GDP Growth	2.1204 (3.7248)	1.9119 (3.7261)	3.0517 (3.7678)	2.6529 (3.7794)
Marginal effect	0.0850	0.0742	0.1136	0.0967
INFLATION	−1.1147 (7.8971)	1.2550 (7.8429)	−6.5223 (7.1736)	−4.0696 (7.0708)
Marginal effect	−0.0447	0.0487	−0.2429	−0.1484
GDP TO CAPITA	−0.0058 (0.0137)	−0.0070 (0.0138)	−0.0046 (0.0129)	−0.0054 (0.0131)
Marginal effect	−0.0002	−0.0003	−0.0002	−0.0002
FISCAL SURPLUS TO GDP	−6.3043 (3.9522)	−6.3746 (3.9922)	−5.0237 (3.8862)	−5.0808 (3.9248)
Marginal effect	−0.2526	−0.2475	−0.1871	−0.1853
CREDIT TO PRIVATE SECTOR/GDP	0.0014 (0.0047)	0.0020 (0.0047)	−0.0009 (0.0050)	−0.0002 (0.0050)
Marginal effect	0.0001	0.0001	0.0000	0.0000
COUNTRY YTM	2.5568 (5.6634)	1.5760 (5.6108)	1.4896 (5.6052)	0.5227 (5.5353)
Marginal effect	0.1024	0.0612	0.0555	0.0191
ROA	−6.1987 (12.4099)	−8.4344 (12.4630)	−7.0856 (12.3523)	−9.3013 (12.4877)
Marginal effect	−0.2484	−0.3275	−0.2638	−0.3392
LIQUIDITY RATIO	−2.0400** (0.8470)	−1.9074** (0.8240)	−1.4568* (0.8311)	−1.3552* (0.8104)
Marginal effect	−0.0817	−0.0741	−0.0542	−0.0494
COST-TO-INCOME	0.2263 (0.4989)	0.1999 (0.5103)	0.1452 (0.5161)	0.1081 (0.5321)
Marginal effect	0.0091	0.0078	0.0054	0.0039
CR	−4.8240 (6.2282)	−5.3613 (6.2079)	−2.4521 (5.9275)	−3.1736 (5.9201)
Marginal effect	−0.1933	−0.2081	−0.0913	−0.1157
NPL/TL	4.7649** (2.1202)	4.7492** (2.1763)	5.7137*** (2.2081)	5.6719** (2.2176)
Marginal effect	0.1909	0.1844	0.2127	0.2068
LR	−21.1348* (11.4216)	−21.6020* (11.2707)	−26.2311** (12.4221)	−26.5153** (12.2331)
Marginal effect	−0.8468	−0.8387	−0.9767	−0.9669
TBTF	2.2551*** (0.5652)	2.2897*** (0.5735)	2.2423*** (0.5716)	2.2649*** (0.5741)

(*continued*)

Table VII.

Variables	(1)	(2)	(3)	(4)
Marginal effect	0.0904	0.0890	0.0835	0.0826
MARKET DISCIPLINE	–	5.7582** (2.3622)	–	5.2246** (2.4546)
Marginal effect	–	0.2236	–	0.1905
REG	–	–	−1.3030* (0.7154)	−1.2706* (0.7104)
Marginal effect	–	–	−0.0485	−0.0463
CONSTANT	−1.8057 (1.8104)	−1.9706 (1.8131)	−1.2886 (1.7018)	−1.4362 (1.7159)
BC	Yes	Yes	Yes	Yes
Type Error I (per cent)	5.0%	5.5%	4.0%	4.6%
Type Error II (per cent)	39.9%	40.7%	40.0%	39.9%
χ^2	72.80***	73.44***	74.11***	75.40***
$\mathbb{R}^2$	0.2785	0.2827	0.2973	0.3004
Observations	1766	1766	1766	1766

Notes: This table reports coefficients of the logit function: $LogL = \sum_{t=1}^{T}\sum_{i=1}^{N}\{Y_{it}log[F(\beta' X_{(it-1)}] + (1 - Y_{it})log[1 - F(\beta' X_{(it-1)}]\}$ where Y_{it} stands for a dummy variable that takes value of one if the bank was bailed out by the government or went bankrupt in time period t, and zero otherwise; X_{it-1} stands for the explanatory variables lagged by one period. The sample period is from 2000 to 2012. GDP GROWTH is the rate of real GDP's growth; INFLATION is the inflation rate; GDP per CAPITA is the GDP per capita; FISCAL SURPLUS/GDP is the ratio of government surplus to GDP; CREDIT TO PRIVATE SECTOR/GDP is the ratio of credit to the private sector to the GDP and COUNTRY YTM is the yield to maturity of country's treasury bonds; ROA is the return on assets ratio (and is computed as the quotient between bank's net income and average assets for the last two years); LIQUIDITY RATIO is the ratio of liquid assets to total deposits plus short term funding; COST TO INCOME is the ratio of fixed costs (computed as total staff costs plus general administrative costs plus amortization and depreciation costs) to total gross profit (computed as net interest margin plus income from capital instruments plus income from services and commissions plus results from financial operations plus other operating profit and loss); CR is the ratio of total capital to risk-weighted assets; NPL/TL is the ratio between non-performing loans (computed as impaired loans) to total gross loans; LR is the leverage ratio computed as defined in Table I; TBTF controls for the too-big-to-fail argument being a dummy variable that takes the value of 1 if the bank has an average assets throughout the period equal or higher than percentile 75th and 0 otherwise; MARKET DISCIPLINE computed as the ratio of "other interest expenses" over "other liabilities"; and REG is a dummy variable that assumes the value of one if the number of measures applied with a tightening nature surpasses the ones with a loosening nature throughout the period 2000-2008 that is, at the inception of the financial crisis, and 0 otherwise and is based on the data collected by Cerutti *et al.* (2017); and BC stands for banks' controls such as merger, listed/unlisted and banks' business models. Robust standard errors are in parentheses. *denotes significance at the 10 per cent, **at the 5 per cent and ***at the 1 per cent level. Marginal effect stands for marginal effects at the mean, which are more informative than coefficients in a non-linear model

marginal effect, 1 percentage point increase of the leverage ratio results in a reduction of the probability of distress between 0.85 and 0.98 (p.p.).

In addition, the results point to the importance of strengthening capital ratios which is aligned with the introduction of the capital conservation buffer envisaged in the Basel III accord and described in Section 2.

It is hardly surprising that non-performing loans ratio increases the probability of banking distress taking into account that a higher ratio generates losses to the bank through an increase of impairment flow as well as through a lower interest margin. High non-performing loans ratios dwell commonly on periods of excessive credit growth in which banks grant credit to the economy (to public and private sectors), without stringent risk standards, with the aim of maximizing profitability. The economic impact, measured by its marginal effects, is also high, an increase of 1 percentage point in this ratio leads to a rise of the probability of distress between 0.19 and 0.21 p.p.. This result evidences the importance of the introduction of the counter-cyclical capital buffer described in Section 2.

Regarding bank's size, Table VII gives support to the moral hazard related to the "too big to fail" argument, which points that banks perceived as too big to fail are arguably encouraged to increase risks because they expect a bailout by governments when the probability of distress raises (an example of the well-known "moral hazard" problem), for governments to mitigate the negative effects of bank failures in the economy. In this vein the introduction in the recent regulatory framework of a capital buffer to systemically important institutions (described in Section 2) is of utmost importance to mitigate this risk which is aligned with the conclusions drawn by Vazquez and Federico (2015). Using a sample of 11,000 banks in the USA and Europe during 2001-2009, they concluded that banks with higher leverage in the pre-crisis period were more likely to fail afterward and capital requirements (measured by the book value of equity as well as by tier 1 ratio) play an important role in reducing the probability of their default.

In terms of the role played by regulation and market discipline, the results outlined in Table VII generally confirm our hypotheses. To this end, the market penalizes banks with a higher probability of distress, demanding higher interest rates to compensate for the risk taken which in turn means that the market played well its role in disciplining banks.

In what regards regulation, the results evidence that banks subject to tightening regulatory measures taken in a pre-emptive way are less prone to experience financial problems. These measures include, among others, caps on loan-to-value ratios regarding residential and commercial real estate loans, changes in sector-specific capital buffers, concentration limits and limits on interbank exposures[11].

In what regards macroeconomic variables, contrary to what we were expecting and shown in some studies such as Martin and Schaeck (2007) and Betz *et al.* (2014), they show up as not having a statistically significant impact on banking distress (except in the case of the surplus/GDP). As explained by Poghosyan and Čihak (2011), this lack of significance might stem from the high degree of economic integration within the EU (illustrated by relatively low cross-country differences in inflation rates, and relatively high synchronization of business cycles).

To sum up, the results show that market discipline is good in monitoring banks. In what regards regulation, this paper outlines that regulatory authorities that adopted preventive measures such as caps on loan-to-value ratios regarding residential and commercial real estate loans, changes in sector specific capital buffers, concentration limits, limits on interbank exposures, at the inception of the crisis, were able to reduce the probability of distress of banks headquartered in those jurisdictions. Additionally, giant steps have been undertaken by the regulators, which culminated with a new regulatory framework, the well-

known Basel III accord, which has revealed to be on the right path to address some the main risks identified in this paper. Notwithstanding there are some aspects which are not complete yet and new areas deserve more attention by the regulators. Some of them stem directly from the results obtained by this paper, whereas others deserve more empirical work. They are discussed in the conclusions' section.

Using a neutral cut-off probability of 5 per cent, we can see that the model classifies between 4.6 per cent and 5.0 per cent of all banks with problems incorrectly as "healthy" banks (Type I error) which is the main concern for supervisors. In this vein, the results obtained for this type of error are not worrying, especially comparing with other studies such the ones developed by Martin and Schaeck (2007) (11 per cent and 27 per cent) and Poghosyan and Čihak (2011) (31 per cent and 44 per cent).

We also observe, through Figure 6, the discriminatory power of our logit model, measured by the AUC, varying between 86 and 88 per cent, which is indicator of the very good model's performance.

Considering that the effects of regulation and market discipline could differ across banks, we follow the study developed by Klomp and De Haan (2012) and carry out a sensitivity analysis to assess in particular if the effects of regulation and market discipline on banking distress vary with banks' size and the fact of being listed/unlisted by interacting the variables too-big-to-fail (TBTF) and listed (a dummy variable that assumes the value of one if the banks have their equity quoted in the capital markets and 0 otherwise) with the variables regulation dummy and market discipline. In this regard Table VIII shows that, for the sample and the time period used in this paper, regulation and market discipline do not vary with banks' size and the fact of if they are listed or unlisted.

5.2 Robustness checks

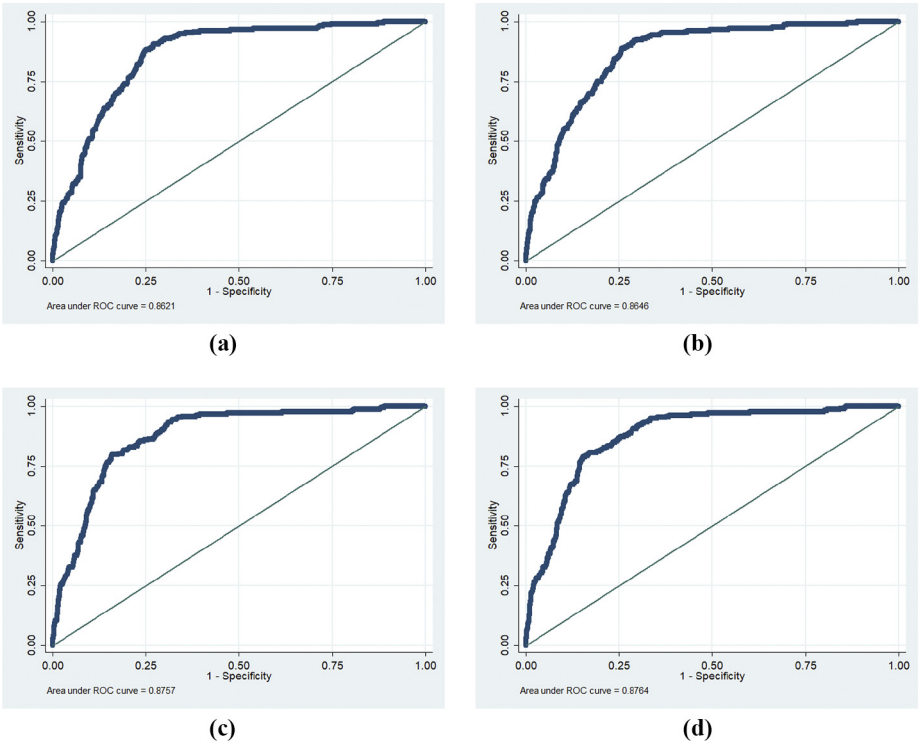
Table IX shows that the results are robust both to changes in the database of regulatory measures, since REG maintains the same significance and signal, and to the introduction of a variable that tries to capture all the specificities of a country (COUNTRY $\times$ YEAR). In addition the results support the argument that market discipline is not only useful to signal banking distress up to one year but also with two years ahead (Regression 3).

Regarding the use of an alternative model (duration analysis), the results outlined in Table X confirm the ones obtained by the logit model. The surprise was non-performing loans, which loses significance. This might stem from the shrinkage of the number of observations.

6. Main conclusions and policy actions

This paper raises the question of how regulation and market discipline influence banking distress in Europe during the past financial crisis. Additionally we assessed how some of the changes performed by regulators which culminated with a new regulatory framework known as Basel III accord are on the right path to address the main risk that lead to the financial crisis experienced.

Using a logistic regression, as widely used in early warning models applied to a sample of European countries we find that the main risks dwell on the relaxing of credit standards which evolve to high non-performing loans ratios, undercapitalized banks and moral hazard related to the "too-big-too-fail" issue. Interesting is that the unweighted capital ratio, known as leverage ratio, has a more pronounced negative effect on the likelihood of banking distress. This is addressed by the introduction of the novelty leverage ratio and gives support to its introduction as a binding capital requirement together with the already used regulatory capital ratio.



Notes: (a) This figure presents the ROC curve for Regression (1) (Table VI). The receiver operating characteristic (ROC) is a graphical method for determining the discriminatory power of signalling variables. With regard to the goodness of fit, the discriminatory power of the logit model, measured by the area under the receiver operating characteristics curve (AUC) is 86.21%; (b) This figure presents the ROC curve for Regression (2) (Table VI). The receiver operating characteristic (ROC) is a graphical method for determining the discriminatory power of signalling variables. With regard to the goodness of fit, it turns out that the discriminatory power of the logit model, measured by the AUC is 86.46%; (c) This figure presents the ROC curve for Regression (3) (Table VI). The ROC is a graphical method for determining the discriminatory power of signalling variables. With regard to the goodness of fit the discriminatory power of the logit model, measured by the AUC is 87.57%; (d) This figure presents the ROC curve for Regression (4) (Table VI). The ROC is a graphical method for determining the discriminatory power of signalling variables. With regard to the goodness of fit the discriminatory power of the logit model, measured by the AUC is 87.64%

Figure 6.
ROC curve
Regressions 1-4

Regarding the role played by the market in disciplining banks, it appears as a good monitor of banks' risks. Regarding regulation, this paper evidences that few jurisdictions that undertook some regulatory tightening measures to mitigate the accumulation of risks specific to their banking systems until the inception of the financial crisis (2000-2008) and beyond the simple transposition of the measures brought by Basel I and Basel II, contribute to the reduction of the probability of distress of the banks under those jurisdictions.

Variables	(1)	(2)
GDP growth	2.1620 (3.8238)	2.9932 (3.6776)
INFLATION	−2.5522 (7.2915)	−4.1988 (7.1067)
GDP TO CAPITA	−0.0054 (0.0128)	−0.0046 (0.0137)
FISCAL SURPLUS TO GDP	−5.2547 (3.8750)	−5.1047 (3.9837)
CREDIT TO PRIVATE SECTOR/GDP	0.0000 (0.0052)	−0.0002 (0.0051)
COUNTRY YTM	−0.4804 (5.7863)	0.7226 (5.5467)
ROA	−11.2426 (12.7584)	−8.7962 (12.7098)
LIQUIDITY RATIO	−1.2020 (0.7741)	−1.3852 (0.8767)
COST-TO-INCOME	0.0221 (0.5306)	0.0644 (0.5315)
CR	−2.5423 (6.0341)	−3.1428 (5.7177)
NPL/TL	5.3306** (2.4339)	5.8803*** (2.2352)
LR	−27.5218** (11.6743)	−26.5947** (12.4505)
TBTF	2.0505*** (0.6933)	2.2476*** (0.5763)
MARKET DISCIPLINE	1.9027 (3.4209)	6.5921** (2.7904)
REG	−0.2957 (1.2841)	−0.9182 (1.1013)
MARKET DISCIPLINE*TBTF	8.0460 (6.9040)	–
REG*TBTF	−1.1317 (1.4684)	–
MARKET DISCIPLINE*LISTED	–	−4.0723 (5.3610)
REG*LISTED	–	−0.6438 (1.3815)
CONSTANT	−1.4111 (1.6742)	−1.6192 (1.7846)
BC	Yes	Yes
χ^2	81.88***	76.48***
$\mathbb{R}^2$	0.3041	0.3023
Observations	1766	1766

Notes: This table reports coefficients of the logit function: $LogL = \sum_{t=1}^{T}\sum_{i=1}^{N}\{Y_{it}log[F(\beta' X_{(it-1)}] + (1 - Y_{it})log[1 - F(\beta' X_{(it-1)}]\}$ where Y_{it} stands for a dummy variable that takes value of one if the bank was bailed out by the government or went bankrupt in time period t, and zero otherwise; $X_{it\text{-}1}$ stands for the explanatory variables lagged by one period. The sample period is from 2000 to 2012. GDP GROWTH is the rate of real GDP's Growth; INFLATION is the inflation rate; GDP per CAPITA is the GDP per capita; FISCAL SURPLUS/GDP is the ratio of government surplus to GDP; CREDIT TO PRIVATE SECTOR/GDP is the ratio of credit to the private sector to the GDP and COUNTRY YTM is the yield to maturity of country's treasury bonds; ROA is the return on assets ratio (and is computed as the quotient between bank's net income and average assets for the last two years); LIQUIDITY RATIO is the ratio of liquid assets to total deposits plus short term funding; COST TO INCOME is the ratio of fixed costs (computed as total staff costs plus general administrative costs plus amortization and depreciation costs) to total gross profit (computed as net interest margin plus income from capital instruments plus income from services and commissions plus results from financial operations plus other operating profit and loss); CR is the ratio of total capital to Risk Weighted Assets; NPL/TL is the ratio between non-performing loans (computed as impaired loans) to total gross loans; LR is the leverage ratio computed as defined in Table I; TBTF controls for the Too-Big-to-Fail argument being a dummy variable that takes the value of 1 if the bank has an average assets throughout the period equal or higher than percentile 75th and 0 otherwise; MARKET DISCIPLINE computed as the ratio of "other interest expenses" over "other liabilities"; and REG is a dummy variable that assumes the value of one if the number of measures applied with a tightening nature surpasses the ones with a loosening nature throughout the period 2000-2008 that is, at the inception of the financial crisis, and 0 otherwise and is based on the data collected by Cerutti *et al.* (2017); and BC stands for banks' controls such as merger, listed/unlisted and banks' business models. Robust standard errors are in parentheses. *Denotes significance at the 10 per cent, **at the 5 per cent and ***at the 1 per cent level

Table VIII.
Likelihood of bank failure – sensitivity analysis

Variables	(1)	(2)	(3)
GDP growth	4.5818 (3.7448)	–	4.9121 (4.0760)
INFLATION	−5.1740 (7.3707)	–	−6.5783 (7.2970)
GDP TO CAPITA	0.0024 (0.0129)	–	−0.0025 (0.0124)
FISCAL SURPLUS TO GDP	−6.8662* (3.9510)	–	−5.3192 (4.0964)
CREDIT TO PRIVATE SECTOR/GDP	0.0012 (0.0049)	–	−0.0015 (0.0053)
COUNTRY YTM	2.8524 (5.3188)	–	2.5338 (5.9718)
ROA	−10.8338 (11.8811)	−12.8654 (11.8849)	−10.0913 (12.8191)
LIQUIDITY RATIO	−2.0320** (0.8175)	−1.5336* (0.8684)	−1.1919 (0.7959)
COST-TO-INCOME	0.0394 (0.5954)	0.0363 (0.5195)	0.0970 (0.5273)
CR	−5.7616 (6.1533)	−2.8668 (4.4145)	−2.2613 (5.3479)
NPL/TL	5.3178** (2.1975)	6.2229** (2.4733)	5.7732*** (2.1586)
LR	−18.2533* (10.6256)	−26.4458** (10.6098)	−24.6060** (12.0725)
TBTF	2.1790*** (0.5572)	2.2859*** (0.5485)	2.2743*** (0.5824)
MARKET DISCIPLINE	4.9130* (2.6074)	4.6457* (2.6984)	3.9855** (1.8102)
REG	−1.2648** (0.6400)	−1.4771** (0.6617)	−1.3927** (0.6977)
Country*Year	–	0.0000 (0.0000)	–
CONSTANT	−2.5598 (1.8135)	−1.1083 (1.1061)	−1.8517 (1.6510)
BC	Yes	Yes	Yes
χ^2	72.54***	72.51***	68.38***
$\mathbb{R}^2$	0.2980	0.3094	0.3011
Observations	1766	1766	1609

Notes: This table reports coefficients of the logit function: $LogL = \sum_{t=1}^{T}\sum_{i=1}^{N}\{Y_{it}log\left[F\left(\beta' X_{(it-1)}\right]\right.$ $+ (1 - Y_{it})log\left[1 - F\left(\beta' X_{(it-1)}\right]\right\}$ where Y_{it} stands for a dummy variable that takes value of one if the bank was bailed out by the government or went bankrupt in time period t, and zero otherwise; $X_{it\text{-}1}$ stands for the explanatory variables lagged by one period (except in the case of Regression 3 where MARKET DISCIPLINE is lagged by two periods). The sample period is from 2000 to 2012. GDP GROWTH is the rate of real GDP's growth; INFLATION is the inflation rate; GDP per CAPITA is the GDP per capita; FISCAL SURPLUS/GDP is the ratio of government surplus to GDP; CREDIT TO PRIVATE SECTOR/GDP is the ratio of credit to the private sector to the GDP and COUNTRY YTM is the yield to maturity of country's treasury bonds; ROA is the return on assets ratio (and is computed as the quotient between bank's net income and average assets for the last two years); LIQUIDITY RATIO is the ratio of liquid assets to total deposits plus short term funding; COST TO INCOME is the ratio of fixed costs (computed as total staff costs plus general administrative costs plus amortization and depreciation costs) to total gross profit (computed as net interest margin plus income from capital instruments plus income from services and commissions plus results from financial operations plus other operating profit and loss); CR is the ratio of total capital to risk-weighted assets; NPL/TL is the ratio between non-performing loans (computed as impaired loans) to total gross loans; LR is the leverage ratio computed as defined in Table I; TBTF controls for the too-big-to-fail argument being a dummy variable that takes the value of 1 if the bank has an average assets throughout the period equal or higher than percentile 75th and 0 otherwise; MARKET DISCIPLINE computed as the ratio of "other interest expenses" over "other liabilities". In Regressions 1 and 2 is lagged by one period whereas in regression 3 is lagged by 2 periods; and REG is a dummy variable that assumes the value of one if the number of measures applied with a tightening nature surpasses the ones with a loosening nature throughout the period 2000-2008 that is, at the inception of the financial crisis, and 0 otherwise and is based on the data collected by Cerutti *et al.* (2017) – regression 2 or gathered by Budnik and Kleibl (2018) – Regression 1; and BC stands for banks' controls such as merger, listed/unlisted and banks' business models. Robust standard errors are in parentheses. *Denotes significance at the 10 per cent, **at the 5 per cent and ***at the 1 per cent level

Table IX.
Likelihood of bank failure – robustness tests

Table X.
Time to failure – duration analysis results

Variables	(1)	(2)	(3)	(4)
GDP growth	−4.2292 (3.2280)	−3.9461 (3.2332)	−5.0327 (3.3804)	−4.3135 (3.4126)
INFLATION	−2.9755 (7.0072)	−5.4995 (6.7373)	1.8086 (6.5443)	−1.2436 (6.3635)
GDP TO CAPITA	0.0066 (0.0063)	0.0076 (0.0060)	0.0049 (0.0062)	0.0055 (0.0059)
FISCAL SURPLUS TO GDP	7.3426*** (2.0268)	7.3057*** (2.0202)	6.0605*** (2.0807)	5.9874*** (2.0807)
CREDIT TO PRIVATE SECTOR/GDP	−0.0021 (0.0018)	−0.0028 (0.0018)	0.0001 (0.0020)	−0.0007 (0.0019)
COUNTRY YTM	−7.1597 (4.9542)	−5.4339 (4.8953)	−7.3677 (4.9220)	−5.4587 (4.9054)
ROA	−21.341 (13.5242)	−18.0772 (12.6601)	16.1829 (13.2462)	−12.5624 (12.6592)
LIQUIDITY RATIO	1.4279*** (0.5085)	1.2648*** (0.4894)	1.0725** (0.5237)	0.9151*** (0.5035)
COST-TO-INCOME	0.6372 (0.8706)	0.6747 (0.8330)	0.8710 (1.0011)	0.9254 (0.9595)
CR	17.5378*** (4.8202)	17.7931*** (4.8663)	14.8761*** (4.9636)	15.3266*** (4.9907)
NPL/TL	0.2467 (2.5589)	−0.0290 (2.4392)	0.2488 (2.5214)	−0.0135 (2.4681)
LR	17.9071*** (6.0248)	18.4819*** (5.8891)	20.9482*** (5.9653)	21.3231*** (5.8352)
TBTF	−1.5698*** (0.2188)	−1.6245*** (0.2240)	−1.5428*** (0.2187)	−1.5780*** (0.2207)
MARKET DISCIPLINE	–	−6.7086*** (1.4012)	–	−6.2096*** (1.5882)
REG	– –	– –	1.3498*** (0.3282)	1.3047*** (0.3266)
CONSTANT	2.9034** (1.3210)	3.1467*** (1.2212)	2.4309* (1.3311)	2.6710** (1.2553)
BC	Yes	Yes	Yes	Yes
Observations	1.608	1.608	1.608	1.608

Notes: This table reports coefficients of the duration model: $\lambda(t;X) = \lim_{x \downarrow 0} \frac{P(t \leq T < t+h | T \geq t, X)}{h}$ where T is length of time the bank remains in the sample until becoming bankrupt or being bailed out by the government, and X is a vector of explanatory variables. The sample period is from 2000 to 2012. GDP GROWTH is the rate of real GDP's Growth; INFLATION is the inflation rate; GDP per CAPITA is the GDP per capita; FISCAL SURPLUS/GDP is the ratio of government surplus to GDP; CREDIT TO PRIVATE SECTOR/GDP is the ratio of credit to the private sector to the GDP and COUNTRY YTM is the yield to maturity of country's treasury bonds; ROA is the return on assets ratio (and is computed as the quotient between bank's net income and average assets for the last two years); LIQUIDITY RATIO is the ratio of liquid assets to total deposits plus short-term funding; COST TO INCOME is the ratio of fixed costs (computed as total staff costs plus general administrative costs plus amortization and depreciation costs) to total gross profit (computed as net interest margin plus income from capital instruments plus income from services and commissions plus results from financial operations plus other operating profit and loss); CR is the ratio of total capital to risk-weighted assets; NPL/TL is the ratio between non-performing loans (computed as impaired loans) to total gross loans; LR is the leverage ratio computed as defined in Table I; TBTF controls for the too-big-to-fail argument being a dummy variable that takes the value of 1 if the bank has an average assets throughout the period equal or higher than percentile 75th and 0 otherwise; MARKET DISCIPLINE computed as the ratio of "other interest expenses" over "other liabilities"; REG is a dummy variable that assumes the value of one if the number of measures applied with a tightening nature surpasses the ones with a loosening nature throughout the period 2000-2008 that is, at the inception of the financial crisis, and 0 otherwise and is based on the data collected by Cerutti *et al.* (2017); and BC stands for banks' controls such as merger, listed/unlisted and banks' business models. Robust standard errors are in parentheses. *Denotes significance at the 10 per cent, **at the 5 per cent and ***at the 1 per cent level

Additionally, the changes undertaken by the regulators, which culminated with a new regulatory framework, the well-known Basel III accord, have revealed to be on the right path, as they have targeted most of the aforementioned risks that led to the banking crisis. However, no regulatory framework can reduce the probability of a crisis to zero.

Despite the welcomed changes performed by regulators, some aspects are not complete yet and new areas deserve more empirical work and attention by the regulators. The following three stem directly from the results obtained with this paper. Other aspects deserve more empirical work.

Taking into account the good performance outlined by market participants in signalling banking distress, we suggest deepening transparency through the enhancement and a close monitoring of the current Pillar 3 framework.

Regarding regulation and given the evidence brought by this paper, regulatory authorities should take the opportunity and the mandate of CRD IV to adopt targeted measures in a pre-emptive and counter-cyclical way to reduce the accumulation of risks in some sectors. This gains importance in the current context of an accommodative monetary policy, characterized by a low interest rate environment, which is considered necessary to contain deflationary pressures and bring inflation to its target level. Notwithstanding such policy, while being necessary for achieving price stability, may undermine financial stability by inflating asset prices and by creating incentives for search for yield. Considering the performance obtained with the leverage ratio indicator in this paper, completing the implementation of this ratio should also be one of the priorities.

The transposition into the European legal regulatory framework of some of the proposals envisaged in the last Basel Committee on Banking Supervision paper entitled "Basel III: Finalizing Post-Crisis Reforms" (BCBS, 2017) on the necessary post-crisis reforms, should also deserve the attention of the regulators, with the special focus on more constraints in using internal models in order to reduce unwarranted variability in banks' calculations of risk-weighted-assets such as the revision of the output floor limits, i.e. the amount of capital benefit a bank can obtain from its use of internal models relative to using the standardized. According to the Regulatory Consistency Assessment Programme (RCAP) published in March 2018 by the Basel Committee on Banking Supervision, one of the divergences from the Basel standard in the EU includes the greater latitude given to banks using sophisticated approaches in calculating their capital requirements.

Other aspects that do not gathered consensus is the regulatory treatment of sovereign exposures to which a zero risk weight is ascribed, i.e. banks do not need to have capital to cover the exposures of some type of sovereign exposures for instance the ones denominated and financed in euros. This issue gains relevance in the context of the new liquidity buffers. Given that sovereign debt securities are considered as high liquidity assets and are necessary to comply with these buffers coupled with the fact that there is no need to have capital allocated to them, the links between banks and sovereigns are an issue that will remain a challenge to the regulatory authorities. Therefore, according to Kahlert and Wagner (2017), the revision of the regulatory treatment given to the great majority of the sovereign debt securities, in terms of risk weights and limits to concentration, according to their market fundamentals, shall be considered by the regulators. Additionally, as a result from the new developments in information technologies new areas such as fintech and cyber security should deserve a particular attention by the regulators.

Finally, as advocate by Breitenfellner and Wagner (2010), tighter regulation is not the sole answer to mitigate that a turmoil like the global financial crisis does not repeat. It shall be accompanied by an appropriate risk management and risk assessment by financial institutions instead of short-term profitability. The introduction of the Resolution framework might incentivize this type of behaviour by the institutions' shareholders.

Notes

1. For more details, please see the article published in *The New York Times* on April 21, 2009, entitled as "I.M.F. Puts Bank Losses From Global Financial Crisis at $4.1 Trillion."
2. For one example, please see the Global Financial Stability Report of October 2018 – Chapter 2 "Regulatory Reform 10 Years After the Global Financial Crisis: Looking Back, Looking Forward", published by the International Monetary Fund.
3. The EU Directives introduce the changes brought by Basel I and Basel II in the EU regulatory framework.
4. We use total assets as a proxy since the converter factors applied to the off-balance bank's exposures depending on their risk are not available.
5. Additionally, since the models incorporate only a limited number of observations, past crises were not reflected in estimates of future losses (short term bias).
6. We have also performed analysis clustering by country, and the results remain valid.
7. The receiver operating characteristic (ROC) is a graphical method for determining the discriminatory power of signalling variables.
8. In the case of liquidity, the figure depicts a significant increases in 2008 which is related with the fact that the banks with higher liquidity ratios weights more on the average of "healthy banks" liquidity ratios.
9. It is worth mentioning that the majority of the "unhealthy banks" faced a bailout instead of bankruptcy or liquidation.
10. Uncertainty and the possibility of structural breaks mean that the distributions of PD and LGD might not be fully known for certain types of exposure.
11. For further details please consult the data gathered by Cerutti *et al.* (2017). As set out in Table 7, the standard errors are corrected using clustering at the bank level (as widely used in empirical studies). As already mentioned in Section 5, as a robustness check and given the regulation dummy is a country-specific variable we have re-run the model using clusters at the country level. The result obtained for this variable does not show up with material changes maintaining its sign and statistical significance.

References

Allen, F., Carletti, E. and Marquez, R. (2011), "Credit market competition and capital regulation", *Review of Financial Studies*, Vol. 24 No. 4, pp. 983-1018.

Arena, M. (2008), "Bank failures and bank fundamentals: a comparative analysis of Latin America and East Asia during the nineties using bank-level data", *Journal of Banking and Finance*, Vol. 32 No. 2, pp. 299-310.

Arnould, G. Bruneau, C. and Peng, Z. (2017), "Liquidity and equity short term fragility: stress tests for the European banking system", *Available at SSRN 2784664*.

Ashcraft, A.B. (2008), "Does the market discipline banks? New evidence from regulatory capital mix", *Journal of Financial Intermediation*, Vol. 17 No. 4, pp. 543-561.

Babecký, J., Havránek, T., Mateju, T., Rusnák, M., Smídkoá, K. and Vasicek, B. (2012), "Banking, debt, and currency crises", *European Central Bank Working Paper Series*, pp. 1-43.

BCBS (2006), "International convergence of capital measurement and capital standards: a revised framework comprehensive version", pp. 1-322.

BCBS (2010), "Basel III: a global regulatory framework for more resilient banks and banking systems", pp. 1-69.

BCBS (2012), "A framework for dealing with domestic systemically important banks", pp. 1-11.

BCBS (2014), "Basel III: leverage ratio framework".

BCBS (2017), "Basel III: finalizing post-crisis reforms", pp. 1-162.

Berger, A., Herring, R. and Szego, G. (1995), "The role of financial institutions", *The Journal of Banking and Finance*, Vol. 19, pp. 393-430.

Barth, J., Caprio, G. and Levine, R. (2013), "Bank regulation in 180 countries from 1999 to 2011", *World Bank Working Paper Series*, pp. 1-110.

Betz, F., Oprică, S., Peltonen, T.A. and Sarlin, P. (2014), "Predicting distress in European banks", *Journal of Banking and Finance*, Vol. 45, pp. 225-241.

Brei, M. and Gambacorta, L. (2016), "Are bank capital ratios pro-cyclical? New evidence and perspectives", *Economic Policy*, Vol. 31 No. 86, pp. 357-403.

Breitenfellner, B. and Wagner, N. (2010), "Government intervention in response to the subprime financial crisis: the good into the pot, the bad into the crop", *International Review of Financial Analysis*, Vol. 19 No. 4, pp. 289-297.

Budnik, K.B. and Kleibl, J. (2018), "Macroprudential regulation in the European Union in 1995-2014: introducing a new data set on policy actions of a macroprudential nature".

Calomiris, C. and Wilson, B. (2004), "Bank capital and portfolio management: the 1930s capital crunch and the scramble to shed risk", *The Journal of Business*, Vol. 77 No. 3, pp. 421-455.

Cerutti, E., Correa, R., Fiorentino, E. and Segalla, E. (2017), "Changes in prudential policy instruments-a new cross-country database", Imf Working Papers, Vol. 13, pp. 478-503.

Cole, R.A. and Gunther, J.W. (1998), "Predicting bank failures: a comparison of on-and off-site monitoring systems", *Journal of Financial Services Research*, Vol. 13 No. 2, pp. 103-117.

Cole, R.A. and White, L.J. (2012), "Déjà vu all over again: the causes of us commercial bank failures this time around", *Journal of Financial Services Research*, Vol. 42 Nos 1/2, pp. 5-29.

Danielsson, J. (2008), "Blame the models", *Journal of Financial Stability*, Vol. 4 No. 4, pp. 321-328.

Davis, E.P. and Karim, D. (2008), "Comparing early warning systems for banking crises", *Journal of Financial Stability*, Vol. 4 No. 2, pp. 89-120.

De Jonghe, O. and Öztekin, Ö. (2015), "Bank capital management: international evidence", *Journal of Financial Intermediation*, Vol. 24 No. 2, pp. 154-177.

Demirgüç-Kunt, A. and Detragiache, E. (1998), "The determinants of banking crises in developing and developed countries", *Staff Papers – International Monetary Fund*, Vol. 45 No. 1, pp. 81-109.

Demirgüç-Kunt, A. and Detragiache, E. (2005), "Cross-country empirical studies of systemic bank distress: a survey", *National Institute Economic Review*, Vol. 192 No. 1, pp. 68-83.

DeYoung, R. and Torna, G. (2013), "Nontraditional banking activities and bank failures during the financial crisis", *Journal of Financial Intermediation*, Vol. 22 No. 3, pp. 397-421.

Directive/2013/36/EU (2013), "Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013".

Directive/2014/59/EU (2014), "Directive 2014/59/EU of the European Parliament and of the Council of 15 May 2014".

Distinguin, I., Kouassi, T. and Tarazi, A. (2013), "Interbank deposits and market discipline: evidence from Central and Eastern Europe", *Journal of Comparative Economics*, Vol. 41 No. 2, pp. 544-560.

Distinguin, I., Rous, P. and Tarazi, A. (2006), "Market discipline and the use of stock market data to predict bank financial distress", *Journal of Financial Services Research*, Vol. 30 No. 2, pp. 151-176.

Drehmann, M. and Juselius, M. (2013), "Evaluating early warning indicators of banking crises: satisfying policy requirements", Bank for International Settlements Working Papers, pp. 1-35.

Duca, M.L. and Peltonen, T.A. (2013), "Assessing systemic risks and predicting systemic events", *Journal of Banking and Finance*, Vol. 37 No. 7, pp. 2183-2195.

ESRB (2017), "Financial stability implications of IFRS 9", Technical report, ESRB Report.

Flannery, M.J. (1994), "Debt maturity and the deadweight cost of leverage: optimally financing banking firms", *The American Economic Review*, Vol. 84 No. 1, pp. 320-331.

Flannery, M.J. and Rangan, K.P. (2008), "What caused the bank capital build-up of the 1990s?", *Review of Finance*, Vol. 12 No. 2, pp. 391-429.

Flannery, M.J. and Sorescu, S.M. (1996), "Evidence of bank market discipline in subordinated debenture yields: 1983-1991", *The Journal of Finance*, Vol. 51 No. 4, pp. 1347-1377.

Grill, M., Lang, J. and Smith, J. (2015), "The leverage ratio, risk-taking and bank stability", *Working Paper*, pp. 1-46.

Gropp, R. and Heider, F. (2010), "The determinants of bank capital structure", *Review of Finance*, Vol. 14 No. 4, pp. 587-622.

Gropp, R. and Vesala, J. (2004), "Deposit insurance, moral hazard and market monitoring", *European Central Bank Working Paper Series*, pp. 1-37.

Hadad, M.D., Agusman, A., Monroe, G.S., Gasbarro, D. and Zumwalt, J.K. (2011), "Market discipline, financial crisis and regulatory changes: evidence from Indonesian banks", *Journal of Banking and Finance*, Vol. 35 No. 6, pp. 1552-1562.

Hoang, K.T., Faff, R. and Haq, M. (2014), "Market discipline and bank risk taking", *Australian Journal of Management*, Vol. 39 No. 3, pp. 327-350.

Hosono, K.I.H. and Tsuru, K. (2005), "Bank regulation and market discipline around the world", *Working Paper*, Development Bank of Japan, pp. 1-50.

Jahn, N. and Kick, T. (2012), "Early warning indicators for the German banking system: a macroprudential analysis", *Deutsche Bundesbank Working Papers*, pp. 1-43.

Jordan, D.J., Rice, D., Sanchez, J., Walker, C. and Worth, D. (2010), "Predicting bank failures: evidence from 2007 to 2010", Working Paper, pp. 1-27.

Kahlert, D. and Wagner, N. (2017), "Are systemically important Eurozone banks undercapitalized? A stress testing approach", *A Stress Testing Approach (April 2017)*.

Kick, T. and Koetter, M. (2007), "Slippery slopes of stress: ordered failure events in German banking", *Journal of Financial Stability*, Vol. 3 No. 2, pp. 132-148.

Kinateder, H. (2016), "Basel II versus III: a comparative assessment of minimum capital requirements for internal model approaches", *Journal of Risk*, Vol. 18 No. 3.

Klomp, J. and De Haan, J. (2012), "Banking risk and regulation: does one size fit all?", *Journal of Banking and Finance*, Vol. 36 No. 12, pp. 3197-3212.

Laeven, M.L. and Valencia, F. (2010), "Resolution of banking crises: the good, the bad, and the ugly", *Number 10-146. International Monetary Fund.*

Larosière, J., Balcerowicz, L., Issing, O., Masera, R., Mc Carthy, C., Nyberg, L., Pérez, J. and Ruding, O. (2009), *Report of the High-Level Group on Financial Supervision in the EU*, European Commission, Brussels, pp. 1-78.

Martin, Č. and Schaeck, K. (2007), "How well do aggregate bank ratios identify banking problems?"

Martinez Peria, M.S. and Schmukler, S.L. (2001), "Do depositors punish banks for bad behavior? Market discipline, deposit insurance, and banking crises", *The Journal of Finance*, Vol. 56 No. 3, pp. 1029-1051.

Nier, E. and Baumann, U. (2006), "Market discipline, disclosure and moral hazard in banking", *Journal of Financial Intermediation*, Vol. 15 No. 3, pp. 332-361.

Nieto, M. (2012), *What Role, If Any, Can Market Discipline Play in Supporting Macroprudential Policy*, Documentos Ocasionales Banco de España, pp. 1-24.

Poghosyan, T. and Čihak, M. (2011), "Determinants of bank distress in Europe: evidence from a new data set", *Journal of Financial Services Research*, Vol. 40 No. 3, pp. 163-184.

Porath, D. (2004), "Estimating probabilities of default for German savings banks and credit cooperatives", *Deutsche Bundesbank Discussion Papers*, pp. 1-438.

Rajan, R.G. and Zingales, L. (1995), "What do we know about capital structure? Some evidence from international data", *The Journal of Finance*, Vol. 50 No. 5, pp. 1421-1460.

Regulation(EU)575 (2013), "Regulation (EU) no 575/2013 of the European Parliament and of the Council of 26 June 2013".

Santos, J.A. (2001), "Bank Capital regulation in contemporary banking theory: a review of the literature", *Financial Markets, Institutions and Instruments*, Vol. 10 No. 2, pp. 41-84.

Sarlin, P. and Peltonen, T.A. (2013), "Mapping the state of financial stability", *Journal of International Financial Markets, Institutions and Money*, Vol. 26, pp. 46-76.

Sironi, A. (2003), "Testing for market discipline in the European banking industry: evidence from subordinated debt issues", *Journal of Money, Credit and Banking*, Vol. 35 No. 3, pp. 443-472.

Vazquez, F. and Federico, P. (2015), "Bank funding structures and risk: evidence from the global financial crisis", *Journal of Banking and Finance*, Vol. 61, pp. 1-14.

Whalen, G. (1991), "A proportional hazards model of bank failure: an examination of its usefulness as an early warning tool", *Economic Review-Federal Reserve Bank of Cleveland*, Vol. 27 No. 1, p. 21.

Corresponding author
Vitor Branco Oliveira can be contacted at: vmboliveira@gmail.com