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Systemic Risk in Europe: A bank-level evaluation of the implications of financial interconnections, public bailouts, and corporate governance mechanisms in the aftermath of the financial crisis.

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Abstract of the Ph.D. dissertation

The global crisis produced negative externalities both for the financial services industry and for the real economy by contributing to enhancing the debate on the systemic risk. In fact, in response to the banking crises, regulatory agencies encouraged more efforts to monitor, analyse and understand systemically important financial institutions to better identify the determinants of the bank's contribution to the overall systemic risk. Furthermore, public authorities launched banks' rescue programs to contain the systemic risk, ensure the solvency of financial institutions, and restore the confidence in financial markets. For instance, the US governments launched TARP in the October 2008. A few months later, the British government announced a public intervention of 740 billion euros to insure bank's assets. Finally, de Larosière Group (2009) and Basel Committee on Banking Supervision (2010) revealed deficiencies in the bank's corporate governance by identifying a strong link with risk-taking and systemic risk. (Ellis et al., 2014).

The aim of this dissertation is to investigate the potential sources of systemic risk by analysing respectively: i) financial interdependencies among banks: quantifying network effects and the stress at which banks are exposed (Battiston et al., 2012) during banking crises by bridging the banking literature with the social network literature; ii) public bailouts: understanding whether safety-nets may create (or mitigate) systemic effects (Acharya and Yorulmazer, 2007) intended as fuelling (or smoothing) bank moral hazards of rescued banks and the possible introduction of competitive distortions in the banking system; iii) corporate governance: investigating the link between bank's board diversity and bank's risk.

Paper 1 analyses both the cohesion evolution of the European banking sector during the pre-crisis and post-crisis period and whether network effects, measured in terms of bank's centrality, may help to predict substantial changes in the level of bank's contribution to systemic risk.

Paper 2 explores the systemic effects of public bailouts by analysing both the effects on rescued banks' activities and the competitive effects of such public policies on rescued banks' competitors. Furthermore, the paper also investigate on the evaluation effects of these policies in short-term period by using the event-study approach.

Paper 3 investigates whether corporate governance mechanisms may impinge on the bank's risk-taking, with a particular focus on the board diversity

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Background of the PhD thesis: An introduction to systemic risk, aims, and contributions of the dissertation to the banking literature

1. Introduction

The global crisis produced negative externalities both for the financial services industry and for the real economy by contributing to enhancing the debate on the systemic risk. Particularly, the theme has raised a renewed attention among policymakers, scholars, and practitioners on three different traits related to: i) the prediction of the systemic risk; ii) the evaluation of the optimal safety-net for the financial stability; iii) the functioning of the bank's corporate governance.

The motivations are related to three specific issues. First, in response to the banking crisis, regulatory agencies encouraged more efforts to monitor, analyse, and understand systemically important financial institutions to better identify the determinants of the bank's contribution to the overall systemic risk. Second, public authorities launched banks' rescue programs to contain the systemic risk, ensure the solvency of financial institutions, and restore the confidence in financial markets. For instance, the US governments launched TARP in the October 2008. A few months later, the British government announced a public intervention of 740 billion euros to insure bank's assets. Third, de Larosière Group (2009) and Basel Committee on Banking Supervision (2010) revealed deficiencies in the bank's corporate governance by identifying a strong link bank corporate governance, risk-taking, and systemic risk. (Ellis et al., 2014).

Hence, this dissertation aims to investigate the potential sources of systemic risk by analysing respectively: i) financial interdependencies among banks; ii) public bailouts; and iii) bank's corporate governance mechanisms with a particular focus on the board diversity.

The rest of this introductory chapter is organized as follows. In Section 2, I describe the theme of the systemic risk by clarifying the concept of systemic events and the related definitions of systemic risk across different perspectives. Then, in Section 3 I highlight why I focus on the systemic risk in

banking rather than in other sectors (financials and non-financials). Section 4 reports the state-of-art on the causes of systemic risk by distinguishing between theoretical and empirical papers in banking. In Section 5, I discuss the aims, the motivations, and the contributions to the literature of the following dissertation. Finally, I explain why I stress the European banking sector as the context of the analyses in Section 6.

2. Systemic events and systemic risk

During the last years, the consciousness and the importance of preventing systemic events in the financial system are increasing by rising the attention of policymakers, supervisory agencies, practitioners, and scholars. Even though the concept is common in the economics literatures, it seems to be better described by an epidemic disease, whose effects and transmission mechanisms affect a significant part of economic actors (De Bandt and Hartmann, 2000).

Before providing any definition of the systemic risk, I first clarify in advance the concept of systemic event and its related characteristics. Systemic event is any event triggers a loss of confidence in the financial system, so that it determines adverse consequences for the real economy (Hendricks, 2009). Past studies usually distinguish between systemic event in the narrow sense and the systemic event in broad sense (De Bandt and Hartmann, 2000). On the one hand, a narrow systemic event consists in a situation where the release of bad news about a financial institution or its failure leads to a trend of adverse effects on other institutions and on financial market as whole. In turn, systemic events in the narrow sense may be strong or weak in relation to institutions involved experience situations than are less intrusive than a crash. On the other hand, broad systemic event consists in a systematic shock may lead to simultaneous negative effects on a large part of financial institutions or markets. Systemic events related to systematic shocks are either strong or weak in relation to the fact that most part of financial institutions in the financial market crash or not. The core apprehension associated to systemic events lies in the possibility of prejudging irremediably working foundations of financial markets, such as their effectiveness and efficiency. Moreover, any systemic event may

also produce negative externalities, whose effect could propagate above and beyond financial markets by paralyzing the real sector.

After having clarified basic concepts, it is possible to provide a first definition of systemic risk, namely the risk of experiencing systemic events in strong sense, whose operating scope may be either national or international (De Bandt and Hartmann, 2000). This definition encloses two key elements - *shock* and *propagation mechanism*. According to the prominent financial literature, shocks may be both idiosyncratic and systematic. On one hand, idiosyncratic shocks affect only the wealth of a single financial institution or, at least, the price of a single asset. One the other hand, systematic shocks refer to generalized business cycle fluctuations or sudden increases in interest rates. The second key element event is about how the transmission mechanism operates. It may operate through either bad information or impaired financial exposures. In the last three decades, international banking authorities, practitioners and scholars have tried to identify other alternative definitions (Giesecke Kim, 2011). Among others, different definitions provided by scholars converge to three broad-spectrum issues:

- Probability of idiosyncratic events experienced by a single operator may interrupt the functioning of the banking system and the financial system (Kaufman and Scott, 2003).
- Potential default of an operator provokes other banks' defaults in financial markets. This definition is related to the concept of contagion. (BIS, 1994)
- Generalized loss of confidence or loss of value for operators in the financial markets, so that the uncertainty threatens both the functionality of markets and the real economy.

All the definitions outline that the systemic risk materializes itself through the transmission of financial stresses from an institution to others.

In the following paragraph, I explain why banks are more likely to trigger systemic events in comparison with non-financial firms and other financial firms.

3. Why systemic risk in banking?

Banks are more likely to threaten the financial stability and pose systemic issues than non-financial firms and other financial firms. By and large, this issue seems also to be confirmed by government approach in facing non-financial firms' distresses. In fact, the failure of non-financial firms is not generally considered as posing systemic risk (Stern and Feldman, 2004). These authors argue that government interventions to support non-financial companies is often driven by the intent of protecting their banking creditors (Wildasin, 1997; Rodden, 2000b). For instance, the Korean government bail Hanbo Steel to prevent the failures of its creditor banks. Similarly, the Japanese government supported the real state in market to preclude any potential spillover effect for banks having more exposures in real estate assets (Gup, 1998).

I do not discuss that non-financial firms are not important, whilst I do want to outline that banks may create risks to the financial stability and negative externalities to real economy more than other players of the economic system. This explain why government worldwide rushed to prop up illiquid banks in response to the last financial crisis. Beyond these considerations, bank may threat the financial stability mainly because of their exclusive traits. Indeed, banks differ in many aspects from both non-financial firms and other financial institutions. Firstly, banks activities are based on the liquidity-producing function (Diamond and Dybvig, 1983), representing the most traditional explanation on why banks may trigger systemic events. Particularly, banks make use of an innate use of the leverage since they are willing to accept a maturity mismatch between assets and liabilities in return for a premium given by the difference between the interest rate on the lending activities and the interest rate on the deposits. As a result, the existence of banks is crucially reliant on the access to liquidity for banks available in different forms (e.g. deposits, funding on the interbank market, funding from public authorities). This justifies why during the last financial crisis and when the liquidity dried up in the bank sector, different authorities intervened to preclude generalized collapse.

Secondly, bank's balance sheets are characterized by a higher level of opacity by impeding a clear assessment of the bank's real soundness. For instance, Morgan (2000) observe that bank are similar to black boxes since "*money goes in, and money goes out, but the risks taken in the process of intermediation are hard to observe from outside"*. Furthermore, the quality of loans and the same financial products are not immediately perceivable given their intangible nature.

Thirdly, banks' risks do not depend only on exposures listed in their balance sheets. In fact, banks are heavily involved in off-balance activities that contribute in changing their risk profile even if they do not take further positions (Mayordomo et al., 2014).

Fourthly, banks are deeply different from other financial institutions. First, most part of banks' business is related to the activities with other banks (e.g. activities on the interbank market, foreign exchange market). This explain why the collapse of a single bank spread to others, since competitors are important business partners posing counterparty risks. Second, the liquidity risk is less effective in insurance companies because of the inverted revenues stream of their activities (Mülhnickel and Weiβ, 2009). In fact, they rely on long-term liabilities, so that they are able to decrease their exposures to liquidity risk. Furthermore, they are less interconnected than banks. It entails a lower probability of contagion among insurers (Bell and Keller, 2009). In this respect, Mülhnickel and Weiβ (2009) show that insurers may determine systemic risk only in a particular situation: when insurers start carrying out non-core activities and are more similar to banks. This perspective seems to be supported by Geneva Association (2010) and International Association of Insurance Supervisors (2012), measuring insurers' systemic importance in relation with level of diversification in non-insurance activities.

However, the 2007 financial crisis have underlined a new specific trait about why banks may threaten more the financial stability than other financial institutions. Acharya et al. (2013) observe that banks may also determine a detrimental transfer of uncertainty to their home-governments. This problem is even more severe when banks are larger. For this reason, regulators started paying

attention on particular financial institutions – *Systemically Important Financial Institutions* (SIFIs) - whose collapse could endanger both the financial stability and the real economy because of their level of entangledness in the banking system. The problem of entangledness is crucial since it could determine both shocks transmission and ineffectiveness of the macro-prudential policies. To counterbalance potential threats for the financial stability, supervisory agencies worldwide introduced a new set of additional regulatory rules aimed at improving the banking sector's ability to absorb shocks, to improve risk management and governance, to strengthen and promote banks' transparency and disclosures both at bank-level and at system-level, and to restore the *level playing field* in the banking industry (e.g. additional capital buffers and issuance of bail-in-debt). Additionally, larger banks benefit from implicit guarantees (e.g. government bailouts in case of bank distress) that smaller banks do not. In fact, Basel III required the introduction of additional capital requirements to bush their opportunity costs and reduce governments' activities over the banking industry.

4. Causes of systemic risk

In this paragraph I will discuss the determinants of systemic risk in banking. For this purpose, I will focus on theoretical models and empirical studies. Firstly, I will analyse macroeconomic and microeconomic models. Secondly, I will focus on the empirical literature.

4.1. Theoretical models on systemic risk

Although the recent historical events raised the attention of policy makers, supervisory agencies and scholars on systemic risk, its importance has always been recognized. The early studies relate the systemic risk either to liquidity problems due to their deposits (*bank runs*) or to the mismatch between short-term liabilities and long-term investments (*maturity transformation function*).

This section is organized as follows. Firstly, I introduce the bank runs theory since it represents the precursors of more contemporary studies. Secondly, I discuss the emerging field of research

represented by the network theory (Babus, 2007). Last but not least, I analyse all those studies related on the evaluation of aggregate shocks. Finally, I move onto the moral hazard theory.

4.1.1 Bank run-*based models*

This stream of research finds its logical premise in the seminal paper of Diamond and Dybvig (1983). According with the aforementioned study, *bank runs* represent random phenomena usually triggered by bank depositors when they experience a sudden liquidity shock (Diamond and Dybvig, 1983). Furthermore, the banking literature also recognizes that bank-runs are not random phenomena led by depositors' liquidity shock, but might be driven by the fact that they might receive imperfect information about risky investments of banks or negative performance of bank's assets (Chari and Jaghanathan, 1988). Jacklin and Bhattacharya (1998) show that depositors may also behave compulsory by herding among each other and enact a generalized bank-run. Waldo (1985) shows that when these events occur, they create an adverse effect on bank stability since it induces it to fire sale by determining both a reduction in asset prices and an increase in interest rates.

Other scholars extended these seminal papers to allow for the fact that *bank-runs* cannot be considered in a stand-alone basis, since they may create a spillover effect - a cross-country effect and a cross-entity effect. On the one hand, Garber and Grilli (1989), extending the Waldo's model and assuming a two-countries setting, demonstrate that bank activity in a given country may lead to fire sales of long-term securities and increase the interest rates in the other country. On the other hand, Rochet and Tirole (1996) show that the probability of default of one bank is a direct function of the liquidity shock hitting the other bank.

Allen and Gale (2000) put at centre of their analysis the physical exposures among banks in different regions. They find that bank failures in the economy depend on the level of the liquidity of the banks in the other region and on the number of banks are affected by the deposits withdrawal of a given bank. Along the same lines, Flannery (1996) stress better the contagion idea by showing that it operates by means of interbank linkages. In his framework, banks receive imperfect signals on the

quality of their borrowers and, thus, they may not discriminate between bad and good counterparts in the interbank market. As a result, if an adverse event occurs (or negative shock), healthy banks might not satisfy their obligations and experience larger losses due to temporary increase in the interest rates.

4.1.2 Network theory in banking

Allen and Gale (2000) and Flannery (1996) prelude the development of banking network theory, mainly based on the concept of interconnections among financial institutions (De Bandt and Hartmann, 2000).

The theoretical literature provides two alternative explanations on the possible implications of banking network on bank risk-taking and financial stability. For instance, Leitner (2005) develop a model based on the assumption that bank returns rely on the investments of other banks with which the bank is connected with and analyses the trade-off between risk-sharing and contagion risk. In this setting, the structure of the network has an important advantage because it might prevent bank defaults and contagion. Furthermore, analysing the network formation in the interbank market, Babus (2007) outlines that bank interconnections might strengthen the overall financial stability to detriment of bank's risk. In fact, more-interconnected network in the interbank mark could be more resilient to contagion by lowering its risk. In her framework, financial institutions have incentives to behave in order to reach the optimal level of safety.

Conversely, Zawadowski (2013) points out that network structure may transmit crisis. This stance could justify the activities of central banks (or government) as a lender of last resort in the banking system. Similarly, Haldane and May (2011) stress that network formation increase the level of complexity in the banking system to detriment of the financial stability. Hence, financial interconnections might be related to higher level of systemic risk. Additionally, this relation might not be necessarily monotonic, because it is function of the general wealth of the banking system and the nature of the links among banks (De Bandt and Hartmann, 2000).

4.1.3 Macroeconomic conditions

This strand of literature stresses mainly the relation between bank fundamentals and macroeconomic shocks. This strand is strongly related to the seminal papers of Jacklin and Bhattacharya (1998) and Chari and Jaghanatan (1988). The assumption is that news about possible economic downturns could transmit negative signals about bank's loans to all depositors. For instance, Hellwing (1998) points out that the non-contingent nature of bank deposit contracts represents an important source of the bank's vulnerability to systematic shocks. Indeed, in case of an adverse macroeconomic shock bank deposits represent an element of rigidity for banks because they have a fixed nature unrelated to bank's returns. In this contest, Chen (1999) points out that a negative macroeconomic shock may especially increase the probability of contagion and by endangering the conditions of the banking system creating negative feedback loops between the wealth of the banking system and macroeconomic conditions.

Furthermore, macroeconomic conditions may also create incentives for banks to expand their activities (e.g. low interest rates) and induce managers to pursue risky lending strategies (so-called *moral hazard problem*) by increasing the financial instability (Banerjee, 1992; De Bandt and Hartmann, 2000). The moral hazard is intrinsic part of the bank activities because of their reliance on the use of the leverage for the financial intermediation (Dewatripoint and Tirole, 1994). In fact, in response of generalized distresses in the economy, central banks may find optimal to intervene on the banking sector to restore the confidence and the stability. Among others, Diamond and Rajan (2005) show that expansive monetary interventions may produce two effects. On the one hand, they may encourage banks to continue investing in riskier projects because of lower interest rates. This issue is confirmed in Adrian and Shin (2010). In fact, the authors find that lower interest rates spur banks to increase their risk-appetite due a greater tightness of the balance sheets. In turn, this situation

encourages uncontrolled credit booms.[1] On the other hand, expansive monetary interventions may encourage banks to loosen monitoring efforts on the borrowers because of increased liquidity in the interbank market (Dell'Ariccia et al., 2006).

4.2 Empirical studies on systemic risk

4.2.1 Empirical studies on systemic risk before 2007-financial crisis

The recent financial crisis is only one of a series of systemic events in the history (e.g. Great Depression, Asian Crisis, and Nordic Crisis). In the empirical literature, majority of studies associates systemic risk to macroeconomic conditions ignoring that banks may endogenously trigger systemic risks. Particularly, previous studies detect that macroeconomic fluctuations may pose systemic risk. On the one hand, Gorton (1988) analyses the US banking sector during the National Banking Era by finding out panics are not random phenomena as in Diamond and Dybvig (1983), but normal reactions of depositors to cyclical downturns. Gonzalez- Hermosillo et al. (1997) show that market and liquidity position of the banking sector help to explain bank distresses during different episodes in the USA. Calomiris and Mason (2000), using data on US banks during the period from January 1930 to March 1933, show that as well as macroeconomic fundamentals bank-specific variables play a role for bank survival odds. As well as the strong impact of macroeconomic conditions, Demirgüç-Kunt and Detragiache (1998) investigating the determinants of a large number of banking crises occurred in 45 countries during the period from 1980 to 1994 find that the existence of explicit deposit insurance scheme and some law may play a central role in threating the financial stability and posing systemic risk.

The empirical literature also investigated the release of relevant information on banks and on economy as a potential source of systemic risk. In finance literature, the common method to evaluate

[1] I assume a definition of credit boom in line with De Bandt and Hartmann (2000) referring to a situation where banks herd among each other, exploit low interest rates in the economy, and experience troubles simultaneously whey they reach a certain turning point of the cycle.

spillover effects of particular information is the event study method, based on the standard capital market equilibrium model (CAPM). For instance, Aharony and Swary (1983) analyse the effect of three bank failures on other financial institutions in the United States before 1980: National Bank of San Diego (1973), Franklin National Bank of New York (1974), and Hamilton National Bank of Chattanooga (1976). They find that the failures of the aforementioned banks caused significant abnormal returns for other entities (especially, small and medium bank). Wall and Peterson (1990) find that negative stock prices responses can also generated by bad news. The literature also stresses the fact that there are also other kind reactions to the release of bad news. For instance, Calomiris and Mason (1997) find that analysing the 1932 Chicago Crash during the Great Depression, they find statistically significant deposit withdrawals from banks during their period of investigation. Additionally, they also find that contagious withdrawals also led to other failures.

Overall, the previous empirical literature considers as main causes of systemic: risk the release of bad news, the reaction of depositors to economic downturns, and macroeconomic conditions. Whereas, there is only some evidence (Calomiris and Mason, 2000) indicating that banks' fundamentals can cause systemic risks to the banking sector.

4.2.2. Evidences on systemic risk in the post-crisis period

The 2007-2008 Financial Crisis has raised new attention on the debate about the systemic risk and its determinants. More recent studies report both internal factors (Demirgüç-Kunt and Huizinga, 2013; Pais and Stork, 2013; Jorion, 2009; Acharya and Thakor, 2016; Brunnermeier et al., 2012; Pais and Stork, 2013; Mayordomo et. al, 2014) and external factors (e.g. institutional and macroeconomic factors) (Anginer et al. 2013) explain the level of systemic risk in the banking system.

In this context, the main explanation of systemic risk is the bank's size (Jorion, 2009). The idea lies in the special status of large banks and in their possible effects in terms of spillovers over their counterparties. Elyasiani et al. (2007) measure systemic risk and potential spillover effects of large

versus small banks by estimating the changes in the level and volatility of the stock returns. They find larger institutions have higher volatility than smaller ones.

The larger bank's size is often associated with an aggressive use of the leverage (Stern and Feldman, 2004; Acharya and Thakor, 2016). Penas and Unal (2004), analysing M&A operations, find that mergers among banks have a positive effect on bond returns if the resulting bank becomes larger. The reason lies in the fact that bondholders profit from both the potential implicit guarantees in bank's size that reduces the likelihood of default. In principle, leverage should impose market-discipline on banks (Calomiris and Kahn, 1991; Dewatripont and Tirole, 1994; Diamond and Rajan, 2000; Acharya and Viswanathan, 2011). In contrast, the managers and the creditors of these institutions can take advantage of the bank's size maximising leverage aggressively in the expectations of achieving higher returns (Adrian and Shin, 2010). In particular, some scholars show that banks exploit mainly the short-term leverage (Adrian and Shin, 2010; Mian and Sufi, 2010; Shleifer and Vishny, 2010; Acharya and Thakor, 2016; Acharya et al., 2013; Goel et al., 2014). It increases both the bank's risk-taking and market fragility in view of any possible liquidity shock (Balasubramanian and Cyree, 2011).

DeFerrari and Palmer (2001) show that the reference to the term *large* should be studied in relation to the bank's involvement in different activities, such as activities in derivatives market, trading activities and the geographic extent of operations. In line with this argument, De Jonghe (2010) finds as well as bank size (the main driver of banks' tail betas, using the Extreme Value Theory) the level of diversification may increase large banks' systemic risk. Brunnermeier et al. (2012) stress more deeply the linkage between diversification strategies and banks' systemic risk, by documenting that banks with higher non-interest income have a higher level of systemic risk than traditional banks, whose activity is based only on deposit-taking and lending.

Developments in the financial innovation encouraged new financial products including a wide range of structured derivatives (Stulz, 2010). In fact, during the last years, there has been an extensive

intra-system activities on the derivatives markets for hedging purposes (Calmès and Théoret, 2010). Many large banks play significant roles in the construction, sale, and trading of these products. A higher degree of participation in these markets makes banks more prone to threaten the financial stability, even if each class of derivatives (credit derivatives, interest rate derivatives, foreign exchange derivatives equity derivatives) has a different impact on bank's systemic risk. Mayordomo et al. (2014) find that banks' holdings of credit and foreign exchange derivatives have an increasing effect on systemic risk, while holdings of interest rate derivatives have a decreasing effect.

After the beginning of the financial crisis, much attention was devoted to bank's executive compensation to detriment of corporate governance (Bebchuck, 2007; Falenbrach and Stulz, 2010; Beltratti), namely the set of internal and external mechanisms ensuring that decisions (e.g. definition of objectives and actions) at different levels of bank's organisation are taken in favour of its shareholders (Zingales, 2010). Whilst, there is no a general consensus in the literature on the effect of executive compensations on bank's risk and how they affected the last financial turmoil. On the one hand, some scholars support the view that executive compensation formulas may have spur managers to undertake riskier investments to detriment of shareholders (Bebchuck et al., 2011). On the other hand, others argue that shareholders might use executive compensations as a means for inducing top managers/executives to accept higher levels of riskiness (Beltratti and Stulz, 2010).

Systemic risk posed by banks may be either worsened or reduced by countries' institutional factors. Anginer et al. (2013) study the relation among the institutional factors, the regulatory environment and the level of competition in a particular country and bank's systemic risk by attaining two important results. Firstly, they show that when financial systems become more competitive, the bank's contribution to the overall systemic risk tends to decrease, especially in those countries with strong investors' protection and less generous safety-net mechanisms. Secondly, bank's systemic risk is higher in countries with weak supervision and private monitoring, greater government ownership of banks, and public policies that restrict competition. It suggests that mechanisms that reduce the

market power of large banks are associated with higher financial stability.

5. Aims of the thesis, motivations, and contributions

The following PhD dissertation include a collection of three studies:

1. Bank's centrality in the European banking market and systemic risk
2. Public bailouts, bank's risk, and spillover effects: the case of European banks
3. Government interventions and gender diversity in bank's boards in Europe.

More specifically, the aim of this dissertation is to investigate the potential sources of systemic risk by analysing respectively: i) financial interdependencies among banks, ii) public bailouts, and iii) corporate governance mechanisms with a particular focus on gender diversity in the bank boards.

First, although the last financial crisis has shown the intertwined nature of the banking system, none of studies, mentioned in Section 6, take fully into account the financial dependencies among credit institutions to explain bank's contribution to systemic risk. On the one hand, previous studies show that bank's size (O'Hara and Shaw, 1990; Boyd and Gerler, 1993; Demsetz and Strahan, 1997; Kane, 2000; Penas and Unal, 2004; Ennis and Malek, 2005; Demirgüç-Kunt and Huizinga, 2013; Pais and Stork, 2013; Jorion, 2009), the financial leverage (Acharya and Thakor, 2016), the extent of diversification activities (Brunnermeier et al., 2012), the holdings of financial derivatives (Mayordomo et. al, 2014), and other external factors (Anginer et al. 2013) may affect the level of systemic risk of larger banks. On the other hand, network studies in banking analysed the problem of bank's interconnectedness by using, for instance, co-movements between asset returns to generate the network structure in a particular market (Adrian and Brunnermeier, 2009). Both literatures offer different possibilities of research because the banking literature usually analyses the behaviour of banks with little focus on how banks are related to other institutions, while the literature on network formation is focused on linkages making up the overall network (Mistrulli, 2010; Craig and Von Peter, 2014, Pecora and Spelta, 2015). In contrast with Adrian and Brunnermeier (2009), I bridge the

banking literature to the social network literature. Thus, the aim of this study is to understand how topological properties of large banks may predict bank's contribution to the systemic risk. To our knowledge, this is the first study aimed at testing how measures of centrality, quantifying network effects due to financial interactions among banks predict the bank's contribution to systemic risk. This allows for enlarging the understanding of the large and complex financial institutions and the risk posed by their financial dependencies and explaining why some larger banks are riskier than other bank of comparable size. Therefore, quantifying network effects is crucial to potentially identify the stress at which banks are exposed (Battiston et al., 2012) during banking crises.

Second, Anginer et al. (2013) show that as well as bank-specific variables institutional factors and macroeconomic factors may influence the level of systemic risk in the banking sector. Among their results, they find that bank's contribution to systemic risk is higher in those countries characterised by greater government ownership of banks and strong public policies restricting the competition. Furthermore, in their study, they focus mainly on the national deposit insurance characteristics without taking into account, for instance, specific public policies undertaken by national governments during banking crises. Indeed, in response to the 2007-08 financial crisis authorities and governments worldwide launched rescue measures for their national banks by acquiring large stakes in banks with the aim of restoring the financial stability and reducing spillover effects to the real economy. Besides these considerations, an emerging body of literature posits that public bailouts may create economic distortions in the banking sector (Hakenes and Schnabl, 2010; Gropp et al., 2011; Dam and Koetter, 2012) by raising the fundamental question "bail or not to bail out banks". Dam and Koetter (2012) find that a change of bailout expectations increases the probability of bank default. This is in line with the Merton's argument (1977) that is the presence of these arrangements may encourage banks to take additional risk in order to maximise the value of the put-option value on the insurance corporation's funds. Additionally, Gropp et al. (2011) argues that the effects of public bailouts might not exhaust their effects on the protected banks but also to their competitors. In fact, Hakenes and Schnabel (2010) observe that the possibility of future bailouts

increases the bank's risk of *protected banks'* competitors because these policies create incentives for protected banks to expand by depressing the competitors' margins due to a higher level of rivalry in the deposit market. This distortion is even more severe in presence of generalized distresses in the banking industry (Acharya and Yorulmazer, 2007). By now, there is currently no evidence in the literature on whether these policies undertaken by national government restore the financial stability or smooth the systemic risk in the banking sector by reducing *moral hazard problem*. In addition, there is no other study investigating on the impact of such policies in Europe on banks during the whole crisis period. Furthermore, the majority of previous studies focus mainly on the rescued banks neglecting possible spillover effects on the rescued banks' competitors. Thus, this is the first paper aiming to provide a comprehensive evidence of the effects of public bailouts on bank conduct in Europe (15 countries) during the whole crisis period by considering both the direct effect on rescued banks and the spillover effects on banks' competitors. Then, we also document that European investors do not welcome the introduction of such policies in the banking system. The resulting evidences also contribute to timely debate on optimal safety-net.

Finally, as a further source of systemic risk investigated, I focus on the corporate governance mechanisms with particular focus on gender diversity in bank boards. After the beginning of the crisis, many publications dealing with the causes of the financial crisis do not even take into account the corporate governance of the banks, with the only exception of remuneration schemes. Majority of studies conclude that heavily-incentivised and short-term oriented executive compensation schemes were the major causes of the last financial crisis (Beltratti and Stulz, 2010; Falenbrach and Stulz, 2010). Conversely, de Larosière Group (2009) observed that poor corporate governance mechanisms of the banks played a central role in the financial crisis, without any reference to executive compensations. Similarly, the Basel Committee on banking supervision paid attention on the need of enhancing the corporate governance of the banks because a better corporate governance improves the efficiency of monitoring by representing the foundation for a sound financial system (Principles for Enhancing Corporate Governance, BCBS, 2010). Surprisingly, recent studies do not

postulate any support for the hypothesis of the corporate governance failures in banks. For instance, Beltratti and Stulz (2010) do not find any evidence that banks with better governance (measured as Corporate Governance Quotient) over-performed during the crisis. Whilst, they also find that more shareholder-friendly boards experience poor performance during the crisis. Erkens et al. (2012), focusing on the board composition, find that financial institution with more independent directors experience a worse performance of stock returns during the crisis. Among board characteristics, gender diversity in bank boards has become one of the major issues in the corporate governance literature. However, the academic research has yet to reach a general consensus on the relation among board diversity, bank performance, and risk. Furthermore, little is known whether all laws and other policies aiming at enhancing bank governance are effective for the sake of the financial stability (Caprio et al., 2007).

6. The EU-banking sector as context of analysis

In this dissertation, I focus on the European banking market because it represents an important field of investigation for several reasons.

First, the EU-banking market is *bank-based* system, since banks play a central role for the credit allocation favouring both the mobilization of savings and the monitoring on investments. This is in a sharp contrast with a market-based market, such as US banking market, where financial markets carry out the credit allocation.

Second, in contrast with other markets, the European bank system is characterised by that majority of bank activities are run by *Systemically Important Financial Institutions* (SIFIs). In fact, they represent the 65% of the whole banking sector. In contrast, the American system is historically widely-fragmented and characterised by a large quantity of small credit institutions.

Third, supervisory agencies pursue their stability objectives to enhance the stability of the financial sector in different ways. For instance, in case of bank's default, EU-supervisors might tolerate the

possibility that an ailing bank may operates even if it does not comply with the minimum regulatory capital required in order to spread bank panics. Conversely, in the US context, authorities may intervene through Prompt Corrective Actions (PCAs) in the case in which the failing bank does meet the capital requirements. Additionally, the FIDC may also dispose the closure and a possible takeover.

Fourth, both systems handled with the last financial crisis in different ways. In Europe, national governments are supposed to define the local schemes for the ailing banks. Once defined, the European commission approves the rescue package based on the premise to not distort the *level-playing-field*. In the USA, the banks submitted their needs of funding on the US Treasury. In turn, the latter decided on the approval on the bank's requests. In addition, the Central banks could also intervene on the banks directly. This feature is not provided for the EU regulations

Fifth, the central banking activities are run differently. The FED accomplishes its aims independently in regards of the monetary policy. By contrast, European Central Bank (ECB) refinances credit institutions only through liquidity extensions. Alternatively, it may operate on the corridor of the standing facilities (as in 2009).

Sixth, the 2007-2008 financial crisis raised new challenges for the European Union and determined new institutional settings. In fact, the EU-institutions agreed to establish the creation of the Banking Union, based on the *Single Supervisory Mechanism*,[2] a *Single Resolution Mechanism*[3] for banks, and a common *European Deposit Insurance Guarantee.*[4]

[2] The Single Supervisory Mechanism (SSM) places the European Central Bank as the central prudential supervisors of financial institution in the Euro Area. According to the SSM, the European Central Bank monitors directly the largest banks, while the national supervisors continue to monitor the smaller ones. The aim is to tackle problems early on.
[3] The Single Resolution Mechanism (SRM) applies to banks under the SSM. In case of bank's failure, the mechanism allows bank resolution to be managed through a Single Resolution Board and a Single Resolution Fund, financed by the whole banking sector. The purpose is to ensure an orderly resolution of failing banks in order to reduce the costs for taxpayers and real economy.
[4] The European Deposit Insurance Scheme would apply to deposits below 100.000 euros of all banks in the Euro Area. When a bank is placed to insolvency, the national deposit insurance schemes and EDIS will intervene to protect depositors.

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Paper 1: Bank's centrality in the European banking market and systemic risk

Abstract

The last financial crisis revealed the interconnections among financial institutions might drive the shock propagation and amplification throughout the banking system. In this paper, we analyse the cohesion evolution of the European banking market during the whole crisis and investigate whether topological properties of banks in the European network predict changes in the bank's contribution to systemic risk. First, we find that that the EU-banking sector become more interconnected during the European sovereign debt crisis than during the US-mortgage crisis. Second, we find that the bank's network measures help to predict substantial changes in the bank's contribution to systemic risk (at least 3%). Our results are robust to sample selection issues and potential omitted variable bias.

1. Introduction

Do financial interconnections matter? Does the bank's centrality in the European banking market predict changes in the bank's contribution to systemic risk?

In the following paper, we seek to provide some evidence on these timely questions on the role of financial interconnections for the systemic risk. First, since 2008 the last financial turmoil has reminded how crucial it is to acknowledge that the consequences of bank's default may not be considered in stand-alone basis (Battison et al., 2012; Zawadowski, 2013). Financial regulators used to monitor the level of entangledness of the banks with their size: larger balance sheets, stronger spillover effects in case of a possible bank's failure. Second, it is also in line with the timely debate among policymakers and scholars in proposing new frameworks (e.g. early-warning signals) for monitoring the financial stability and understanding the structure and the network dynamics among banks. A network perspective entails that the banking system is a complex network where nodes are the banks and the links are the financial dependencies among each other.

Though recent papers have investigated what are the key contributors of the systemic risk (Brunnermeier et al., 2012; Anginer et al., 2014; Mayordomo et al., 2014; Acharya and Thakor, 2016), to the best of our knowledge, there is currently no evidence about how topological properties of the banks contribute predicting substantial changes in the level of systemic risk.

Our main findings are as follows. After mapping all the interconnections among all listed banks across EU-15 countries, the results indicate that the cohesion evolution of the European banking sector changes continuously over the time span by showing that the level of interconnectedness among banks is higher during the period of the European sovereign crisis (Battiston et al., 2012) than during the period of the US-mortgage crisis period. In fact, during this period, many European banks received state aids from public authorities through rescue package measures (Berger et al., 2016) to counterbalance spillover effects on the banking system. Second, to address whether bank's centrality predicts substantial changes of systemic risk, we use ordered logit models in which we regress the

changes of *SRISK* and the marginal expected shortfall on social network centralities and a set of control variables. We find that bank's network measures help to predict changes in the bank's contribution to systemic risk around at least 3% by reaching the peak of 5% in some specifications. In addition, we also perform several sensitivity tests to assess the robustness of the results. On the one hand, we employ different cut-offs to define what represents a substantial change in the bank's contribution to systemic risk. On the other hand, we run regressions to tackle sample selection and omitted variable issues. In all cases, we obtain results which are qualitatively and quantitatively unaltered to the main findings.

To examine the research questions, we build a unique dataset on the interconnections among all listed banks in the European banking sector during the period from 2005 to 2013. The reason why we focus on the European banking market is twofold. First and foremost, the European banking market is at the centre of important regulatory changes, such as the Banking Union (for instance, the *Single Supervisory Mechanism*,[5] the *Single Resolution Mechanism*[6] for banks, and the common *European Deposit Insurance Guarantee*[7]). Second, analysing European countries permits to cover the European sovereign debt crisis that has shown that the spillover of the 2007-08 crisis produced effect far beyond 2009, as suggested in other papers (among others, Aït Sahalia et al., 2012, Fiordelisi and Ricci, 2016).

However, addressing the research questions of this paper is challenging because information on banks' interactions are often hidden because of the well-known issue of confidentiality constraints. To overcome this problem, we rely on the linear Granger-causality test to generate the economic network in line with Billio et al., (2012) among all the banks across EU-15 countries. Although some

[5] The Single Supervisory Mechanism (SSM) places the European Central Bank as the central prudential supervisors of financial institution in the Euro Area. According to the SSM, the European Central Bank monitors directly the largest banks, while the national supervisors continue to monitor the smaller ones. The aim is to tackle problems early on.
[6] The Single Resolution Mechanism (SRM) applies to banks under the SSM. In case of bank's failure, the mechanism allows bank resolution to be managed through a Single Resolution Board and a Single Resolution Fund, financed by the whole banking sector. The purpose is to ensure an orderly resolution of failing banks in order to reduce the costs for taxpayers and real economy.
[7] The European Deposit Insurance Scheme would apply to deposits below 100.000 euros of all banks in the Euro Area. When a bank is placed to insolvency, the national deposit insurance schemes and EDIS will intervene to protect depositors.

weaknesses related to the aforementioned method, it allows constructing a network by using only partial information, such as the availability of share prices, and evaluating the dynamics of shocks propagation from a bank to others after allowing for the autocorrelation of asset returns (Billio et al., 2012). The main weakness is related to the fact that it is suitable only for those banks which are listed.

The contribution of this paper to the literature is twofold. First and foremost, this paper maps the financial dependencies among banks in the European banking sector by using the Granger-causality test and then analyses whether network-based measures of connectedness predict changes in systemic risk at bank-level. Quantifying network effects is crucial to potentially identify the stress at which banks are exposed and thus bank's contribution to the overall systemic risk (Battiston et al., 2012). In turn, this is also related to the more general issue of financial networks concerning the understanding of the systemically important financial institutions.

Second, we provide novel evidence since we extend Billio et al., (2012) along two dimensions: i) the countries analysed; ii) the time period analysed. On the one hand, we focus on the European banking market covering EU-15 countries. Most studies focus on a specific geographic area (e.g. *US*) with little focus on European banking sector, which has been characterised by several and unprecedented policymakers' interventions in regards to the banking system and higher instability because of the European sovereign debt crisis. On the other hand, we also extend the time period analysed from 2008 to 2013. This extension is essential especially in lights of the last events related to the 2007-financial crisis demonstrating that the turmoil did not culminate in 2009. By including all the years until 2013, we also able to cover the aforementioned European sovereign debt crisis and provide evidence of the shock propagation during the whole financial crisis period.

The rest of the paper is organised as follows. Section 2 provides how this paper is related to the previous literature, highlights the main contribution, and develop the research hypotheses. Section 3 presents the data and describe the main measures used. Section 4 describes the methodology. Section

5 reports the evolution of network dynamics, while Section 6 and Section 7 show our main findings and robustness tests, respectively. Section 8 provides concluding remarks and policy implications.

2. Literature, contributions, and research hypotheses

The 2007-08 financial crisis raised new attention on the debate about the systemic risk. This paper is related to two strands of the literature.

The closest strand of literature that this paper is related to is the emerging body of the determinants of systemic risk. Many papers have investigated bank's characteristics and macroeconomic and institutional factors as the main contributors of the systemic risk. In this context, the main explanation of systemic risk is the bank's size (Jorion, 2009), since large banks in case of default may create spillover effects not only for the banking system but also for the real economy (Elyasiani et al., 2007). Furthermore, larger bank's size is often related to more aggressive use of the leverage. In theory, the leverage should impose market-discipline on banks (Calomiris and Kahn, 1991; Diamond and Rajan, 2000; Acharya and Viswanathan, 2011). In contrast, the managers and the creditors of these institutions can take advantage of size maximising leverage aggressively in the expectations of achieving higher returns (especially short-term leverage (Adrian and Shin, 2010; Mian and Sufi, 2010; Shleifer and Vishny, 2010; Acharya et al., 2013; Acharya and Thakor, 2016). It increases both the bank's risk-taking and market fragility in case of a liquidity shock (Balasubramanian and Cyree, 2011). Besides these arguments, empirical studies have also looked for evidence of financial innovation and the related holding of derivatives (Calmès and Théoret, 2010; Mayordomo et al., 2014), the level of diversification (De Jonghe, 2010; Brunnermeier et al., 2012), the bank's executive compensation schemes (Bebchuck, 2007; Falenbrach and Stulz, 2010; Bebchuck et al., 2011), and the countries' institutional factors (Anginer et al., 2014).

The second strand of the literature that this paper is related to is the fast-growing research on networks in economics and finance. Mainly, the literature has focused either on network effects or network formation (Allen and Babus, 2009). Scholars have used network analysis to investigate the

interbank market and tiering (Freixas et al., 2000; Karlan et al., 2009; Craig and Von Peter, 2014), the investment decisions (Cohen et al., 2008; Hochberg et al., 2007), the IPO characteristics (Bajo et al., 2016), shock propagation dynamics (Billio et al., 2012), and the dependency among bank's portfolios (Lagunoff and Schreft, 2001: de Vries, 2005; Cifuentes et al., 2005). However, although many applications, the literature on financial networks is still scant and at the early stage.

Despite the increased attention to investigating the systemic risk, little research analyses empirically how bank's interconnections predict changes in the bank's contribution to the overall systemic risk defined as the risk of default of considerable number of financial institutions in the banking sector. For this purpose, we bridge the banking literature to social network literature as the banking literature examines the behaviour of banks with little emphasis on how they relate to others, whereas the literature on network formation is more focused on linkages among nodes that make up the network (Craig and Von Peter, 2014). A remarkable exception is a recent paper by Billio et al. (2012), which quantifies interdependences among banks. In their study, they find that financial institutions become more interconnected during their sample period from 1996 to 2008.

However, this paper may be considered either an examination or an extension of the previous literature on the systemic risk. First and foremost, this paper maps the financial dependencies among banks in the European banking sector by using the Granger-causality test and then analyses whether network-based measures of connectedness predict changes in systemic risk at bank-level. Thus, the logical premise is to examine the structure of the European banking sector and its evolution over the period starting from 2005 to 2013. Quantifying network effects is crucial to potentially identify the stress at which banks are exposed and thus bank's contribution to the overall systemic risk (Battiston et al., 2012). In turn, this is also related to the more general issue of financial networks concerning the understanding of the systemically important financial institutions. Indeed, there is some evidence that a specific network position given a certain network structure may be either beneficial or detrimental (Podolny, 1994; Gulati, 1995; Gulati, 1998).

Second, we provide novel evidence since we extend Billio et al., (2012) along two dimensions: i) the countries analysed; ii) the time period analysed. On the one hand, we focus on the European banking market covering EU-15 countries. Most studies focus on a specific geographic area (*US*) with little focus on European banking sector, which has been characterised by several and unprecedented policymakers' interventions in regards to the banking system and higher instability because of the European sovereign debt crisis. On the other hand, we also extend the time period analysed from 2008 to 2013. This extension is essential especially in lights of the last events related to the 2007-financial crisis demonstrating that the turmoil did not culminate in 2009. By including all the years until the 2013, we also able to cover the aforementioned European sovereign debt crisis and provide evidence of the shock propagation during the whole financial crisis period.

In this paper, the primary idea is to understand whether the bank's network centrality may be helpful to predict changes in the bank's contribution to the overall systemic risk. In absence of specific predictions, we borrow some hints from the previous works in anthropology, economics, and sociology focusing on the spreads of infections and epidemics (Bailey, 1975; Morris, 1993), where the crucial characteristic of network processes in these studies is the concept of *centrality* (broadly defined as the relevance of the position of an agent in the network). It is widely-accepted that network connections may produce benefits for agents (Podolny, 1994; Gulati, 1994; Gulati, 1998; Larson, 2011; Acemoglu et al., 2016) both direct and indirect. Conversely, links may also expose banks (or other agents in the financial system) to negative payoff since they may be involved in cascading defaults (Allen and Gale, 2000; Blume et al., 2011; Acemoglu et al., 2016). Billio et al., (2012) suggest that financial companies tend to become more interconnected among each other over the past decade by reaching the peak of connectivity among banks and other financial institutions during the *US-mortgage crisis* period. Furthermore, they find that the increased connectivity is also related to higher level of the centrality of financial institutions. Speculatively, we expect that during periods of generalized bank's distresses, a higher centrality is positively related to changes in the systemic risk. we also expect that not all bank's network centralities predict changes in the systemic risk. In fact,

there is some evidence that institutions suffered more losses during the first part of the recent financial turmoil were those ones that greatly influenced other institutions and not the institutions that were influenced by others (Billio et al., 2012).

3. Methodology

3.1 Building the financial network

To quantify the network effects for each node, we build the financial network. As mentioned, as well as identifying the shock propagation during the waves of crisis this process is auxiliary to define the topological properties of nodes (centrality measures). To construct the network, the underlying idea is that there exists a relation, given two banks *i* and *j* in a specific year, whether the time series of the asset returns of bank *i's* Granger-causes significantly the time series of assets returns of the bank *j's*.

For any given year *t* of the sample period (from 2005 to 2013) we construct the adjacency matrix X_t to compute the centrality measures. Since the aim is to investigate the dynamics of shock propagation and its implications for systemic risk, we also take into account the directionality of the relation. Thus, the adjacency matrix for each year might not be symmetric and, thus, each cell takes the value of one only if the asset returns of bank *j* have predictive power for those of bank *i*. To build the matrices over the sample period, we follow a multi-step procedure. First, we calculate all EU-15 listed banks' assets returns (133 banks). Secondly, we rely on the linear Granger causality method[8] to identify the bank's interconnections (Billio et al., 2012). Although banks' interactions are often hidden because of the well-known practice of the confidentiality, the Granger causality test allows to construct a measure of interconnected based only on partial information (e.g. availability of share prices). As well as to identify the network, the method is particularly suitable because it allows evaluating the dynamics of shocks propagation from a bank to others after adjusting for the

[8] In this framework, given two-time series – *i* and *j* – the time series *i's* granger-causes the time series *j's* if the past values of *i* predict the values of *j* after controlling for the information contained in the past of values of the latter.

autocorrelation of asset returns (Billio et al., 2012). Following this study, we assume that the bank's asset returns follow a generalized autoregressive conditional heteroscedasticity *GARCH* model (1,1)[9] process defined as

$$R_{i,t+1} = \mu_{i,t} + \sigma_{it}\epsilon_{i,t} \quad (1)$$

where $\epsilon_{i,t} \sim WN(0,1)$ and $\sigma_{it} = \omega_i + \alpha_i(R_{i,t-1} - \mu_i)^2 + \beta_i\sigma^2_{it-1_{it}}$

Then, I employ the following mathematical specification[10]

$$R_{i,t+1} = a_i R_{i,t} + b_{ij} R_{j,t} + e_{i,t+1} \quad (2)$$

$$R_{j,t+1} = a_j R_{j,t} + b_{ji} R_{j,t} + e_{i,t+1} \quad (3)$$

where the error terms are two uncorrelated white noise processes, while the other coefficients represent the parameters of interest. Hence, if the coefficient of the equation (2) is statistically different from zero, it means that the time series *j's* granger-causes the time series *i's*. Furthermore, if the b_{ji} is also significant, it entails that as well as time series *i's* affects *j's*, there exists a feedback loop between the two bank's time series of asset-returns. The same procedure is repeated year by year along the sample period, which is from 2005 to 2013. Finally, we evaluate the possible rejection of the Granger-causality test and define an indicator of relation (of *Granger causality*) such that

$$(i \to j) = \begin{cases} \mathbf{1}\ if\ i\ Granger\ causes\ j \\ \mathbf{0}\ otherwise \end{cases}$$

and $(i \to i) \equiv 0$. This step is auxiliary for the construction of the matrices of adjacency among all European banks.

3.2 Regression framework

For this analysis, we model the changes in the systemic risk as different functions of centrality measures and a set of explanatory variables. More specifically, the main analysis makes use of the

[9] Lo (2012), Getmansky et.al. (2004), Billio et al., (2012) suggest that considering the autocorrelation of returns in the specification allows for the liquidity risk of a given bank.
[10] Along the same line of Billio et al. (2012), the *i* and *j* are two stationary time series.

ordered logit model (Ferrer-i-Carbonell and Frijters, 2004), which may be able to predict changes in the bank's contribution to the systemic risk. Additionally, this empirical framework allows avoiding that my results are driven by small changes in the systemic risk. Hence, our regression framework is based on an ordered logit model, where the dependent variable takes either the value of 1 if the bank *i's* experience a decrease in systemic risk, compared to the previous year, of more than 3% (*DROP*) or the value of 2 if the changes in the systemic risk ranges between -3% and 3% (always compared to the previous year) (*CONS*) or the values of 3 if the bank systemic risk increases compared to the previous year by more than 3% (*RISE*). Moreover, in alternative specifications, we also employ different threshold for the change in the bank's risk to exclude that our results are dependent on the cut-off that was previously chosen.

We rely on the following specification for an ordered logit model with three categories modelling the probability of an observation *i's* of the dependent variable in year *t* falling into one of the ranges expressed above:

$$P(Y_{i,t} = 1) = 1 - P(Y_{i,t} > 1); \qquad (4)$$

$$P(Y_{i,t} > k) = \frac{\exp(\alpha_k + \beta X_{i,t})}{1 + \exp(\alpha_k + \beta X_{i,t})} \qquad (5)$$

and k=1, 2

where $X_{i,t}$ is the vector of independent variables for observation *i's* in year t and ß are the coefficients of the variables of our interest and the other explanatory variables. Finally, we cluster standard errors at bank-level to allow for serial correlation within bank. In some robustness checks, we also cluster standard errors at country-level and bank-country-level. Along the same line of Ferrer-i-Carbonell and Frijters (2004), we also account for time and bank fixed effects.

4. Data and Variables

We start from the sample of all EU-15 listed banks available in Datastream (133 banks). Second, we consider all those banks whose data information is also available in Bankscope (100 banks). Third,

to enhance the comparability among the banks in the sample, we focus only on those banks classified as bank holding companies, commercial banks, and cooperative banks and adopting IFRS accounting standards. This criterion is required to avoid that my estimates are driven by national accounting regimes. Fourth, we exclude banks if they have: i) no information on the components of the financial intermediation activities (deposits and loans), ii) no information on regulatory capital ratios iii) total assets less than 1 billion of euros. This latter criterion is applied both during the pre-crisis period and the post-crisis period to avoid any possible bias (Mayordomo et al., 2014). Finally, we also stipulate to remove banks for which I do not have an annual reports to allow the hand-collection of the corporate governance variables. These criteria lead to a final sample composed of yearly information for 61 banks from 2005 to 2013. Although the small size of my sample, the sampled banks represent the 70% of the total assets of the EU-15 banking sector.

As outlined before, we match data from different data sources for the statistical analysis. The data on bank's stock prices are from Datastream. We collect data on bank-specific variables from either V-Stern Lab (systemic risk measures) or Bankscope (balance sheet and other financial ratios). For corporate governance variables, we hand-collect information from annual reports. Finally, the data on macroeconomic and institutional factors are collected from World Bank Database.

4.1 Measures of centrality

To understand whether a bank is central in the EU-banking market, we use various SNA measures. Some scholars have argued that the social network analysis may be of particular interest for understanding the implications of interconnections among banks in lights of the recent financial crisis. According to the network theory, a network is defined as a set of nodes (in this case, banks) and links (namely financial relationships) among. An essential feature of the network structure is the concept of centrality, broadly defined as the relevance of the node in a given network. Billio et al. (2012) suggest that the centrality may provide some insights into which nodes might be considered

systemically important. For this purpose, we use various measures of centrality to investigate the dynamics of shock propagation and understanding the node's contribution to the systemic risk.

We make use of four social network analysis measures. The degree is the simplest centrality measure since it counts the number of bank's interconnections that a financial institution has in the network. In social network analysis, it is considered as measure of prestige due the number of interconnections that an agent (in this case, the bank) has in its environment (Wasserman and Faust, 1994).

The second measures that we consider is the *Closeness*. It is the inverse of the sum of the geodesic distance from actor *i* to all actors (Sabidussi, 1966; Wassermann and Faust, 1994). The underlying idea is to analysed node's centrality by stressing the concept of proximity to all other nodes. The higher the score, the lower the distance separating a node from the others. For instance, in statistical mechanics, this index is interpreted as the expected time until the arrival of something flowing into the network (e.g. shock propagation). A higher value for this variable entails that a lower distance is necessary to reach a given node from others.

The third measure considered here is the *Betweenness*. In contrast with other centrality measures, the latter has another logical premise. It measures the probability with which a node lies on the shortest path between any two unconnected nodes (Freeman et al., 1979, Craig and Von Peter, 2014). It assesses the centrality of any node as the extent to which a bank may operate as a bridge between two unconnected banks (Bajo et al. 2016). Thus, it provides a hint on the control that an individual node may exert on what is flowing across the nodes within the network. Finally, we consider the eigenvector centrality which measures the importance of a bank in the system by associating scores to banks considering how they are connected to the rest of the network (Billio et al., 2012). As underlined in Bajo et al. (2016), more extensive networks are characterised by the fact that more links are in place. As a consequence, it produces higher centrality measures. This represents a minor problem in cross-sectional analysis, while in a panel setting, this might create to a time-bias problem

in the estimates since the network might change in size (some operators may exit from the market of banks) and in composition (higher/lower concentration). The aforementioned problem is particularly severe on extended sample period. For this reason, we normalize all SNA measures.

4.2 Measures of systemic risk

Among the proposed (backward- and forward-looking) measures for the systemic risk in the literature (Bisias et al., 2012), we consider two specific measures for the main results and the robustness tests, respectively SRISK and long-run marginal expected shortfall (*LRMES*).

In comparison with backward-looking measures of systemic risk, *LRMES* and *SRISK* have various benefits. Firstly, both measures are updated frequently, while bank balance sheet information is available only on a quarterly/yearly basis. Secondly, being forward-looking measures, they also reflect stock market information and, thus, market-expectations. Thirdly, they require for the estimation only publicly available data. Both measures estimate the capital shortfall of a bank during a financial crisis based on its stock return volatility and systematic correlation with the market.

The *SRISK* is six-month simulated measures of the bank's contribution to the systemic risk and is defined as the expected capital shortfall of the bank in the case if it experienced another financial crisis, where another financial crisis (Acharya et al., 2012) is defined whenever a broad market index falls around 40% over six months. Higher value of this measure, higher the contribution of the bank in case of crisis. Formally, *SRISK* for the bank *i's* at year *t* is given by the following formula:

$$SRISK_{i,t} = k\big(Debt_{i,t}\big) - (1-k)\big(1 - LRMES_{i,t}\big)Equity_{i,t}$$

where k referring to the capital regulatory requirement in force, while *Debt* and *Equity* are respectively the value of value and Equity. We will discuss more in details the LRMES later.

For these left-tail scenarios, the expected loss of equity value of the bank *i*'s is called long-run marginal expected shortfall (*LRMES*). This measure also represents one of the factors required to estimate the aforementioned *SRISK*. For the sake of interpretation, the higher LRMES, more equity

capital will be drained during a potential systemic event. We use this latter measure as in the robustness checks.

4.3 Control variables

We also consider a set of control variables. First, we allow for bank's size, defined as the log of bank's total size (*Size*). Although being a proxy of the well-established argument of the too-big-to-fail issues, it also proxies for the bank's business model, market power and diversification. Regarding to the latter issue, there are some arguments that larger banks are also more diversified.

Second, in the spirit of Acharya and Thakor (2016), we also control for bank capital structure since it has been considered as a contributor to the 2007-08 financial crisis. As a proxy for capital structure, we use the ratio of bank's total equity to total assets (*Capital ratio*). Speculatively, there are some evidence in the literature that high financial leverage ratio (especially in the form of short-term leverage) leads banks to pursue illiquid and riskier activities (among others, Adrian and Shin (2010)).

Third, we account for growth opportunities using the Market-to-book ratio (*MTB ratio*) (Onali et al., 2016) are in principle more likely to engage go-for-broke activities and thus show a higher level of bank's risk (Herring and Vankudre. 1987). Fourth, we also take into account *Deposits ratio*, which is given by the ratio between bank's total deposits to total assets. EBA (2016) reports that banks with higher dependency from deposits for their activities are more stable than others.

Finally, macroeconomic and institutional factors are also considered in my specification to take into account the fact that competitive forces may play a central role in determining the bank performance. In line with Anginer et al. (2014), we control for the level of the competition and market structure by using Herfindahl-Hirschman index (*HHI index*), defined as the sum of squared market shares expressed in terms of total assets. Then, following the previous work of Demirguç-Kunt and Huizinga (2004), we control for the gross domestic product annual growth rate to allow for the business cycle effects. In line with Billio et al., 2012, controlling for these variables allows to better disentangle the possible contagion from common-factor exposures.

Table 1 reports all the descriptive statistics for the sample.

[INSERT TABLE 1]

5. The topology of the European banking sector

Table 2 reports the results for the cohesion evolution of the European banking sector. More specifically, we explore the topology of European banking network by analysing the behaviour of the network statistics during the sample period from 2005 to 2013. We begin analysing the descriptive statistics of the European banking sector at network-level. Then, we also describe the network statistics at dyadic-level.

[INSERT TABLE 2]

First, we note that the *Average Degree*, namely the average total number of links with which a bank has a Granger-causality relation, is 13.211 in 2005. The indicator rapidly increases over the sample period in line with the development of the *US-Mortgage* crisis. By the end of 2010, the average value skyrockets in 2010 by reaching the value of 36 (2010 is the year of the outbreak of the EU-Sovereign debt crisis). Similar patterns are verified for the In-degree H-index.

Turning our attention to the *Density*, that is the number of links scaled by the total number of links possible, the statistics reveal a tendency for banks to move closer among each other over the sample span (2005-2013). The network seems to be more cohesive, and the network density increases rapidly between the year 2005 and the year 2010, while a sharp decrease is observed for the subsequent years.

Then, we check whether all the nodes of the resulting network satisfy the property of *Closure*, defined as the number of transitive triples divided by the number of paths of length. This measure is based on the assumption that networks expand to reach multiple nodes in only a few steps.

Moving onto *Closure*, as well as changing continuously over the time span, it maintains the value of at least 0.4 over the whole sample period with the only exception of two years – 2006 and 2008 - by reaching its peak of 0.607 in 2009 meaning that the European banking network is composed of

strongly interconnected elements. However, the closure property might be resulting too extreme to hold across all nodes in a vast network, especially in this case where the number of nodes changes continuously over the time.

We also consider some distance measures to evaluate the average distance within the European banking network. First, we consider the average distance among banks in the network. Unsurprisingly, the average distance is lower during the pre-crisis period, while it assumes the value of 1 during both the *US-mortgage crisis period* and the *EU-sovereign debt crisis*. This result appears to be consistent with Billio et al. (2012). Second, we also take into account a measure aimed at evaluating how dispersed (alternatively, clustered) nodes are around the average distance. The corresponding values drop in 2007, 2008, and 2010 respectively (0.616, 0.598, and 0.565). This pattern is also reflected in the fact that the average distance among financial institutions in the network reduces considerably because of the outburst of the two waves of crisis.

Finally, another way to look at the cohesion in network studies, it is based on the concept of distance. For this purpose, we calculate *Compactness*, defined as the average of all the reciprocal distances. Compactness is higher than 0.500 in all the years of the sample period, by reaching the maximum peak in 2010 (0.637). Thus, the economic network appears to be cohesive both in terms of distance (Compactness) and links (*Density*).

The Granger-causality is, by definition, based on the predictive power of two-time series (Billio et al., 2012). Implicitly, it assumes a dyadic feature. For this purpose, we investigate the presence of mutual, asymmetric, and nulls dyads for each year of the sample period. Although the period of profound financial instability in the European banking sector, mutual state for dyadic relations are rare with the only exception of the year 2010, while, unexpectedly, during the whole sample period the proportion of null dyads is indeed higher. Furthermore, the percentage of asymmetric dyads is not trivial in our sample, indicating that there are some institutions drive the shock propagation and the cohesion evolution of the European banking sector.

6. Main results

Table 3 reports the results for our main regressions. The dependent variables are both *SRISK* and *MES*. All regressions include bank and year fixed effects. The first and the fourth regressions include as a measure of social network centrality *Degree* and a set of bank-level and macro-level control variables commonly used in the literature of systemic risk. The coefficient for *Degree* enters regressions statistically insignificant. Turning our attention to other measures of centrality, the coefficient on *Closeness* enters regressions positively and statistically significant. This is an important result indicating that higher centrality in the European banking sector is related to an increase in the level of bank's contribution to the overall systemic risk. Whilst, the coefficients on the other measures of centrality are not statistically significant.

[INSERT TABLE 3]

Moving onto control variables, *Size* is positively related to changes in systemic risk, but it is not statistically significant. Although the literature provides unclear results on the effects of bank's size on systemic risk, this result might be in contrast with the *too-big-to-fail* dilemma that considers bank's size as one of the main determinant of systemic risk. In fact, there is some evidence that large banks as well as having higher systemic risk, do not manage properly their risk-taking and are characterised by misaligned incentives since the market discipline for them is less effective (Jorion, 2009; Pais and Stork, 2013). A possible explanation might be related to the fact that the sample investigated is composed by only the largest EU-banks across 15 countries.

In line with Acharya and Thakor (2016), we find that *Capital ratio* is negatively related to changes in systemic risk. This entails that higher level of bank's equity buffers helps to reduce bank's contribution to the systemic risk. In fact, the last financial crisis has demonstrated that high bank leverage has been one of the main contributor to the financial system. Furthermore, there are also some arguments in favour of the fact that highly levered banks are those that firstly suffer from portfolio shocks (Acharya and Thakor, 2016). Additionally, Adrian and Shin (2010), and Mian and

Sufi (2010) show that higher leverage induce banks to pursue illiquid and riskier activities by implicitly assuming that bank's leverage increases the systemic risk.

It is worth noting that the coefficient on *MTB Ratio* is negatively related to bank's systemic risk and statistically significant at 5%. This result supports the view that banks with valuable market growth opportunities might have less incentives in engaging riskier activities (Herring and Vankundre, 1987), and thus, have a lower systemic risk.

At macro-level, we also control for level of competition and economic trend (as well as year fixed effects). We find some weak evidence that higher concentration in the country where the bank's headquarters are located is related to an increase in the level of bank's contribution to systemic risk. This result appears to be in line with Anginer et al. (2014). Whilst, the coefficient on *GDP growth* is not significant across all specifications.

Thus far, we have reported ordered logit models with standard errors clustered at the bank-level to allow for the serial correlation within bank. However, it may be also possible that errors are correlated across different dimensions, such as country or bank and country (Petersen, 2009). As indicated in Table 4, the results do not alter when we cluster standard errors at country-level and at bank-country level. The results are quantitatively and qualitatively similar to those reported in Table 3 and remain statistically significant.

[INSERT TABLE 4]

Next, one may argue that the results are driven by the choice of a specific cut-offs of +/- 3%. For this reason, we investigate whether the results are sensitive to aforementioned choice. Thus, we check whether the results reported in Table 3 changes when I use +/-1% and +/-5% cut-offs for the two dependent variables. We find that even using alternative cut-offs, bank's centrality, defined in terms of *Closeness*, increases bank's systemic risk and the coefficient remains statistically significant at 5% or better.

7. Robustness tests and extensions

7.1 Sample selection issues

Thus far, we have reported results for the full unbalanced sample. One may argue that the unbalanced panel might introduce a possible selection bias that could drive the results (Chhaochharia and Laeven, 2009). We therefore run the main specification for only observations that composed the balanced sample. The results are reporter in the first four columns of Table 5. The results based on the balanced sample are similar to those obtained for the full sample.

[INSERT TABLE 5]

Then, we drop observations for which we have only few observations. The underlying idea is to understand whether a possible little within-country variation in countries with only a few observations may drive the results and thus the resulting sample of banks considered might violate the representativeness for these countries. When we exclude from the estimation countries with only few observations, we obtain similar results.

Finally, we drop countries from GIIPS (Greece, Italy, Ireland, Portugal, and Spain). We have concerned that the presence of banks from these countries may introduce a selection bias that might drive the results. In fact, the literature shows that these countries may have had particularly unstable banking system (Acharya et al., 2014; Bruno et al., 2018). Thus, the higher level of systemic risk might be led by higher sovereign debt risk in these countries. We therefore re-estimate the main specification by dropping banks from GIIPS countries. The results are reported in the last four columns of Table 6. Again, the results are very similar to those reported in Table 3 for the coefficients of our interest (centrality measures).

7.2 Omitted variable bias: corporate governance, managerial entrenchment, and public interventions.

Previous studies have demonstrated that bank's performance may be affected by bank's corporate governance mechanisms (Chhaocharia and Laeven, 2008) and managerial entrenchment (Onali et al., 2016). Furthermore, systemic risk may be also driven by policy intervention provided by public authorities (Acharya and Yorulmazer, 2007; Gropp et al., 2011) (e.g, public bailouts). In addition, there is some evidence that governance may affect bank valuation through another channel: the ownership structure (Rajan and Zingales, 2005). Thus, we also control for bank's ownership structure.

To construct measures to take into account the corporate governance, the managerial entrenchment, and ownership structure we collect data from annual reports. Whilst, we use Mediobanca document to collect information on public interventions on banks. We explore these further channels to avoid that the results reported in Table 3 are driven by other arguments that are not taken into account Specifically, we construct the following variables: i) *Board Size* is defined as the logarithm of board size of directors; ii) *Board independence* is the ratio between the number of independent directors to total board size; iii) *Widely bank* is an indicator variable equal to one if there is no owner with more than 10% of bank share rights, and zero otherwise; iv) *Public intervention* is a dummy variable takes the value of one if the bank has received a public intervention and zero otherwise; v) *CEO ownership* is the percentage of CEO equity stake in the bank; vi) *Board ownership* is the percentage of board members' equity stake in the bank. Therefore, the results are reported in Table 6 and confirm previous evidences.

[INSERT TABLE 6]

7. Conclusions

The last financial crisis has revealed the entangled nature of the financial system and the related implications for systemic risk. The lack of data and the confidentiality issues limit the study of the

financial interdependencies among banks and their implications for the systemic risk and financial stability. In this paper, we first try to overcome this problem by generating the European banking network by only considering the bank's asset returns, and then we provide another attempt aimed at bridging the banking literature with the social network analysis to better enlarge the understanding of systemically important financial institutions. In particular, after analysing the topology of the European banking market across 15 countries to explain its cohesion evolution over the whole crisis period, we stress whether EU-larger banks' topological properties predict the bank's contribution to systemic risk. For this purpose, we use four well-established measures of centrality in the social network analysis literature: i) degree; ii) closeness; iii) eigenvector centrality; and iv) betweenness. We provide interesting results. First, we show that the cohesion evolution of the European banking network changes sharply over the sample period from 2005 to 2013. In line with Billio et al. (2012), the level of connectivity and the density among banks (measured in terms of assets' returns) are rapidly increased in 2007 in comparison with the non-crisis period. In addition, we also show that this connectivity is even higher in the outbreak of the European sovereign debt crisis (2010) than US-mortgage crisis by providing further evidences that the global financial crisis did not exhaust its contagion effects in Europe in 2009, as other papers supposed (among others, Aït Sahalia et al. (2012)), while it dropped drastically in 2013.

Second, we find that bank's centrality expressed in terms of proximity, help to explain changes in systemic risk (Closeness), while Degree, Betweenness, and Eigenvector centralities do not.

We also acknowledge for some limitations in this study. First, although we use the Granger causality test has the advantage of quantifying network effects by merely using bank's assets returns, it may be interesting to understand whether these results are sensitive if considering real financial exposures among banks (for instance, either the interbank market or the derivatives market). Second, the analysis focuses only on the European Union. It may be interesting to quantify the network effects of financial interdependencies across different currency areas and how they interact with each other

at aggregate-level. Despite the limitations, our results strongly suggest that more central financial institutions are more systemically important. The results are also robust to a variety of tests related to the sample selection issues and omitted variables bias.

This paper would also have some policy implications. First, it contributes to the debate on the development of models founded on multiway-data analysis (especially early-warning systems), namely simultaneous consideration of individual firm data (including forward- and backward-looking measures), macroeconomic variables and indicators of interconnectedness, to allow a better evaluation of financial risks. Second, the study hints at the crucial role of financial networks during the crisis period. It might help to improve the understanding of the increased complexity of the financial system, the behaviour of larger financial institutions, the risk posed by financial dependencies and providing the explanation why specific larger banks may threaten the financial stability more than other banks of similar size.

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Tables

Table 1.

The table shows the summary statistics for the sample. *Degree*, *Closeness*, *Betweenness*, and *Eigenvector* are measures of bank's centrality in the European banking sector. Systemic risk measures are expressed in changes. SRISK is the amount of capital that a bank needs if it experienced another financial crisis. *MES* is the marginal expected shortfall of a stock given that the market return is below its 5th percentile. *Size* is the log of total assets. *Capital ratio* is the ratio of bank equity capital over total assets. *MTB ratio* is the market value of equity divided by the book value of equity. *Deposits ratio* is the ratio of bank total customer deposits to total assets. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP.

Variables	*N*	*Mean*	*SD*	*Min*	*Max*
Systemic risk measures					
Changes in SRISK	542	0.0014	0.0626	-0.3330	0.4957
Changes in MES	542	0.0901	0.3188	-0.8188	3.0344
Centrality measures					
Degree	542	0.3248	0.1823	0.0270	1.0000
Closeness	542	0.6061	0.0889	0.4975	1.0000
Eigenvector	542	0.1280	0.0492	0.0259	0.3744
Betweenness	542	0.0053	0.0116	0.0000	0.1250
Controls					
Size	513	18.0423	2.3573	12.0717	21.6736
Capital ratio	513	0.0678	0.0449	0.0086	0.4727
MTB ratio	478	0.9741	0.6405	0.0196	3.5931
Deposits ratio	519	0.8805	0.6399	0.0663	10.0368
HHI	523	0.0822	0.0617	0.0174	0.3950
GDP growth	523	0.2065	2.9160	-9.1324	6.3341

Table 2. Cohesion evolution of the European banking sector.

The table reports the descriptive statistics of the European banking sector. Panel A shows the descriptive statistics at network-level, while Panel B indicates the descriptive statistics at dyadic-level. *Avg. Degree* stands for the average degree in the network of 133 banks. *H-index* is defined as the maximum value h such that there exist at least h neighbours of degree no less than h. *Density* is determined as the number of connections divided by the maximum number possible. *Closure* is calculated as the number of non-vacuous transitive triples divided by number of paths of length 2. *Avg. Distance* stands for the average geodesic distance amongst reachable pairs. *SD Distance* is the standard deviation of the geodesic distances amongst reachable pairs. *Compactness* is defined as the mean of all the reciprocal distances. *Breadth* is described as one minus *Compactness*. *Mutuals* stands for dyads with reciprocated ties. *Asymmetrics* stands for dyads with unreciprocated ties. Nulls stands for dyads with no tie.

Panel A: Descriptive statistics at network-level									
	2005	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Avg. Degree	13.211	16.227	17.608	18.456	23.194	30.529	15.712	21.312	13.536
Indeg H-Index	17.000	23.000	24.000	25.000	27.000	36.000	22.000	25.000	18.000
Density	0.141	0.169	0.174	0.181	0.227	0.296	0.153	0.197	0.122
Closure	0.449	0.357	0.414	0.333	0.607	0.553	0.426	0.535	0.388
Avg Distance	2.173	2.029	2.026	1.988	1.938	1.774	2.225	2.021	2.215
SD Distance	0.664	0.672	0.616	0.598	0.637	0.565	0.750	0.670	0.666
Breadth	0.481	0.463	0.446	0.437	0.418	0.363	0.483	0.446	0.507
Compactness	0.518	0.537	0.554	0.563	0.582	0.637	0.517	0.554	0.493
Panel B: Descriptive statistics at dyadic-level									
	2005	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*
Mutuals	0.020	0.036	0.039	0.034	0.047	0.114	0.018	0.041	0.016
Asymmetrics	0.242	0.266	0.271	0.294	0.360	0.365	0.270	0.313	0.213
Nulls	0.739	0.698	0.690	0.672	0.592	0.522	0.713	0.646	0.772

Table 3. Main results

The table reports the estimates for the ordered logit models for changes in the bank's contribution to systemic risk. The dependent variable takes the value of one if there was a drop in the bank's systemic risk, measured as both *SRISK* (the amount of capital that a bank needs if it experienced another financial crisis) and *MES* (it stands for the the marginal expected shortfall of a stock given that the market return is below its 5th percentile), of at least 3% relative to previous year, it takes the value of two if the bank's systemic risk remains unaltered and fall into the range (-3%, 3%), and takes the value of three if there is an increase in the level of bank's systemic risk of more than 3%. *Degree*, *Closeness*, *Betweenness*, and *Eigenvector* are measures of bank's centrality in the European banking sector. *Size* is the log of total assets. *Capital ratio* is the ratio of bank equity capital over total assets. *MTB ratio* is the market value of equity divided by the book value of equity. *Deposits ratio* is the ratio of bank total customer deposits to total assets. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. Standard errors are clustered at bank-level. Robust z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Variables	*SRISK* (1)	*SRISK* (2)	*SRISK* (3)	*SRISK* (4)	*MES* (5)	*MES* (6)	*MES* (7)	*MES* (8)
Degree	-0.0152				-0.0101			
	(-1.2434)				(-1.5367)			
Closeness		0.5963***				0.3192***		
		(3.9778)				(3.1903)		
Eigenvector			-0.0466				-0.0027	
			(-1.2176)				(-0.1360)	
Betweenness				-0.1785				-0.1481
				(-1.2193)				(-1.5612)
Size	0.6838	0.6310	0.7267	0.6385	0.0838	-0.4454	0.0377	0.0558
	(0.7461)	(0.6370)	(0.7979)	(0.6917)	(0.1367)	(-0.7014)	(0.0622)	(0.0932)
Capital ratio	-10.1365	-8.1617	-10.3466	-10.0614	-8.4384**	-6.3228*	-8.8356**	-8.3340**
	(-1.4455)	(-1.1631)	(-1.4660)	(-1.4639)	(-2.2457)	(-1.8332)	(-2.3193)	(-2.2622)
MTB ratio	-1.2797**	-1.2269**	-1.2687**	-1.2488**	-0.2634	-0.2392	-0.2409	-0.2526
	(-2.4503)	(-2.3680)	(-2.4749)	(-2.5105)	(-1.0411)	(-0.9752)	(-0.9512)	(-1.0049)
Deposits ratio	-0.3657***	-0.4438***	-0.3637***	-0.3672***	-0.2883***	-0.3561***	-0.2768**	-0.2941***
	(-3.2942)	(-3.8249)	(-3.2906)	(-3.3593)	(-2.5764)	(-3.7644)	(-2.5063)	(-2.7707)
HHI	7.3820	4.5572	7.5290	6.7832	8.8763**	7.5420*	9.0562**	8.4277*
	(1.6399)	(0.8135)	(1.6271)	(1.3351)	(2.0068)	(1.7391)	(2.2500)	(1.9511)
GDP growth	-0.0667	-0.0787	-0.0624	-0.0666	0.0855	0.0516	0.0953*	0.0856
	(-0.7602)	(-0.8120)	(-0.6991)	(-0.7492)	(1.5566)	(0.8588)	(1.6671)	(1.5439)
∂_1	8.8629	38.8185*	9.5477	8.2188	-0.0962	8.3110	-0.7970	-0.5145
	(0.4579)	(1.6552)	(0.4973)	(0.4215)	(-0.0075)	(0.5695)	(-0.0630)	(-0.0411)
∂_2	15.1546	45.3848*	15.8308	14.4980	1.3918	9.9049	0.6842	0.9742
	(0.7804)	(1.9254)	(0.8218)	(0.7411)	(0.1087)	(0.6790)	(0.0540)	(0.0777)
Observations	478	478	478	478	478	478	478	478
Bank FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank

Table 4. Clustering at different level of analysis.

The table shows the robustness results for the main results by clustering standard errors at different levels (at country level, and at bank-country level). The dependent variable takes the value of one if there was a drop in the bank's systemic risk, measured as both *SRISK* (the amount of capital that a bank needs if it experienced another financial crisis) and *MES* (it stands for the the marginal expected shortfall of a stock given that the market return is below its 5th percentile), of at least 3% relative to previous year, it takes the value of two if the bank's systemic risk remains unaltered and fall into the range (-3%, 3%), and takes the value of three if there is an increase in the level of bank's systemic risk of more than 3%. *Degree*, *Closeness*, *Betweenness*, and *Eigenvector* are measures of bank's centrality in the European banking sector. *Size* is the log of total assets. *Capital ratio* is the ratio of bank equity capital over total assets. *MTB ratio* is the market value of equity divided by the book value of equity. *Deposits ratio* is the ratio of bank total customer deposits to total assets. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. Robust z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Variables	*SRISK* (1)	*SRISK* (2)	*SRISK* (3)	*SRISK* (4)	*SRISK* (5)	*SRISK* (6)	*SRISK* (7)	*SRISK* (8)
Degree	-0.0152				-0.0152			
	(-1.2476)				(-1.2434)			
Closeness		0.5963***				0.5963***		
		(4.2638)				(3.9778)		
Eigenvector			-0.0466				-0.0466	
			(-1.2828)				(-1.2176)	
Betwenness				-0.1785				-0.1785
				(-1.2582)				(-1.2193)
Size	0.6838	0.6310	0.7267	0.6385	0.6838	0.6310	0.7267	0.6385
	(1.0617)	(0.9074)	(1.1162)	(0.9411)	(0.7461)	(0.6370)	(0.7979)	(0.6917)
Capital ratio	-10.1365**	-8.1617**	-10.3466**	-10.0614***	-10.1365	-8.1617	-10.3466	-10.0614
	(-2.4525)	(-2.2583)	(-2.4180)	(-2.6448)	(-1.4455)	(-1.1631)	(-1.4660)	(-1.4639)
MTB ratio	-1.2797***	-1.2269***	-1.2687***	-1.2488***	-1.2797**	-1.2269**	-1.2687**	-1.2488**
	(-2.9370)	(-2.8986)	(-3.0177)	(-3.2262)	(-2.4503)	(-2.3680)	(-2.4749)	(-2.5105)
Deposits ratio	-0.3657***	-0.4438***	-0.3637***	-0.3672***	-0.3657***	-0.4438***	-0.3637***	-0.3672***
	(-4.9831)	(-5.8381)	(-4.8680)	(-5.1670)	(-3.2942)	(-3.8249)	(-3.2906)	(-3.3593)
HHI	7.3820*	4.5572	7.5290*	6.7832	7.3820	4.5572	7.5290	6.7832
	(1.6942)	(0.7611)	(1.6978)	(1.3239)	(1.6399)	(0.8135)	(1.6271)	(1.3351)
GDP growth	-0.0667	-0.0787	-0.0624	-0.0666	-0.0667	-0.0787	-0.0624	-0.0666
	(-0.6926)	(-0.6846)	(-0.6367)	(-0.6854)	(-0.7602)	(-0.8120)	(-0.6991)	(-0.7492)
∂_1	8.8629	38.8185**	9.5477	8.2188	8.8629	38.8185*	9.5477	8.2188
	(0.6743)	(2.2124)	(0.7216)	(0.5914)	(0.4579)	(1.6552)	(0.4973)	(0.4215)
∂_2	15.1546	45.3848**	15.8308	14.4980	15.1546	45.3848*	15.8308	14.4980
	(1.1420)	(2.5688)	(1.1860)	(1.0333)	(0.7804)	(1.9254)	(0.8218)	(0.7411)
Observations	478	478	478	478	478	478	478	478
Bank FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Country	Country	Country	Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country

Table 5. Alternative cut-offs

The table shows the robustness results for the main results. In these estimate I re-run the analysis presented in Table 2 by using alternative cut-offs for the ordered logit model. The dependent variable takes the value of one if there was a drop in the bank's systemic risk, measured as both *SRISK* (the amount of capital that a bank needs if it experienced another financial crisis) and *MES* (it stands for the marginal expected shortfall of a stock given that the market return is below its 5th percentile), of at least 1% (or 5%) relative to previous year, it takes the value of two if the bank's systemic risk remains unaltered and fall into the range [-1%, 1%] (or -5%,5%), and takes the value of three if there is an increase in the level of bank's systemic risk of more than 1% (or 5%). *Degree*, *Closeness*, *Betweenness*, and *Eigenvector* are measures of bank's centrality in the European banking sector. *Size* is the log of total assets. *Capital ratio* is the ratio of bank equity capital over total assets. *MTB ratio* is the market value of equity divided by the book value of equity. *Deposits ratio* is the ratio of bank total customer deposits to total assets. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. Robust z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Variables	$SRISK_{\%1}$ (1)	$SRISK_{\%1}$ (2)	$SRISK_{\%1}$ (3)	$SRISK_{\%1}$ (4)	$SRISK_{\%5}$ (5)	$SRISK_{\%5}$ (6)	$SRISK_{\%5}$ (7)	$SRISK_{\%5}$ (8)
Degree	0.0014				0.0008			
	(0.1948)				(0.0566)			
Closeness		0.4539***				0.7632***		
		(3.7264)				(3.1216)		
Eigenvector			0.0137				0.0082	
			(0.6020)				(0.2129)	
Betweenness				-0.0083				0.0479
				(-0.1069)				(0.4443)
Size	1.5398*	1.3640*	1.5090*	1.5522*	-0.9587	-1.1791	-0.9733	-0.9664
	(1.9245)	(1.6628)	(1.8783)	(1.9517)	(-1.1208)	(-1.1154)	(-1.1341)	(-1.1259)
Capital ratio	-10.7415	-9.1454	-10.8098	-10.6329	-17.4738**	-16.3827*	-17.4950**	-17.6904**
	(-1.5039)	(-1.2984)	(-1.5184)	(-1.4880)	(-2.0278)	(-1.8776)	(-2.0259)	(-2.0449)
MTB ratio	-1.0023**	-0.9000**	-0.9917**	-1.0096***	-1.1252**	-1.0578*	-1.1178**	-1.1189**
	(-2.5678)	(-2.3493)	(-2.5473)	(-2.5935)	(-2.1119)	(-1.9592)	(-2.1227)	(-2.1222)
Deposits ratio	-0.1824**	-0.2552***	-0.1780**	-0.1858**	-0.2550**	-0.3010**	-0.2540**	-0.2522**
	(-2.2644)	(-3.3022)	(-2.2124)	(-2.3631)	(-2.2292)	(-2.3118)	(-2.2170)	(-2.1841)
HHI	9.0607***	7.6389**	9.1859***	8.9388***	2.8760	1.0119	3.0165	3.2464
	(2.7515)	(2.2624)	(2.8001)	(2.6833)	(0.6477)	(0.2290)	(0.6565)	(0.6617)
GDP growth	-0.0626	-0.0870	-0.0615	-0.0643	-0.0073	-0.0126	-0.0069	-0.0045
	(-1.1653)	(-1.4690)	(-1.1342)	(-1.2029)	(-0.0529)	(-0.0963)	(-0.0493)	(-0.0319)
∂_1	28.5943*	49.4148***	28.1185*	28.7978*	-26.3570	9.1642	-26.5523	-26.4865
	(1.7040)	(2.8876)	(1.6714)	(1.7235)	(-1.4673)	(0.3941)	(-1.4736)	(-1.4690)
∂_2	32.2697*	53.2062***	31.7962*	32.4735*	-18.4822	17.5499	-18.6777	-18.6009
	(1.9184)	(3.1049)	(1.8858)	(1.9388)	(-1.0306)	(0.7510)	(-1.0384)	(-1.0335)
Observations	478	478	478	478	478	478	478	478
Bank FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank

Table 6. Sample selection issues

The table reports the robustness tests for the results reported in Table 2 by allowing for sample selection issues. The dependent variable takes the value of one if there was a drop in the bank's systemic risk, measured as both *SRISK* (the amount of capital that a bank needs if it experienced another financial crisis) and *MES* (it stands for the the marginal expected shortfall of a stock given that the market return is below its 5th percentile), of at least 3% relative to previous year, it takes the value of two if the bank's systemic risk remains unaltered and fall into the range (-3%, 3%), and takes the value of three if there is an increase in the level of bank's systemic risk of more than 3%. *Degree*, *Closeness*, *Betweenness*, and *Eigenvector* are measures of bank's centrality in the European banking sector. *Size* is the log of total assets. *Capital ratio* is the ratio of bank equity capital over total assets. *MTB ratio* is the market value of equity divided by the book value of equity. *Deposits ratio* is the ratio of bank total customer deposits to total assets. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. Standard errors are clustered at bank-level. Robust z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Variables	*SRISK* (1)	*SRISK* (2)	*SRISK* (3)	*SRISK* (4)	*SRISK* (5)	*SRISK* (6)	*SRISK* (7)	*SRISK* (8)	*SRISK* (9)	*SRISK* (10)	*SRISK* (11)	*SRISK* (12)
Degree	-0.0155				-0.0158				-0.0333***			
	(-1.2517)				(-1.2571)				(-2.8049)			
Closeness		0.6088***				0.5905***				0.8018***		
		(3.9752)				(3.9368)				(3.0975)		
Eigenvector			-0.0472				-0.0492				-0.1016**	
			(-1.2293)				(-1.2486)				(-2.3997)	
Betweenness				-0.1791				-0.1825				-0.3958***
				(-1.2212)				(-1.2489)				(-4.3566)
Size	0.6684	0.6049	0.7143	0.6252	0.5033	0.4626	0.5515	0.4621	0.5492	0.7889	0.6088	0.6080
	(0.7266)	(0.6074)	(0.7817)	(0.6751)	(0.5222)	(0.4405)	(0.5754)	(0.4764)	(0.4921)	(0.5595)	(0.5508)	(0.5324)
Capital ratio	-10.1484	-7.7052	-10.3559	-10.1019	-9.9303	-8.0861	-10.1383	-9.8467	-70.3802**	-71.5663**	-70.9565**	-64.6638**
	(-1.4538)	(-1.1228)	(-1.4730)	(-1.4734)	(-1.4458)	(-1.1714)	(-1.4662)	(-1.4593)	(-2.3717)	(-2.2000)	(-2.4179)	(-2.1570)
MTB ratio	-1.2655**	-1.2100**	-1.2538**	-1.2342**	-1.2958**	-1.2443**	-1.2832**	-1.2585**	-1.7686*	-1.6212	-1.7702*	-1.7307*
	(-2.4473)	(-2.3629)	(-2.4731)	(-2.5070)	(-2.3546)	(-2.2635)	(-2.3792)	(-2.4077)	(-1.8945)	(-1.6312)	(-1.8805)	(-1.8880)
Deposits ratio	-0.3607***	-0.4421***	-0.3587***	-0.3618***	-0.3526***	-0.4295***	-0.3510***	-0.3553***	0.0060	-0.3033	0.0177	-0.0476
	(-3.2788)	(-3.8830)	(-3.2745)	(-3.3388)	(-2.9128)	(-3.4122)	(-2.9045)	(-2.9806)	(0.0041)	(-0.1886)	(0.0122)	(-0.0337)
HHI	7.4369	4.3294	7.5551	6.8508	7.3129	4.5569	7.4429	6.7111	6.0159	2.4156	6.2809	5.1850
	(1.6390)	(0.7699)	(1.6215)	(1.3456)	(1.6367)	(0.8173)	(1.6206)	(1.3300)	(1.0131)	(0.4158)	(0.9983)	(0.7993)
GDP growth	-0.0642	-0.0790	-0.0602	-0.0640	-0.0792	-0.0915	-0.0745	-0.0788	0.3731*	0.4528*	0.3899*	0.3841*
	(-0.7316)	(-0.8195)	(-0.6747)	(-0.7195)	(-0.8947)	(-0.9423)	(-0.8250)	(-0.8765)	(1.7225)	(1.9069)	(1.7201)	(1.6995)
∂_1	8.5911	38.9506*	9.3362	7.9982	5.1011	34.9083	5.8785	4.5593	3.8849	50.3369	4.6707	5.8451
	(0.4423)	(1.6554)	(0.4847)	(0.4090)	(0.2500)	(1.4167)	(0.2904)	(0.2220)	(0.1643)	(1.3571)	(0.2004)	(0.2428)
∂_2	14.8267	45.4620*	15.5629	14.2208	11.4031	41.4841*	12.1731	10.8485	10.7326	57.7498	11.4694	12.6886
	(0.7608)	(1.9228)	(0.8052)	(0.7249)	(0.5576)	(1.6763)	(0.5997)	(0.5270)	(0.4515)	(1.5375)	(0.4891)	(0.5245)
Observations	469	469	469	469	470	470	470	470	264	264	264	264
Bank FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank

Table 7. Corporate governance, managerial entrenchment, public bailouts

The table reports the estimates for the ordered logit models for changes in the bank's contribution to systemic risk. Systemic risk measures are expressed in changes. The dependent variable takes the value of one if there was a drop in the bank's systemic risk, measured as both *SRISK* (the amount of capital that a bank needs if it experienced another financial crisis) and *MES* (it stands for the the marginal expected shortfall of a stock given that the market return is below its 5th percentile), of at least 3% relative to previous year, it takes the value of two if the bank's systemic risk remains unaltered and fall into the range (-3%, 3%), and takes the value of three if there is an increase in the level of bank's systemic risk of more than 3%. *Degree*, *Closeness*, *Betweenness*, and *Eigenvector* are measures of bank's centrality in the European banking sector. *Board Size* is defined as the logarithm of board size of directors. *Board independence* is the ratio between the number of independent directors to total board size. *Widely bank* is an indicator variable equal to one if there is no owner with more than 10% of bank share rights, and zero otherwise. *Public intervention* is a dummy variable takes the value of one if the bank has received a public intervention and zero otherwise. *CEO ownership* is the percentage of CEO equity stake in the bank. *Board ownership* is the percentage of board members' equity stake in the bank. All controls are the same reported in Table 2 (*Size*, *Capital ratio*, *MTB ratio*, *Deposits* ratio, *HHI*, and *GDP growth*). Standard errors are clustered at bank-level. Robust z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Variables	*SRISK* (1)	*SRISK* (2)	*SRISK* (3)	*SRISK* (4)	*SRISK* (5)	*SRISK* (6)	*SRISK* (7)	*SRISK* (8)
Degree	-0.0154				-0.0144			
	(-1.2774)				(-1.1558)			
Closeness		0.6131***				0.5458***		
		(3.9793)				(3.6728)		
Eigenvector			-0.0479				-0.0448	
			(-1.2612)				(-1.1450)	
Betwenness				-0.1918				-0.1595
				(-1.2991)				(-1.0718)
Board Size	1.2264	1.6433*	1.2396	1.3209				
	(1.3786)	(1.6820)	(1.4101)	(1.4993)				
Board independence	0.0090	0.0082	0.0092	0.0094				
	(0.8958)	(0.8416)	(0.9074)	(0.9357)				
Widely bank	-0.3138	-0.4388	-0.3149	-0.3331				
	(-0.3688)	(-0.4952)	(-0.3704)	(-0.3874)				
Public Intervention	-0.0473	-0.1705	-0.0538	-0.0219				
	(-0.1024)	(-0.3842)	(-0.1167)	(-0.0485)				
CEO Ownership					-0.0035***	-0.0032***	-0.0035***	-0.0033***
					(-4.9063)	(-4.5761)	(-4.9638)	(-5.0326)
Board Ownership					0.0001	0.0000	0.0001	0.0000
					(0.7460)	(0.2906)	(0.7725)	(0.6771)
Size	0.5374	0.4027	0.5801	0.4705	0.6765	0.6319	0.7200	0.6284
	(0.6309)	(0.4462)	(0.6832)	(0.5518)	(0.7269)	(0.6341)	(0.7784)	(0.6710)
Capital ratio	-8.9332	-7.2090	-9.1101	-8.7397	-14.3367**	-12.7449*	-14.5171**	-14.1801**
	(-1.2400)	(-0.9800)	(-1.2582)	(-1.2484)	(-2.0079)	(-1.7587)	(-2.0296)	(-1.9998)
MTB ratio	-1.2521**	-1.2091**	-1.2418**	-1.2189**	-1.5035***	-1.4238**	-1.4941***	-1.4657***
	(-2.3536)	(-2.2919)	(-2.3650)	(-2.4013)	(-2.6257)	(-2.5266)	(-2.6521)	(-2.7020)
Deposits ratio	-0.3563***	-0.4337***	-0.3540***	-0.3587***	-0.4363***	-0.4886***	-0.4358***	-0.4314***
	(-3.3668)	(-4.1079)	(-3.3494)	(-3.4703)	(-3.8623)	(-3.9767)	(-3.8931)	(-3.9107)
HHI	6.5079	3.6290	6.6220	5.8019	8.1631*	5.6296	8.2935*	7.6657
	(1.4080)	(0.6520)	(1.3994)	(1.1234)	(1.7444)	(0.9509)	(1.7200)	(1.4456)
GDP growth	-0.0763	-0.0878	-0.0720	-0.0768	-0.0488	-0.0614	-0.0449	-0.0490
	(-0.8304)	(-0.8787)	(-0.7700)	(-0.8266)	(-0.5430)	(-0.6352)	(-0.4908)	(-0.5383)
∂_1	9.6683	39.6671*	10.3883	8.8498	8.3458	35.8186	9.0428	7.6545
	(0.5259)	(1.7848)	(0.5688)	(0.4808)	(0.4240)	(1.5200)	(0.4632)	(0.3863)
∂_2	15.9414	46.2305**	16.6528	15.1161	14.7112	42.4102*	15.4013	14.0052
	(0.8632)	(2.0655)	(0.9075)	(0.8176)	(0.7450)	(1.7920)	(0.7861)	(0.7046)
Observations	469	469	469	469	468	468	468	468
Bank FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank

Paper 2: Public bailouts, bank's risk and spillover effects: the case of European banks

Do EU-rescue program announcements produce a positive effect on financial markets? Do these actions influence the financial stability during banking crises? And, especially, are these effects limited to rescued banks' stakeholders or spread out to stakeholders of other banks? By using an event study approach, we estimate stock price reactions to the announcement of public bailout programs run in Europe between 2007 and 2014. We show that these policies attract negative abnormal returns. Second, we hand-collected a dataset on all public interventions in Europe from 2007 to 2014. By employing a dynamic difference-in-difference approach, we show that public interventions affect the behavior of both bailed-out banks (e.g. by increasing their risk and the supply of credit) and we find evidence of significant spillover effects.

1. Introduction

Since 2007, governments and central banks have faced the financial crisis by a wide range of policy actions dealing with impaired bank assets, recapitalizing or restructuring of troubled banks, and measures designed to inject liquidity into the banking system.[11] Between 2008 and 2014, governments in the European Union (EU) approved state aids to banking systems amounting to 45.8% of GDP comprising €1.49 trillion of capitalization and asset relief programs and €4.3 trillion of guarantees and liquidity measures. Most state authorized aid was in the form of guarantees, some €3.9 trillion in total (most of which was granted at the peak of the crisis during 2008).[12]

The scale of government aid provided to the financial sector has generated a great debate about the justification of these actions (White, 2009; Carletti and Vives, 2009; Beck et al., 2010; CEPS, 2010; Lyons and Zhu, 2013). Although there is a substantial empirical literature on the effect of public bailouts on rescued banks in the US (Veronesi and Zingales, 2010; Berger et al., 2016; Giannetti and Simonov, 2013; Dam and Koetter, 2012; Gropp et al. 2011; Duchin and Sosyura, 2014), there is no evidence for Europe. This leads us to the following questions: Do EU-rescue program announcements calm the financial markets? Do these policies undermine the financial stability during banking crises? Do EU-rescue program announcements produce a positive effect on financial markets? Do these actions influence the financial stability during banking crises? And, especially, are these effects limited to rescued banks' stakeholders or spread out to stakeholders of other banks?

We show that EU-rescue programs are not value-enhancing policies in the short-term period. Both national and cross-country reactions are negative and statistically significant in two out three event windows. This adverse reaction by investors may be due to the idea that government intervention impose either restrictions on banks reducing their profitability or dilution of shareholding rights (Fiordelisi and Ricci, 2016). This issue is also in line with the information-signalling perspective

[11] See BIS (2009), Group of Thirty (2009) and Brunnermeier (2009) for detailed perspectives on the causes and consequences of the global financial crisis. For European insights see De Larosière (2009) and Goddard et al. (2009).
[12] Information from the EC State Aid to the banking sector scoreboard: http://ec.europa.eu/competition/state_aid/scoreboard/financial_economic_crisis_aid_en.html.

according to which the government commitment toward national banks may raise uncertainty, by conveying bad signals on the overall wealth of the banking sector. Interestingly, reactions are not statistically significant looking at the post announcement two-day event window (0, 1). This may be a signal that the market is able to anticipate public announcements (Bayazitova and Shivdsani, 2012). Our second finding is that public bailouts produce both a direct effect on the rescued bank's risk and a spillover effect on their competitors. On the one hand, banks receiving a public bailout increase their risk by augmenting their volume and worsening the quality of their lending activities (and thus lessening their monitoring activities). Although these policies may stimulate the supply of credit, they create incentives for banks to pursue riskier (*NPLs ratio*) and more illiquid (*Liquid assets ratio*) strategies. On the other hand, public bailouts determine a spillover effect on their competitors running through their margins. Since rescued banks receive public protection and are able to aggressively expand the supply of credit, the competitors' margins may decrease (Gropp et al., 2011). In our sample, this effect is statistically and economically significant at 5% during the whole post-bailout period.

To examine our research questions, we build a dataset on all public interventions provided by national governments in Europe for a sample of 296 commercial banks across 15 countries as of 2007 to 2014. The reason why we focus on European banks is threefold. First, it allows studying a more-extended period covering the sovereign debt crisis (Fiordelisi and Ricci, 2016). Second, past works (e.g. Dam and Koetter, 2012; Berger et al., 2016; Kick et al., 2016) are one-country setting studies without providing a comprehensive view of the effects of public bailouts across different countries both in the short-term and in the long-term periods. Third, focusing on Europe allows us to cover different rescue measures for banks (e.g., state guarantee schemes, recapitalization, and provision of loans).

The main contribution of this paper is manifold.

First, we provide novel empirical evidence on the stock market reaction to rescue program announcements, comparing the effect for banks that are directly involved in the program and their

competitors. Although there is some evidence in the economics and finance literature that these announcements might create (or destroy) value for the investors in the country where the announcement takes place (Veronesi and Zingales, 2010; Bayazitova and Shivdasani, 2012; Fiordelisi and Ricci, 2016), little is known on how investors from other countries may react to the announcement. Assessing spillover effects in market reaction has important policy implications, since public authorities may find optimal to announce policy interventions to restore the confidence in the financial markets.

Second, to the best of our knowledge, we are the first paper to provide some evidence on the influence of public bailouts on bank conduct in Europe during the whole crisis period by finding that the economic impact of these policies is substantial. In doing so, we also document the mechanism through which public bailout affect the risk-taking of rescued banks. This evidence also provides some insights into the debate on the optimal safety-net among supervisory agencies, policymakers, and scholars.

Third, as far as we are aware, this is the first paper providing empirical evidence on the spillover effects for rescued banks' competitors, on both their level of risk and activities during the crisis period. Spillover effects attracted less attention in the literature (apart few exceptions, as Calderon and Schaeck, 2016; and Gropp et al., 2011). By studying the relation between competitors' conduct and their activities at bank-level by covering the Eurozone crisis, we shed some lights on the fact that public bailouts create incentives for rescued banks to expand by amplifying the competition (Hakenes and Schnabel, 2010).

We have to address various empirical challenging in this paper. First, information on public interventions is usually dispersed among several data sources. We overcome this problem by bringing to bear a unique hand-collected dataset including information on all bailouts issued by public authorities in Europe from 2007 to 2014.

The second challenge is related to our identification strategy. Because of the behavioral component[13] of the public bailouts (Dam and Koetter, 2012), naïve regressions raise endogeneity and reverse causality concerns. For example, troubled banks may be aware of their financial fragility so that they may adjust their riskiness independently of the public bailout in order to avoid the default.[14] Previous papers in the economics and finance literature use an instrumental variable approach to deal with endogeneity (Dam and Koetter, 2012; Berger et al., 2016; Kick et al., 2016). For instance, Dam and Koetter (2012) exploit regional political factors, such as state parliament election, the vote share difference, [15] and the possibility that State and federal prime ministers are from the same party to allow for endogeneity and make inferences on causal explanations for the moral hazard channel for bank bailouts. Conversely, our empirical framework is based on a fully saturated difference-in-difference model (Autor, 2003; Angrist and Pischke, 2008) to identify the causal effects of public bailouts on rescued banks and their competitors. First, it accommodates for a dynamic interpretation of public bailouts effect and may detect the presence of any anticipatory effects in the bank conduct and, then, any reverse causality issues (Angrist and Pischke, 2008). Second, it is also suitable because it fits situation when the treatment variable changes over the time-span in different locations (Cerulli, 2015).

The third challenge of our paper is related to the identification of the rescued banks' competitors. This step is auxiliary to identify the spillover effects of these interventions. Based on the bank's size and home-country (Bayazitova and Shivdasani, 2012), we match rescued banks with their non-rescued peers through their propensity to be treated over the sample period.[16]

The rest of the paper is organized as follows. Section 2 provides the institutional background of public bailouts in Europe during the crisis period. Section 3 discusses how this work is related to the previous literature and highlights the main contributions to the literature. Section 4 discusses the

[13] Bank bailouts are unlikely to be randomly assigned (Dam and Koetter, 2012; Berger et al., 2016; Kick et al., 2016).
[14] Additionally, the treatment may be partially driven by unobservable factors to the econometrician (Angrist, 2006; Dam and Koetter, 2012).
[15] Dam and Koetter (2012) define this variable as the difference between the vote share of total votes cast for the governing coalition less the vote share cast for the strongest opposition party per municipality in state parliament elections.
[16] We use a propensity score matching technique based on a probit model procedure.

development of our testable hypotheses. Section 5 describes our empirical framework. Section 6 presents data and variables, while in Section 7 we report the results. Section 8 provides our concluding remarks.

2. Institutional Background: Public Bailouts in Europe

As of the wake of the 2007 financial crisis, governments and other public authorities launched emergency measures to stabilize the functioning of the European banking sector and to mitigate the negative externalities of bank defaults on the real economy. According to the European Commission State Aid Scorecard (2012),[17] in 2011 EU-governments allocated more than € 3 trillion to bail their credit institutions out under the coordination and close cooperation of the Council of the European Union, the European Central Bank, and the European Commission.

The public interventions were launched across Member states in accordance with guidelines of the Economic and Financial Affairs Council (Ecofin) and as long as they were temporary, of limited amount, and based on the scrutiny of European public authorities to ensure the *level-playing-field* in the European banking industry and to avoid any abuse onto taxpayers' funds.

To counterbalance the spillover effects of the crisis, each member state proceeded differently to fund banks. Generally, all rescue measures may be related to three different categories: i) state guarantee schemes, ii) recapitalization, iii) provision of loans (e.g. credit lines and liquidity facilities), iv) "bad banks" measures, and v) nationalization of distressed financial institutions. Each one of the emergency measures had a specific aim. The guarantee schemes were aimed at calming markets by lowering risk-premia and at preventing potential bank runs. The public authorities made extensively use of recapitalizations to restore banks' capital base. Last but not least, a number of public authorities has also introduced the provision of loans to strengthen bank's liquidity positions. Finally, and in the worst cases, public authorities resorted either to purchasing of impaired assets by taking over the related risks inherent in them or to nationalizing distressed banks with the aim of restructuring them.

[17] http://ec.europa.eu/competition/state_aid/scoreboard/index_en.html

3. Related Literature and Contributions

The first strand is related to the previous literature on the impact of macroeconomic and financial sector policy responses to counterbalance the effects of financial crises (Baba and Packer, 2009;Aït-Sahalia et al., 2012; Pennathur et al., 2014 Fiordelisi and Ricci, 2016). These policies have the general aim to restore the confidence in the financial investors and handle with the potential fragilities of the banking system in short-term period.

The closest strand is the large empirical literature on the effect of public bailouts on rescued banks. Past studies analyze the value of banks' financial claims (Veronesi and Zingales, 2010) bank's liquidity creation (Berger et al., 2016), lending activities (Diamond and Rajan, 2000; Diamond, 2001; Giannetti and Simonov, 2013), and risk-taking (Dam and Koetter, 2012; Gropp et al. 2011; Duchin and Sosyura, 2014). In principle, public bailouts have stabilizing effects especially during financial crises since they may impinge on the cutback of bank's risk (Bhattacharya et al., 1998; Diamond and Rajan, 2005; Hoshi and Kashyap, 2010) allowing the survival of undercapitalized banks and the repayments of bank's creditors.

The third strand of the literature our study is related to is the emerging body of research on the spillover effects of public bailouts on rescued bank's competitors. Indeed, there are some evidence and theoretical arguments outlining the possibility that government interventions affect not only bailed-out banks but also non-bailed-out banks (Acharya and Yorulmazer 2007; Hakenes and Schnabel, 2010; Gropp et al., 2011; Calderon and Schaeck, 2016). Such public policies might distort the competition in the banking industry. Although public bailouts have the stabilizing effect to support the survival of undercapitalized banks, the presence of rescued weak banks (not exiting the market) distorts the optimal resource allocation undermining the competition. Indeed, as well as arguing the bank's possibility to anticipate public bailouts, Gropp et al. (2011) show that a higher protection of the banking industry may encourage a stronger competition among financial institutions by tightening bank's margins.

The starting point for our paper is Gropp et al. (2011): in comparison with other papers in the literature which analyze the effects of public bailout policies on banks' risk-taking, the authors focus not only on the effects of government bailout on *protected banks'*[18] risk-taking, but also on the competitive effects of these policies across OECD countries in the year 2003. To this end, they construct a measure of bailout perception based on bank rating data to understand the effect of such government policies on the risk-taking of competitor banks and rescued banks. Briefly, they find that government guarantees increase the riskiness of competitor banks, but they do not find any evidence that such policies affected *protected banks*. Nevertheless, their article does not take into account effective support measures to banks (e.g. recapitalization, guarantees, and provision of loans) and refers to non-crisis period.

In lights of these considerations, this analysis can be considered both an exploration and the extension of the literature on the effects of public interventions on bank's risk along four dimensions. First, this is the first paper investigating on the effects of public bailouts on bank's risk at *bank-level* across 15 European countries. In fact, other paper in the literature are "one-country setting" studies (Bayazitova and Shivdasani, 2012, Dam and Koetter, 2012; Gropp et al., 2013; Berger et al. 2016). It allows us to take into account the variation in crisis management across countries. Second, to the best of our knowledge, this is also the first paper analyzing empirically the effects of public bailouts on the competition at bank-level over the financial crisis. Calderon and Schaeck (2016) provide some evidence on the distortive effects of public bailouts on the competition but at country-level. Third, in our investigation we cover the whole financial crisis period including both the US-mortgage crisis and the sovereign debt crisis periods, while other papers focus mainly on period of limited turbulence (Dam and Koetter, 2012; Berger et al., 2016). It is more appropriate this setting here since it allows us to evaluate how such policies work on the bank's behavior in the aftermath of the financial crisis. This is also consistent with the growing literature on other public interventions upon the banking

[18] In Gropp et al. (2010), protected banks are those financial institutions protected by government guarantees.

system (Fiordelisi and Ricci, 2016). Fourth, this paper aims at examining the market reaction of European financial market to the announcements of national public bailout programs (or in absence of the entry into the force of the programs) to evaluate whether these interventions are value-enhancing for international investors in the short-term period. Past studies focus mainly on the impact of other macroeconomic and financial sector policies with little emphasis on bailout programs with the only exceptions of Veronesi and Zingales, (2010) and Fiordelisi and Ricci (2016). Complementarily to these studies, we analyze both the market reaction to the national announcements of these policies for those banks located in the country where the announcement takes place and the cross-country reaction of the banks in other countries in Europe.

4. Testable Hypotheses

In this section, we develop our hypotheses. In the first sub-section, we develop the hypotheses related to the market reaction of EU-banks to national bailout program announcements. In the other two sub-sections, we develop the hypotheses referring to the effect of public bailouts on bank's risk and activities and the spillover effects of public bailouts on non-bailed-out banks respectively.

4.1 Market reaction to public bailout programs

International investors pay attention to policy actions. The goal of bailout rescue programs is to restore the confidence in financial markets (Veronesi and Zingales, 2010; Bayazitova and Shivdasani, 2012; Fiordelisi and Ricci, 2016). For this reason, governments and other public authorities may find optimal to announce policy interventions. These interventions may create value for banks in the short-term period. On the one hand, during a period of generalized distresses in the economy, the banking system could be subject to bank-run of short-term creditors since they might refuse to roll their short-term lending over (Veronesi and Zingales, 2010). In the seminal paper of Diamond and Dybvig (1983), the scholars demonstrate that bank runs are not efficient for the banking sector. Thus, the shareholders indirectly may find beneficial a policy intervention aimed at preventing a potential bank-run. The reaction might have worth especially for those banks being more likely to experience a bank-

run. On the other hand, interventions might create also a negative effect on bank's value. For instance, when a bank is involved in a rescue package program (or any other authority), its shareholders might react negatively to the announcement (Fiordelisi and Ricci, 2016) since the bank might experience either restrictions or prohibitions on bank's activities and corporate decisions (Sapienza, 2004; Berger et. al., 2016) by not maximizing their value.

Based on these two conflicting arguments, we might expect both a positive and negative reactions to these policy announcements.

4.2 Direct effects of Public Bailouts on Bank's Risk

In principle, public bailouts have the primary role to relieve troubled financial institutions by lowering their intrinsic riskiness and strengthening bank capital base. However, the literature provides mixed results on the effects of public bailouts on bank's risk.

Some studies argue that public bailouts increasing banks' survival odds through a better level of capitalization. This is particularly confirmed during banking crises (Richardson and Troost, 2009, Berger and Bouwman, 2013). Additionally, public bailouts can also crowd out risk-incentives because rescued banks raise funds at lower refinancing costs than their non-rescued competitors by experiencing higher charter values[19] and, thus, better margins. Hence, because of lower refinancing costs, banks exert more monitoring efforts (Gropp and Vesala, 2004, Mehran and Thakor, 2011) and are less prone to pursue risky strategies to avoid losing this rent.

Along the same lines as the Merton's argument (1977) about the deposit insurance scheme, other set of studies demonstrate public bailouts might encourage banks to take additional risk in order to maximize the value of the put-option against the public authorities in charge of the rescue packages (Hovakiminian and Kane, 2000; Laeven and Valencia, 2012). This problem is more pronounced especially as the number of bank defaults increases in the economy (Acharya and Yorulmazer, 2008).

[19] Following Keeley (1990), charters might be considered the recognised rent to the bank about the possibility to be able to refinance at subsidized rates below the market-rate.

Thus, the relation between public bailouts on bank's riskiness is not a clear *a priori* since it depends on whether the charter values explanations dominates (or compensates) the moral hazard argument, or vice versa. Cordella and Yeyati (2003) posit theoretically that the net effect of public bailouts on bank's risk depends on the trade-off between the two conflicting effects.

4.2 Competitive effects of Public Bailouts

Although we have a relation in mind about the spillover effects of public bailouts on non-rescued banks we borrow some hints on the previous theoretical frameworks (Acharya and Yorulmazer, 2007; Hakens and Schnabel, 2010) to develop the other set of testable hypothesis. Besides the direct effect of the public bailouts on rescued bank's risk, the theoretical and empirical literatures argue also about a competitive effect of such policies. On the one hand, supporting *too-big-to-fail institutions* may have beneficial effects – both in short-run and in long-run periods - on other competitors because of the well-known interconnected nature of financial markets (Zawadowski, 2013). The presence of public bailouts reduces the possibility of endangering bank's counterparts and the real economy (DeBandt and Hartmann, 2000). On the other hand, government interventions on ailing banks may also create economic distortions in the common *level-playing field* inducing banks to anticipate the future bailouts (Claessens, 2009a; Calderon and Schaeck, 2016). Hakenes and Schnabel (2010) argue that the possibility of future bailouts increases the bank's risk of *protected banks'* competitors because these policies create incentives for protected banks to expand by depressing the competitors' margins due to a higher level of rivalry in the deposit market. This distortion is even more severe in presence of generalized distressed in the banking industry (Acharya and Yorulmazer, 2007). Indeed, banks herd ex-ante their rescued-peers in order to increase the likelihood of being bailed out by worsening the level of risk and the quality of their lending activities. Thus, we expect that public bailouts are associated to an increase in the rescued bank competitor's risk.

[INSERT TABLE 1]

5. Methodology

5.1 Market reaction to public bailout announcements: Event study

We estimate the valuation effects of the policy announcements of national programs by using an event study approach. Unlike other papers in the literature, we document both the market reaction of banks located in the country where the national authority announces the program and the cross-country reaction of other banks located in any other country of our sample. For this purpose, we estimate the market reaction of all listed banks in sample countries over the period starting from 2007 through 2014 by estimating the daily Abnormal Returns (hereafter, ARs) as the difference between the stock returns and the estimated returns.

We run the event study over all the events listed in Table 2. For each event, we measure both the market reaction of all the banks located in the country where the public authorities announce the intervention and the cross-country reaction of all other banks located in any other country of the sample to the announcement of public intervention.

[INSERT TABLE 2]

To implement the event study, we employ the market model as described in McKinlay (1997), where the stock returns are expressed as a function of the market portfolio returns. As a proxy for the market portfolio, we use the MSCI EUROPE index. The specification is as follows:

$$R_{it} = \alpha_i + \beta_i R_{Mt} + \varepsilon_{it} \text{ where } E(\varepsilon_{it}) = 0,\ var(\varepsilon_{it}) = \sigma_{\varepsilon i}^2 \quad (1)$$

Consistent with previous works (among others, McKinlay 1997, and Fiordelisi and Ricci, 2016) we employ an estimation window of 252 days that ends 20 days before the announcement to calculate the market model parameters. Thus, the ARs are calculated as the difference between the actual stock returns and the predicted returns of the market model:

$$AR_{it} = R_{it} - (\widehat{\alpha_i} + \widehat{\beta_i} R_{Mt}) \quad (2)$$

Then, we aggregate the ARs over two-day (0,1) three-day (-1,1), and seven-day (-3,3) event windows respectively. Hence the CARs are obtained as follows:

$$CAR(t_1,\ t_2) = \sum_{t=t_1}^{t_2} AR_{it} \tag{3}$$

where t_1 and t_2 are the starting and the ending date of the event window chosen. It follows that the Cumulative Average Abnormal Return is calculated as:

$$CAAR(t_1,\ t_2) = \frac{1}{N}\sum_{i=1}^{N} CAR_{it} \tag{4}$$

5.2 Regression framework

We use a three-step approach to investigate on the direct effect of public bailouts on rescued banks' risk and the spillover effects of such policies on their competitors.

First, we focus on rescued banks by estimating the change in the bank's risk and the level of bank's activities during the years preceding and following the public bailout. For this purpose, we use the following dynamic diff-diff model with three lags and three leads:

$$\frac{Y_{i,c,t}}{Y_{i,c,t-1}} = \beta_0 + \sum_{S=-3}^{-1} \gamma_S\, Pre-Bailout(-s)_{i,j,t} + \sum_{S=0}^{3} \gamma_S\, Bailout(+s)_{i,j,t} + \sum_{m=1}^{M} \omega_m\, Controls_{i,t-1} + \delta_i + \delta_{sxt} + \delta_{cxt} + \varepsilon_{i,c,t} \tag{5}$$

where the dependent variable $\frac{Y_{i,c,t}}{Y_{i,c,t-1}}$ (*i* indexes bank, *c* indexes the bank home country, and *t* indexes the observation year) is the quotient of our measure of bank risk and activities. *Pre-Bailout* is a dummy variable taking the value of one if it "*s*" years before the bank received a public bailout and zero otherwise. For example, *Pre-Bailout -2* is a variable equal to one if it is two years before the bank received a public bailout, while *Bailout +2* is a variable equal to one if it is two years after the bank received the government intervention. The model is fully saturated with the year immediately

before the bank received the public bailout as the excluded category. Furthermore, the coefficients on *Pre-Bailout (-s)* and *Bailout(+s)* compare the level of each dependent variable "*s*" years before and after the public bailout. *Controls* is a vector of lagged variables[20] related to bank-specific and macroeconomic factors. Additionally, using bank-fixed effects allows that each variable is estimated using the within bank variation in the dependent variables. We also include bailout-year fixed effects to control for bailout-time level trends (δ_{sxt}) and the country-year fixed effects (δ_{cxt}). Finally, we use two-way clustered standards errors at bank and country levels (Petersen, 2009; Dam and Koetter, 2012).

As aforementioned, we estimate the regressions by quotienting the dependent variables (*RWA ratio*, *Liquidity assets ratio*, *NPLs ratio*, *Margins ratio*, and *Loans share*) by its lagged value. The reason lies in the fact that because of the financial turbulence during the sample period, we need to disentangle the effects of the crisis on bank's risk from those of the public bailouts to identify any presence of bank's moral hazard. We will explain later the variables of the empirical framework.

Evaluating the effect of such policies on bank risk and level of activities is challenging for different reasons. More specifically, public bailouts are not exogenous shocks since public authorities are more likely to assign them when a bank is in default. However, it may be argued that ailing banks may be aware of their status and modify their conduct endogenously (Dam and Koetter, 2012, Berger et al., 2016) so that naïve regressions ignoring this fact may lead to biased estimates. Hence, our regression setup is appropriate here to identify the effects of the public bailouts on rescued banks' risk and activities. Using lags and leads of the treatment variable (*Public Bailout*) may help to evaluate the presence of any anticipatory effects since banks make decisions not only the ground of past events but also formulating expectations of the future. Furthermore, this kind of econometric models allows to understand how quickly bank's risk (or other dependent variables used to test our hypotheses) grows/reduces after the public bailout take place and whether this impact accelerates, stabilizes, or

[20] All controls are lagged by one year to reduce simultaneity problems.

mean-reverts (Autor, 2003).

Then, we focus on the identification of rescued bank's competitors, namely those banks were not targeted by public authorities, but showed similar characteristics to the rescued banks. In our regression framework, this step is necessary to evaluate the effects of public bailouts on rescued banks' competitors and, thus, the spillover effects. Our analysis implicitly assumes that public bailouts may also influence non-rescued banks. This argument is not far-fetched. Many evidences and theoretical models in the literature (Hakenes and Schnabel, 2010; Gropp et al., 2011; Calderon and Schaek, 2016) outline that public bailouts might trigger changes in competitor banks conducts. The main explanation is that they increase the level of the competition in the banking system and decrease bank competitors' charter values. In contrast with Gropp et al. (2011), we follow an alternative strategy. First, we identify the non-rescued banks (having the same probability to be bailed out) not receiving a public bailout during the sample period. Second, we re-estimate the same fully saturated model for only non-rescued banks by excluding the rescued banks. In other words, we implement a propensity score matching (hereafter, PSM) technique, based on a probit model, in order to measure the spillover effects. This non-parametric approach results in the *ex-ante* probability of receiving a public bailout given a set of explanatory variables, namely the propensity score. The advantage of this procedure lies in the fact that allows identifying a reasonable counterfactual sub-sample of non-treated units with similar characteristics to rescued banks. Along the line of Bayazitova and Shivdasani (2012), we estimate the following probit model to estimate to propensity score matching:

$$\Pr\left(S_i = 1 | V_i\right) = \phi(Size_{i,c,t-1,}, Country_{i,c,t}) \quad (6)$$

where the dependent variable is a dummy taking the value of 1 if the bank has received at least one public bailout during the year from 2007 to 2014. As a key and identifying covariate we use the lagged value of bank's size ($Size_{t-1}$). This variable is often used as indicative for bank's business model, diversification benefits, returns of scale, and systemic risk (Bayazitova and Shivdasani, 2012).

Furthermore, once we compute the propensity score based on bank's size, we match rescued banks yearly by checking whether the matched banks are from the same home country of the rescued banks. In so doing, we use 5-nearest neighbor method that allows to identify the top 5 similar banks for each rescued bank in the same year of treatment. Finally, we generate *Matched*, which is a dummy variable taking the value of one if the bank *i*'s is selected in a given year among one of the top five similar credit institutions of a bank that received a public bailout at time *t* and zero otherwise. The latter variable is then used as a treatment variable to evaluate the spillover effects.

Finally, we now turn our attention on the spillover effects by estimating the following model using three lags and three leads:

$$\frac{Y_{i,c,t}}{Y_{i,c,t-1}} = \beta_0 + \sum_{S=-3}^{-1} \gamma_S \, Pre - Matched(-s)_{i,j,t} + \sum_{S=0}^{3} \gamma_S \, Matched(+s)_{i,j,t} + \sum_{m=1}^{M} \omega_m \, Controls_{i,t-1} + \delta_i + \delta_{sxt} + \delta_{cxt} + \varepsilon_{i,c,t} \quad (7)$$

The dependent variable is defined as before, namely the change in the given measure of bank risk and activities. *Pre-Matched (-s)* is a dummy variable takes the value of one if it is "s" before the bank has been selected as "matched bank" and zero otherwise. *Matched (+s)* is a dummy variable that takes the value of one if it is "s" year after the bank has been selected as "matched bank" and zero otherwise. Again, we include control variables, bank-fixed effects, and country-year fixed effects. Again, standard errors are double-clustered at bank and country level.

6. Data and Variables

To empirically investigate our hypotheses, we build a new hand-collected dataset with information on public bailouts in Europe for the period 2007-2014. Data on stock prices are from Datastream. Then, we collect bank balance sheet data from Bankscope.

The sample period starts in 2007, the year of the first bank bailout in European countries[21] in response to the financial crisis.[22] Furthermore, choosing 2014 as the final year of our sample period allows us to avoid potential distortions in our analysis due to potentially confounding events. For instance, since the beginning of 2015, the European Central Bank has put the quantity easing (QE) into practice.

To define our sample we start from the population of commercial banks,[23] reported in Bankscope, in 13 European countries, Iceland and Switzerland. We include Switzerland and Iceland for the relevance and interconnectedness of their banking system with the banks in the EU (Acharya et al., 2014; Bruno et al., 2018). Additionally, we consider only banks adopting IFRS accounting standards in order to avoid that our results are driven by differences in accounting standards (Onali et al., 2016). A total number of 417 financial institutions satisfied these search criteria. Then, we exclude institutions that are subsidiaries of foreign banks whose headquarters are not in Europe, since these banks are less likely to be rescued from national public authorities. Finally, for the sake of the comparability, we stipulate to consider only those banks having a value of total assets more than 1 billion with a proportion of total loans to total assets and of total deposits to total assets both more than 30%.

The final sample is composed of an unbalanced panel with 1,936 observations for 296 commercial banks.

[INSERT TABLE 2]

Table 2 and Table 3 show respectively the steps of the sample selection and a detailed description of the number of banks per country.

[INSERT TABLE 3]

[21] We consider Europe region all those banks whose headquarters are located respectively in Austria, Belgium, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, Switzerland, and the United Kingdom.
[22] Ryan (2008) highlights that the first effects of the financial crisis find evidence as of 2007.
[23] Commercial banks behave differently from other banks (e.g. investment banks and other specialized financial institutions) by showing distinctive incentives and competitive environments (Fiordelisi and Marqués-Ibanez, 2013). Second, the theory on bank's riskiness stresses mainly the lending and deposit bank activities (Cubillas et al., 2015).

6.1 Public Bailouts

We focus on bank bailouts performed by public authorities on EU-commercial banks between 2007 and 2014. Economists distinguish between explicit guarantees and implicit guarantees (among others, Gropp et al., 2011). The latter represent the market expectations that a financial institution is rescued even if there is no explicit governmental intervention on. For example, larger banks may presumably benefit from a *too-big-to-fail* protection and, thus, they are expected to be rescued more likely. We focus on the explicit measures since they are supposed to have more impact on banks (Philippon and Schnabl, 2013).

As mentioned before, there are several types of public bailouts. First, *recapitalizations* are at the core of different national rescue programs since they enhance the bank likelihood to survive during financial crises (Philippon and Schnabl, 2013). In fact, they are capital injections using public funding to strengthen bank capital base. In some cases, this emergency measure may also give rise to a nationalization whereby the government acquires a controlling equity stake in the distressed bank. Second, *guarantees* are commitments provided by national governments to repay bank's creditors and depositors as the bank may not be able to repay its creditors. They are issued in the effort to re-establish confidence in the banking system and avoid potential bank runs. In this regard, they may be both past or future oriented depending whether they refer to either existing obligations or future debt. Next, liquidity facilities are public interventions aimed to enhance bank liquidity provisions through the provision of loans (*Credit lines*). Finally, governments may also resort to *assets relief measures* which are particular public supports aimed at "relieving" banks from toxic or impaired assets.[24] In this context, there are two possible schemes. The government may either buy directly impaired assets from the financial institutions to prop up them or may arrange transfers of toxic assets to a public asset management agency responsible for the managing over the financial markets.

[24] Impaired assets are both all those assets incorporating high expected losses and long-term assets without incurring high losses, but "*that still need to be hived off the balance sheet, because of the negative carry they generate due to increased funding costs for banks*". (P.32, Boudghene and Maes, 2012).

[INSERT TABLE 4]

For the sake of exposition, we prefer using the term *public authorities* because the decision of bailing out financial institutions in Europe require the consultation of several public authorities (e.g., central banks, governments, supervisory agencies, bankers' associations). In some countries, there is the direct involvement of the government for the provision of bank bailouts (Ireland, Italy, Spain, and the United Kingdom), while in others special entities may rescue banks backed by national governments (Denmark, France, and Germany).

To test our hypotheses, we assume a broader definition of public interventions on banks during the crisis period. Specifically, we make use of a two-step procedure to construct the variable of our main interest, *Public Bailout*. First, we collect information on all different kinds of public interventions on banks across European countries of our sample by classifying them among recapitalizations, guarantees, and provisions of loans. Next, we define three dummy variables for each kind of public intervention: *i) Recapitalization* is a dummy variable taking the value of one if the bank *i*'s received a capital support at time *t* and zero otherwise; *ii) Guarantee* is a dummy variable taking the value of one if the bank *i*'s received a governmental guarantee at time *t* and zero otherwise; *iii)Liquidity facility* is a dummy that takes on the value one if the bank *i*'s received a credit line from public authorities at time *t* and zero otherwise. As the last step, we create a broader dummy which is a combination of the three dummy variables aforementioned. Hence, *Public Bailout* is a variable that takes the value of 1 if the bank *i's* received at least one of any kinds of public interventions at time *t*, and 0 otherwise.

Table 4 reports the number of public interventions over the sample period on banks by year and by country.

6.2 Measures of bank risk and activities

As mentioned, we use all the dependent variables in quotients $\frac{Y_{i,c,t}}{Y_{i,c,t-1}}$. In our regression framework we use various accounting measures for bank risk-taking and activities. Although it may be argued

that accounting data are affected by their well-known drawbacks of *backward-looking* measures, their use is appropriate here because the use of market data would drastically constrain our sample size,[25] which is mainly composed of non-listed commercial banks.

First, we consider *RWA ratio* which is calculated as the ratio between the bank's assets exposures weighted by their intrinsic risk and the bank total assets. It represents a bank measure of riskiness from the supervisory viewpoint. As proxies for bank activities, we consider four other measures: i) *Loans share*, ii) *Margins ratio*, iii) *NPLs Ratio*, and iv) *Liquid assets ratio.* To capture the bank-lending activities, we use *Loans share*, defined as total loans to total assets. *Margins ratio*, defined as net-interest margins to total assets, is auxiliary to test the charter value explanations and to understand whether non-rescued competitors are more likely to behave more aggressively after their peer have been bailed-out (Hakenes and Schnabel, 2010, Calderon and Schaeck, 2016). To understand whether banks lessening their monitoring in lending activities, we use a measure of the bank loan quality, namely *NPLs ratio*, obtained as the ratio between the amount of non-performing loans and bank's total loans. Finally, we consider *Liquid assets ratio* measuring the percentage of total assets that the bank may easily convert into cash.

6.3 Control variables

In the empirical analysis, we use a standard set of bank-specific controls. Furthermore, control variables are lagged by one year to reduce simultaneity problems. We use *Size* (the logarithm of bank's total assets) to control for bank's market power, returns to scale, business model. In addition, the inclusion of this variable is important to disentangle the risk effects of public bailouts and those implicit ones due to bank's size (Bayazitova and Shivdasani, 2012). In the spirit of Acharya and Thakor (2016), we also control for bank's capital adequacy/structure since it has been considered one of the main contributors of the 2007-08 financial crisis. Additionally, the bank risk-appetite literature provides some evidence that higher financial leverage may create some incentives for banks to pursue

[25] Our purpose is to preserve the sample size.

more illiquid and riskier lending activities (Adrian and Shin, 2010). For this reason, we use *Capital ratio* calculated which is given by bank total equity to total assets. Finally, we control for bank's profitability by using *ROA*, defined as the net income of the bank scaled by total assets. Additionally, we also include in the specifications *M&A dummy*, which is a dummy takes the value of 1 if the bank is involved in mergers and acquisitions and 0 otherwise.

6.4 Descriptive Statistics

In Table 5 Panel A, we report the descriptive statistics. For this purpose, we present mean, standard deviation, minimum, and maximum. At first glance, our data show a large variability across the banks during the sample period. For instance, the *RWA Ratio* ranges from a low of about 0.66 to a high of 1.27. Also, the other variables used to test our hypotheses show similar patterns in their range. The mean bank in our sample has 6.92 billion €, while its mean ROA is around 0.5%. Only 3% of our sample is involved in M&A activities.

In Table 5 Panel B, we also provide the univariate comparisons between bailed-out banks and non-bailed out banks along all array of variables used in our tests.[26] Specifically, we present the average values for bailed-out banks and non-bailed out banks and the p-values of two-sided t-tests. Unexpectedly, our evidence suggests that rescued banks do not differ statistically from non-rescued banks in terms of *RWA ratio*, *Margins ratio*, and *Liquid assets ratio*. Whilst, our tests provide some evidence that non-rescued banks have a higher (lower) variation in *Loans share* (*NPLs ratio*) than rescued banks.

Moving onto the control variables, our tests show that banks receiving a public bailout differ in terms of bank's size, capital, and profitability from those that do not: during the crisis, rescued banks are larger, less profitable and less capitalized than non-rescued ones. This evidence confirms previous results in Brei and Gadanecz (2012).

[INSERT TABLE 5]

[26] We run two-sided t-test by allowing for the unequal variance between rescued banks and non-rescued banks.

7. Results

7.1 Market reactions to bailouts programs

We first discuss the empirical findings focusing on the direct effects of the national announcement of public bailout programs for the beneficiary banks. Then, we discuss the results for the cross-country reaction to the national of public bailout programs for the banks located in any other country of our sample. Table 7 reports the results.

Panel A of Table 7 reports the results for the event study run on banks located to in the country where the announcement of national bailout programs take place. There is some evidence that investors of banks located in the country where there was the announcement react negatively to the policy intervention. The reaction ranges statistically from 10% (-1,1,) to 5% (-3,3), while the market reaction over a two-day event window is not statistically significant. A possible argument for this loss of significance might be due to the fact that market anticipates the national announcements (Bayazitova and Shivdasani, 2012; Acharya et al., 2014). The adverse reaction may be related to the possibility that government intervention may impose either restrictions on banks reducing their profitability or dilution of shareholding rights (e.g. votes, dividends). This is also in line with information-signaling perspective according to which the government commitment to national banks convey negative information about the wealth of the banking sector by raising uncertainty (Diamond, 1991).

Moving onto the evaluation of the spillover reaction to national announcement for banks located in other countries of our sample, the evidence suggests there exist contagion-effects, namely the possibility that negative events might have the potential to create external information effects for other banks (Diamond, 1991; Docking et al., 1997) located in other countries. Along the same line of the previous results, the reaction is statistically significance for two out of three event windows.

Overall, our results point toward negative abnormal returns related to the announcements (or the entry into the force of the related law) of national rescue programs across European countries. In fact, the aggregate effect on shareholders of European banks is negative. First, we document that national investors of banks do not welcome the announcements of policy intervention in their country. Second, we also document that the national announcements of rescue programs produce spillover effects in other countries by attracting negative abnormal returns.

7.2 The direct effect of public bailouts on bank risk

Table 8 reports the results on the relationship between public bailouts and bank risk. Our estimates show that public bailouts impinge on the bank's risk-taking positively. This effect is statistically and economically significant. In our sample, the mean value of *RWA ratio* is around 0.9672. Hence, our results suggest that banks increase their riskiness of around 20% (0.2018/0.9672) during the year in which the public bailout is imposed. Furthermore, the increases in the bank-risk taking are 30% after one year and 26% after three years from the public intervention, respectively. Then, Panel A also shows that relative to the three years preceding the public bailout, the pre-bailout indicator variables are not correlated with the quotient of *RWA ratio*. It allows excluding the presence of reverse causality.

[INSERT TABLE 8]

This result seems due to an increase in the level of lending activities. In particular, we find that *Loans share* increases respectively by 18.52% in the year of the policy intervention, 18.64% in the year following the bailout, 19.38% after two years from the rescue, and 13.35% after three years from the public bailout. There is also a similar increase in the fraction of non-performing loans. Although public bailouts may encourage and increase the supply of credit, they create bad incentives for lending decisions by encouraging non-performing loans. This is consistent with Giannetti and Simonov (2013).

Another interesting result of our evidences is that they are not supportive of the charter value hypothesis for European banks during the financial crisis. According to this theory, bailouts affect banks' risk taking through their implications on bank margins (Keeley, 1990). Although we find a positive relation between public bailouts and bank's margins, the coefficients for the post-bailout indicator variables are not statistically significant.

Finally, we find that in the post-bailout period, *Liquid assets ratio* drops drastically, and this result is economically and statistically significant. The mean value of Liquid assets ratio is 1.0149 during the sample period. It entails that Liquid assets ratio declines by 75%, 58%, 56% and 76% respectively during the following three years after the policy intervention. This result is coherent with Adrian and Shin (2010). When banks benefit from lower interest rates in the funding, they increase their risk-appetite (Mian and Sufi, 2010).

Hence, our evidences are consistent with the hypothesis that public bailouts affect bank conduct: when banks receive public bailouts, they increase their risk by augmenting their volume of lending activities and worsening its quality. In fact, although these policies may stimulate the supply of credit, they create incentives for banks to pursue riskier (*NPLs ratio*) and illiquid (*Liquid assets ratio*) strategies (Adrian and Shin, 2010).

7.3 Rescued banks' competitors

In this section, we identify the rescued bank's competitors. In our framework, we consider rescued banks' competitors, those banks having similar characteristics of the rescued banks (in terms of business model, market power, diversification strategies) but did not receive any public support during the financial crisis. For this reason, we resort to propensity score matching estimation procedure. The aim is to find the most comparable non-bailed-out units. Again, this procedure is auxiliary to investigate the spillover effects (or the competitive effects) of public bailouts on non-rescued banks.

The identification of those untreated peers (banks did not receive a public bailout but are similar to bailed-out banks) is related to three variables: bank's size (Bayazitova and Shivdasani, 2012), home-country and year of the intervention. The key idea is to identify for each rescued bank in the year of intervention its counterpart (similar size) *in* its same home-country. Thus, we report the results of cross-sectional probit regressions where the dependent variable is a dummy equal to 1 if a bank was rescued during our sample period from 2007 to 2014 and are reported in Table 8.

[INSERT TABLE 9]

As in Bayazitova and Shivdasani (2012), we find that the probability of receiving a public bailout is positively related to *Size*. This result is consistent with the view that banks with higher systemic risk are more likely to be rescued to avoid negative externalities for the banking system and the real economy.

Furthermore, in Table 8, we show the means of the two groups (treated and untreated), t-tests for equality of the means in the two samples, and the variance ratio respectively. The peers are not statistically different from their rescued counterparts. This result is further confirmed by the variance ratio (1.00) of treated over non-treated units (Austin, 2009), and Figure 1.

[INSERT FIGURE 1]

Finally, we report the goodness-of-fit of our propensity score matching estimation procedure by using the Receiver Operating Characteristic (*ROC*) curves.[27] This test allows understanding the quality of the matching based on probit regressions for the identification of untreated peers by comparing the true positive rate and the false positive rate. In our estimates, the area under the ROC curve is around 0.70.

Overall, our results show relatively good performance in the identification of the rescued banks' competitors.

[27] The ROC curve is estimated by comparing and plotting the true positive rate, labeled "*sensitivity*", and the false positive rate, labelled as "*1-specificity*", at various threshold settings.

7.4 Competitive effects of public bailouts

Now, we turn our attention on the spillover effects of public bailouts for non-rescued competitors. We refer to these banks as "matched" since we identified them through a propensity score matching procedure. Along the same line as before, our main independent variable to test the competitive effects of such policies is a dummy taking the value of one if the bank is among the top-five similar banks,[28] and zero otherwise. As dependent variables, we again use the variables explained in Section 5.2.

We make implicitly an identification assumption: public bailouts have spillover effects on non-rescued banks' competitors risk and activities. This argument is unlikely to be far-fetched because there are some theoretical explanations about the competitive effect of these policies (Acharya and Yorulmazer, 2007; Hakenes and Schnabel, 2010). Furthermore, the empirical evaluation of our assumption has an important policy implication: if such spillover effect is verified public interventions should be discouraged in order to avoid risk-increasing incentives in the bank's competitors during banking crises. Conversely, if no spillover effect is verified, it entails that public bailouts do not undermine the competition.

The econometric strategy follows the same lines of the regression framework used in the section 7.3 for the effects of public bailouts on rescued banks and is based on fully saturated dynamic difference-in-difference with three lags and three leads.

[INSERT TABLE 10]

Table 10 reports the results. We find that competitor banks endogenously increase their risk-taking in response to the bailouts imposed to rescued banks. In fact, the pre-matched indicator variable (*Pre-Matched –(1)*) for *RWA ratio* is statistically significant at 5%, while the coefficient on *Bailout (0)* is also statistically significant at 5% or better.

[28] We use a 5-nearest-neighbor matching on a propensity score.

Furthermore, when a peer received a public bailout, its competitors appear to experience drops in their margins. This link is statistically significant at 5%, and their margins decline from the year of the bailout to three years later. Since the mean of *Margins ratio* is 1.0018, the competitors' margins decline sharply by 24% in the year of the intervention, 47% one year later, 48% two years after the bailout, and 53% three years later respectively.

Hence, our results are consistent with the theory that the effects of public bailouts on banks' competitors run through their margins (Hakenes and Schnabel, 2010). When rescued banks receive a public bailout, they have incentives to expand the supply of credit aggressively by worsening the quality of their loan portfolios. In turn, the augmented protection of rescued banks determines a reduction of the competitors' margins (Gropp et al., 2011).

8. Conclusions

This paper is the first attempt to study the effects of public bailouts in Europe both on rescued banks and on rescued banks' competitors. Building a new hand-collected dataset on all European commercial banks for the period as of 2007 to 2014, our paper examines three timely research questions. First, we find that investors react negatively to national rescue programs. This might entails that European investors do not completely believe in the effectiveness of using taxpayers funds to prop up illiquid banks in the short-term period. Second, we examine whether public bailouts affect the conduct of rescued banks. We find that rescued banks increase their risk by augmenting the supply of credit at the detriment of the quality of their loans, measured as the fraction of non-performing loans. We also find that when banks benefit from lower interest rates in the funding due to the policy intervention, they increase their risk-appetite and pursue more illiquid strategies (Adrian and Shin, 2010 Mian and Sufi, 2010). Third, we document the presence of spillover effects of these policies running through rescued banks' competitors (Gropp et al., 2011).

Our evidence suggests a straightforward policy implication for the EU-banking system: public bailouts might undermine the overall financial stability. Hence, the optimal safety-nets in case of

bank distresses should minimize social costs due to the possible misconduct of beneficiary banks and the potential distortions in the competition.

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Tables

Table 8. Literature on the effects of public bailouts

This table summarizes the literature on the effects of public bailouts.

Panel A: Effect of Public bailout on Rescued Banks							
Authors	*Sample*	*Period of analysis*	*Level*	*Method*	*Dependent Variables*	*Key Variables*	*Main findings*
Gropp et al. (2010)	Cross-section of banks from all OECD countries	2003	Bank	OLS - IV approach	Problem loans ratio, risk asset ratio, liquidity ratio equity ratio	Measure of bailout perceptions based on rating information	There is no evidence that public guarantees increase the risk of protect banks, with the only exception banks having public ownership
Zingales and Veronesi (2010)	All US listed banks*	October 13, 2008	Bank	Event Study	-	-	US government interventions increase the value of banks' financial claims
Dam and Koetter (2012)	All German banks	1995-2006	Bank	IV approach	PD	Dummy variable: 1 if the regulator bails out the bank, 0 otherwise	Bank bailouts increase the probability of distress.
Duchin and Sosyura (2014)	521 US banks	2006-2010	Bank	Linear probability model with Difference-in-difference models	Dummy variable: 1 if the loans was approved and 0 if it was denied	Dummy variable: 1 in 2009-2010 and 0 in 2006-2008 – Loan-to-income	They find that approved banks (TARP) show higher risk-taking.
Berger et al. (2016)	Small and medium banks in Germany	1999-2009	Bank	IV approach	Δ[Z-score(ln)], Δ(RWA/total assets)	Dummy variable: 1 if the bank receives a capital support , 0 otherwise	They find that capital supports decline bank's risk-taking.
Panel B: Effect of public bailout on rescued banks' competitors							
Authors	*Sample*	*Period of analysis*	*Level*	*Method*			*Main findings*
Gropp et al. (2010)	Cross-section of banks from all OECD countries	2003	Bank	OLS - IV approach	Problem loans ratio, risk asset ratio, liquidity ratio equity ratio	Measure of bailout perceptions based on rating information	Government guarantees increase only the risk of competitor banks
Calderon and Schaeck (2016)	124 countries	1996-2010	Country	Difference-in-difference estimation	Lerner Index, Net interest margin	Dummy variables:1 in the year the intervention was announced, and 0 otherwise	They provide evidence that public bailouts increase the competition among banks.
This study	All commercial banks across 15 EU-countries	2007-2014	Bank	Fully satured dynamic difference in difference model	RWA Ratio, Liquidity Assets Ratio, NPLs Ratio, Margins Ratio	Dummy variable: 1 if the bank receives a public bailout, 0 otherwise	During the financial crisis public bailouts create risk-increasing incentives on rescued banks and spillover effects

Table 9.

List of significant events across all European 15 countries.

Date	Description	Country
30/09/08	The Irish government enacts legislation that guarantees the six major banks' liabilities.	IE
02/10/08	The Irish government launches the State Guarantee scheme.	IE
08/10/08	The UK treasury announces a package of rescue measures to ensure the financial stability.	UK
09/10/08	The Belgian government adopts State Guarantee Scheme.	BE
09/10/08	The Italian government adopts guarantees scheme.	IT
10/10/08	The Danish government adopts State Guarantees Scheme.	DK
10/10/08	The Spain government announces measures aimed at stabilizing its banking system.	ES
10/10/08	The prime minister of the Netherlands announces the recapitalization scheme.	NL
13/10/08	The government of the Netherlands announces a series of measures to ensure the financial stability.	NL
13/10/08	The UK ministers announce CGS.	UK
14/10/08	The Spanish government announces State guarantees scheme.	ES
14/10/08	Switzerland announces bank bail-out plan.	CH
16/10/08	French sets out Law on Finance including national bailouts.	FR
18/10/08	Germany adopts rescue packages scheme.	DE
20/10/08	The Irish government launches the Credit Institutions Scheme.	IE
20/10/08	The Portuguese parliament adopts a new law to provide guarantees to credit institutions.	PT
23/10/08	The Greek government adopts the GRL Scheme.	GR
23/10/08	CGS comes to effect in the Netherlands.	NL
27/10/08	The Austrian government announces the adoption of measures to stabilize the local banking system.	AT
30/10/08	Sweden government enacts the Stabilization plan.	SE
25/11/08	The Portuguese parliaments announces other recapitalizations for credit institutions.	PT
12/12/08	The Finnish government enforces State Guarantees Scheme.	FI
22/12/08	Irish government provides injections to the largest Irish Banks.	IE
19/01/09	UK government announces a second program (APS).	UK
28/01/09	The Italian government announces other recapitalization for banks.	IT
29/01/09	Announcement of the amendment of the stabilization plan in Sweden.	SE
03/02/09	The Danish government announces an amendment to extend guarantees to banks.	DK
11/02/09	Sweden: Government recapitalization scheme.	SE
11/03/09	The Irish government announces the adoption of the State loans scheme.	IE
21/11/10	The Irish prime minister announces the request for financial support to the European union and International Monetary Fund.	IE
04/02/11	The Danish government announces a change in the private sector financial support.	DK
06/04/11	The Portuguese government announces that it has requested financial support from the EU.	PT

Table 10. Steps of the sample selection

The table summarizes the research criteria used to define the sample of analysis

Steps	Search Criterion	Number of Banks
Steps 1	Commercial Banks adopting IFRS accounting standards in Bankscope in the World Region: Austria Belgium Denmark France Germany Greece Iceland Ireland Italy Netherlands Portugal Spain Sweden Switzerland UK	417
Steps 2	Removal of all subsidiaries of foreign banks	322
Steps 3	Removal of all banks with a proportion of total loans to total assets and of total deposits to total assets both less than 30% and a value of total assets less 1 billion	296

Table 11. Sample description

The table shows the sample composition by country.

Country	Banks	Sample %	Obs.	Sample %
Austria	9	3.04	71	3.67
Belgium	7	2.36	54	6.47
Denmark	19	6.42	123	6.35
France	21	7.09	165	8.52
Germany	8	2.70	58	3.00
Greece	15	5.07	104	5.37
Iceland	2	0.68	14	0.72
Ireland	6	2.03	40	2.07
Italy	100	33.78	642	33.16
Netherlands	20	6.76	129	6.66
Portugal	11	3.72	77	3.98
Spain	36	12.16	210	10.85
Sweden	12	4.05	56	2.89
Switzerland	5	1.69	29	1.50
United Kingdom	25	8.45	164	8.47
Total	296	100	1,936	100

Table 12. Distribution of Public Bailout by Year and Country, 2007-2014

This table shows the distribution of public interventions on banks in the European banking system between 2007 and 2014. Panel A reports the number of public bailouts performed by public authorities. Data on public bailouts are taken from Mediobanca bulletin and European Commission database. Panel A reports the description of public bailouts by year. Panel B depicts the distribution of public bailouts by country. "Recapitalizations" are a capital injection aimed at strengthen bank capital. "Guarantees" are any governmental commitment to repay bank's creditors and depositors in case of bank distress. "*Liquidity Facilities*" are public interventions aimed to enhance bank liquidity provisions through c*redit lines. "Assets relief measures"* are public supports aimed at "relieving" ailing banks from toxic or impaired assets.

Panel A: Distribution of Public Bailout by year				
Year	Recapitalizations	Guarantees	Liquidity facilities	Asset relief measures
2007	1	0	0	0
2008	8	8	1	2
2009	16	8	0	2
2010	6	5	1	1
2011	12	5	2	0
2012	9	10	1	2
2013	5	2	0	4
2014	1	1	0	1
Total	61	40	5	12
Panel B: Distribution of Public Bailout by country				
Country	Recapitalizations	Guarantees	Liquidity facilities	Asset relief measures
AT	4	3	0	1
BE	2	1	0	0
CH	0	0	0	0
DE	2	1	0	0
DK	2	1	2	0
ES	4	3	1	2
FR	0	0	0	0
GB	4	3	0	0
GR	23	12	1	3
IE	3	5	0	1
IS	0	0	0	0
IT	3	1	0	0
NL	6	4	1	3
PT	8	6	0	2
SE	0	0	0	0
Total	61	40	5	12

Table 13. Descriptive Statistics

This table reports summary statistics. Panel A reports for each variable the following statistics: number of observations (*N*), mean (*Mean*), standard deviation (*Std. dev*), the minimum (*Min*) and the maximum (*Max*). Panel B reports the means and the results for two-sided t-tests by allowing for the unequal variance between rescued banks and non-rescued banks. All variables are winsorized at the 5th and 95th percentiles (with the exception of *Size*).

Panel A: Descriptive Statistics

		N	*Mean*	*Std. dev*	*Min*	*Max*
Dependent variables for the key hypotheses (quotients: Y_t/Y_{t-1})						
RWA ratio$_t$	Risk weighted assets scaled by total assets	1300	0.9672	0.1393	0.6687	1.2711
Loans share$_t$	Total loans to total assets	1607	1.0062	0.1126	0.7896	1.2850
NPLs ratio$_t$	Non-performing loans scaled by total loans	1283	1.2540	0.4856	0.4730	2.5889
Margins ratio$_t$	Net-interest margins to total assets	1595	1.0018	0.1888	0.6625	1.4503
Liquid assets ratio$_t$	Liquid Assets scaled by total assets	1612	1.0149	0.3550	0.4726	1.9370
Control variables						
Size$_{t-1}$	Log of total assets	1623	16.0602	2.4013	9.8037	21.5128
Capital ratio$_{t-1}$	Total equity to total assets	1623	0.0792	0.0458	0.0240	0.2019
ROA$_{t-1}$	Returns to total assets	1623	0.0026	0.0094	-0.0235	0.0190
M&A $_{t-1}$	Dummy variable: 1 if the bank is involved in M&A activities and 0 otherwise	1623	0.0191	0.1369	0.0000	1.0000

Panel B: T-tests

	Non-rescued banks	*Rescued banks*	*Differences in means (p-values)*
Dependent variables			
RWA ratio$_t$	0.9676	.9575096	0.5394
Loans share$_t$	1.007246	.9840382	0.0595
NPLs ratio$_t$	1.242626	1.467333	0.0003
Margins ratio$_t$	1.002662	.9843199	0.4348
Liquid assets ratio$_t$	1.016092	.9894152	0.5386
Control variables			
Size$_{t-1}$	15.9635	17.8870	0.0000
Capital ratio$_{t-1}$	0.0811	0.0520	0.0000
ROA$_{t-1}$	0.0058	-0.0057	0.0000
M&A$_{t-1}$	0.0325	0.0274	0.7938

Table 14. Market reaction to national bailout programs.

This table shows the event study results for 32 announcements for national bailout programs across 15 countries of the European Union over the sample period (2007-2014). It reports Cumulated Abnormal Returns (CARs) the mean (expressed in percentage %) and the Z-statistics. The CARs are estimated over a three-day event window (-1,1), a two-day event window (0,1), and a seven-day event window (-3,3) and adjusted in line with Kolari and Pynnönen (2010) to allow for the cross-sectional correlation of abnormal returns. The reaction is estimated for the stock prices of all listed banks available in Datastream. Daily Abnormal Returns (ARs) are calculated by using the market model with a 252-day estimation window. We use the MSCI Europe as a proxy for the market portfolio. Panel A reports the results for the market reaction to the announcement of national bailout programs, while Panel B reports the results for the cross-country market reaction to the announcement of national bailout programs. ***, **, and * indicate significance at 1%, 5%, and 10% respectively.

Panel A: Market reaction to the announcement of national bailout programs		
	MSCI EUROPE	
	NAT_ANN	**213 obs.**
TEST	Media	Z
CAR(-1,1)	-2.1783%*	-1.6765
CAR(0,1)	-1.6704%	-1.4467
CAR(-3,3)	-2.6107%**	-1.9718
Panel B: Cross-country market reaction to the announcement of national bailout programs		
	MSCI EUROPE	
	SPILLOVER	**2644 obs.**
TEST	Media	Z
CAR(-1,1)	-0.6269%*	-1.8015
CAR(0,1)	-0.3369%	-1.1174
CAR(-3,3)	-1.3673%***	-2.5922

Table 15. The effects of public bailouts on bank's risk and activities

This table shows the results of the effects of public bailouts on bank's risk and activities. The dependent variables are expressed as the quotients respectively of *RWA ratio* (ratio between the bank's assets exposures weighted by their intrinsic risk and the bank total assets), *Loans share* (total loans to total assets), *Margins ratio* (Net interest income scaled by total assets), *NPLs ratio* (non-performing loans to total loans), and *Liquid assets Ratio* (total liquid assets to total assets). *Pre-Bailout* is a dummy takes the value of one if it is "s" year before the bank received a public bailout and zero otherwise. *Bailout* is a dummy takes the value of one if it is "s" year after the bank received a public bailout and zero otherwise. Our regressions include bank-specific and macroeconomic controls. All the controls are lagged by one year. *Size* is logarithm of total assets (€ thousands). *ROA* is calculated as net income scaled by total assets. *Capital ratio* is bank total equity to total assets. *M&A dummy* is a dummy variable takes the value of one if the banks is involved in M&A activities. Robust t-statistics are reported in parentheses. The specification includes year-country effects. Standard errors are double-clustered at bank and country level. All variables are winsorized at the 5^{th} and 95^{th} percentiles (with the exception of *Size* and other dummies). ***, **, and * indicate the statistical significance respectively at 1%, 5%, and 10%.

Variables	*RWA ratio (1)*	*RWA ratio (2)*	*Loans share (3)*	*Loans share (4)*	*Margins ratio (5)*	*Margins ratio (6)*	*NPLs ratio (7)*	*NPLs ratio (8)*	*Liquid assets ratio (9)*	*Liquid assets ratio (10)*
Pre-Bailout (-3)	0.0059	-0.0279	-0.0584	-0.0578	0.0525	-0.0611	0.0554	0.0960	0.4724	0.3951
	(0.0563)	(-0.3018)	(-1.0550)	(-0.9373)	(0.5547)	(-0.5971)	(0.2526)	(0.4317)	(1.6450)	(1.3730)
Pre-Bailout (-2)	-0.0469	-0.0716	-0.0899	-0.0909	-0.0159	-0.1793	-0.3227	-0.3006	-0.0583	-0.1264
	(-0.4495)	(-0.7512)	(-1.3120)	(-1.1591)	(-0.1596)	(-1.5303)	(-1.4292)	(-1.3307)	(-0.2540)	(-0.5073)
Pre-Bailout (-1)	0.1551	0.1151	0.0301	0.0213	0.0197	-0.1063	0.0219	0.0382	-0.1175	-0.1773
	(1.5895)	(1.1039)	(0.4069)	(0.2572)	(0.1448)	(-0.7788)	(0.0900)	(0.1615)	(-0.3832)	(-0.5573)
Bailout (0)	0.1691	0.2018*	0.1519	0.1864**	0.0876	0.0771	0.9210***	0.9619***	-0.7788**	-0.7601***
	(1.5933)	(1.6828)	(1.4836)	(2.0413)	(0.4462)	(0.4110)	(2.7067)	(2.9208)	(-2.5842)	(-2.7461)
Bailout (+1)	0.3050***	0.2915***	0.1657**	0.1876***	0.0758	0.0131	0.3735	0.4371*	-0.5418**	-0.5867***
	(3.3146)	(3.0144)	(2.5732)	(3.0286)	(0.4124)	(0.0720)	(1.4271)	(1.6847)	(-2.4602)	(-2.7871)
Bailout (+2)	0.1608	0.1334	0.0941*	0.1344**	-0.0894	-0.1078	-0.4541*	-0.3296	-0.5006**	-0.5698***
	(1.2605)	(1.1664)	(1.7066)	(2.2846)	(-0.5419)	(-0.6635)	(-1.9723)	(-1.2442)	(-2.4670)	(-2.9158)
Bailout (+3)	0.2098***	0.2548***	0.1583***	0.1951***	-0.1231	-0.1175	-0.0130	0.0074	-0.8433***	-0.7779***
	(4.1877)	(3.4526)	(3.2902)	(3.4364)	(-0.8053)	(-0.6948)	(-0.0913)	(0.0453)	(-5.6252)	(-4.8299)
$Size_{t-1}$		0.2448		-0.0942		-0.2598		-0.5148		0.3542
		(1.5931)		(-0.7916)		(-1.2077)		(-1.0795)		(1.1242)
$Capital\ ratio_{t-1}$		-0.8969		-1.9068		2.5183		-4.7832		4.1580
		(-0.5413)		(-1.4106)		(1.2333)		(-1.3127)		(1.2889)
ROA_{t-1}		-6.5400		-0.8902		-7.6413		6.7116		-13.0740
		(-1.1123)		(-0.2938)		(-1.6406)		(0.5879)		(-1.3460)
$M\&A\ dummy_{t-1}$		0.0603		0.0741		-0.2746**		0.1111		-0.0702
		(0.9594)		(1.2481)		(-2.5501)		(0.6511)		(-0.4955)
Observations	244	244	244	244	244	244	244	244	244	244
R-squared	0.259	0.345	0.362	0.398	0.288	0.383	0.328	0.338	0.353	0.370
Number of bank	134	134	134	134	134	134	134	134	134	134
Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Bank FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time x Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Bailout x Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country

Table 16. Finding rescued banks' competitors

This table shows the propensity score matching estimations. We estimate the propensity score matching using probit model specification. The propensity score matching is based on k-nearest neighbor method with *k=5*. The dependent variable is a dummy variable that takes the value of one if the bank has received a public bailout during the period from 2007 to 2014. *Size* is lagged by one year to reduce simultaneity concerns. The regression uses standard errors which are clustered at bank level. At bottom, we also report the *ROC test* based on the evaluation of the Receiver Operating Characteristic (*ROC*) curves illustrating the goodness-of-fit of the predictive propensity scores. Standard errors are clustered at bank and country level. ***, **, and * indicate the statistical significance respectively at 1%, 5%, and 10%.

Variables	*Bailout*
$Size_{t-1}$	0.1352***
	(3.7952)
Intercept	-3.9123***
	(-6.7750)
Observations	1,623
Number of banks	293
Diagnostics for propensity score matching	
Treated mean	70.6301
Control group mean	70.6086
T-test (p-values)	0.996
Variance Ratio	1.0000
ROC curve	0.7036

Table 17. Spillover effects of public bailouts.

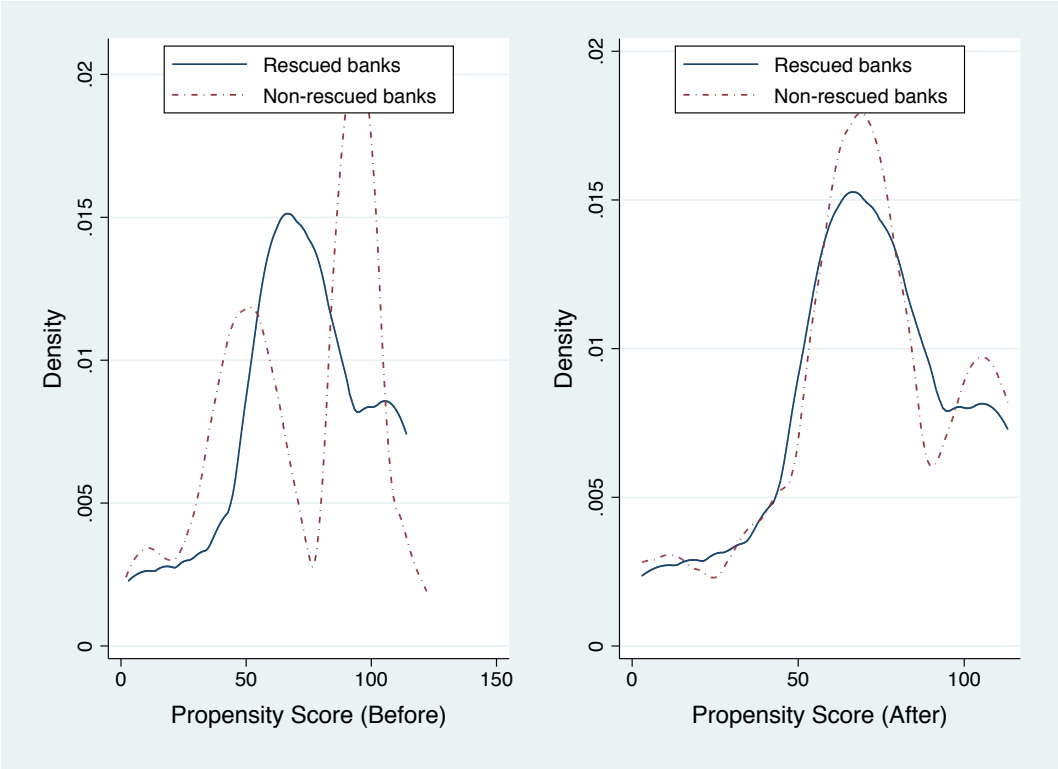
This table shows the results of the effects of public bailouts on bank's risk and activities. The dependent variables are expressed as the quotients respectively of *RWA ratio* (ratio between the bank's assets exposures weighted by their intrinsic risk and the bank total assets), *Loans Share* (total loans to total assets), *Margins ratio* (Net interest income scaled by total assets), *NPLs Ratio* (non-performing loans to total loans), and *Liquidity Assets Ratio* (total liquid assets to total assets). *Pre-Matched (-s)* is a dummy variable takes the value of one if it is "s" before the bank has been selected as "matched bank" and zero otherwise. *Matched (+s)* is a dummy variable that takes the value of one if it is "s" year after the bank has been selected as "matched bank" and zero otherwise. Our regressions include bank-specific controls. All the controls are lagged by one year. *Size* is logarithm of total assets (€ thousands). *ROA* is calculated as net income scaled by total assets. *Equity ratio* is bank total equity to total assets. Robust t-statistics are reported in parentheses. The specification includes year-country effects. Standard errors are double-clustered at bank and country level. All variables are winsorized at the 5^{th} and 95^{th} percentiles (with the exception of *Size* and other dummies). ***, **, and * indicate the statistical significance respectively at 1%, 5%, and 10%.

Variables	*RWA ratio (1)*	*RWA ratio (2)*	*Loans Share (3)*	*Loans Share (4)*	*Margins ratio (5)*	*Margins ratio (6)*	*NPLs Ratio (7)*	*NPLs Ratio (8)*	*Liquidity Assets Ratio (9)*	*Liquidity Assets Ratio (10)*
Pre-Matched (-3)	0.0998	0.1108	-0.0766	-0.0844	-0.3359	-0.3366	-0.6382	-0.7273*	-0.8482**	-0.8772**
	(0.7991)	(0.8529)	(-0.8456)	(-1.0122)	(-1.2994)	(-1.3442)	(-1.5068)	(-1.6632)	(-2.3330)	(-2.2693)
Pre-Matched (-2)	0.1472	0.1902	-0.0795	-0.0805	-0.1142	-0.1249	-0.4567	-0.5652	0.2408	0.2057
	(1.5223)	(1.6099)	(-1.4313)	(-1.6089)	(-0.5709)	(-0.7360)	(-1.2136)	(-1.3542)	(1.0072)	(0.7288)
Pre-Matched (-1)	0.1744**	0.2198*	-0.0390	-0.0434	-0.1566	-0.1926	-0.4891	-0.6154	0.3105	0.2581
	(2.0292)	(1.8513)	(-0.8054)	(-0.9516)	(-0.8459)	(-1.3847)	(-1.4715)	(-1.6174)	(1.3689)	(0.9023)
Matched (0)	0.1752***	0.2352**	-0.0035	-0.0021	-0.2176	-0.2459**	0.0715	-0.0499	0.1480	0.1032
	(6.3624)	(2.5716)	(-0.1019)	(-0.0713)	(-1.2062)	(-2.0789)	(0.5735)	(-0.2778)	(0.6572)	(0.3575)
Matched (+1)	0.1677*	0.2385	-0.0591	-0.0629	-0.3998	-0.4700**	-0.1301	-0.2950	0.3227	0.2457
	(1.7325)	(1.5340)	(-0.7604)	(-0.8603)	(-1.5274)	(-2.4373)	(-0.3982)	(-0.7317)	(0.9631)	(0.5896)
Matched (+2)	0.1852*	0.2293	-0.0114	-0.0206	-0.4605*	-0.4813**	-0.2894	-0.4603	0.0286	-0.0323
	(1.7928)	(1.5436)	(-0.1886)	(-0.3520)	(-1.8726)	(-2.4649)	(-0.7995)	(-1.1311)	(0.0963)	(-0.0879)
Matched (+3)	0.1910	0.1880	-0.1445*	-0.1618**	-0.5500**	-0.5328**	-0.8552*	-0.9968*	0.4716	0.4305
	(1.5117)	(1.2050)	(-1.9279)	(-2.1038)	(-2.1135)	(-2.6121)	(-1.6957)	(-1.8597)	(1.5522)	(1.2171)
$Size_{t-1}$		0.4104**		0.1008		-0.0036		-0.2109		-0.0080
		(2.2942)		(0.8209)		(-0.0154)		(-0.3724)		(-0.0201)
$Capital\ ratio_{t-1}$		0.7768		0.0719		3.7190*		-3.5628		0.5973
		(0.3766)		(0.0562)		(1.7289)		(-0.8393)		(0.1924)
ROA_{t-1}		-4.5824		-2.9455		-10.8317**		-5.7767		-7.6406
		(-0.8010)		(-0.9820)		(-2.2380)		(-0.4896)		(-0.8285)
M&A dummy	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Observations	203	203	203	203	203	203	203	203	203	203
R-squared	0.169	0.266	0.425	0.446	0.432	0.484	0.313	0.322	0.435	0.441
Number of bank	114	114	114	114	114	114	114	114	114	114
Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
Bank FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Time x Country Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Matched x Year FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Cluster SE	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country	Bank & Country

Figures

Figure 1. Balancing for propensity score matching

The figure reports the performance of the balancing test between rescued banks and non-rescued banks for the pre-treatment period (left-hand side) and post-treatment period (right-hand side).



Paper 3: Government interventions and gender diversity in bank's boards in Europe

Abstract

We are the first to examine the impact of gender diversity in bank boards on the probability and size of public bailouts. Our findings, based on a sample of listed European banks over the period 2007-2013, suggest that banks with a more gender-diverse board are less likely to receive a public bailout, and receive a lower amount of bailout funds (in the form of credit lines and capital injections) as a percentage of total assets. Specifically, an increase by one standard deviation in gender diversity decreases the probability of a bailout by at least 4%. Gender diversity is also negatively related to bank risk as proxied by the ratio of non-performing loans to total loans and positively related to bank profitability as proxied by ROA. Furthermore, consistent with previous literature, we also find that more gender-diverse bank boards have higher payout ratios, consistent with an agency costs hypothesis. Our findings are robust to a variety of econometric techniques, including instrumental-variables estimation.

1. Introduction

"When there is a very difficult situation, women are called in to do the work. To sort out the mess."
Christine Lagarde, IMF Managing Director

Does gender diversity in boards affect bank conduct? Are banks with a significant presence of women on their board of directors more or less likely to need a government bailout during banking crises?

In this paper, we are the first to provide evidence on the influence of women in bank boards on the probability of receiving a public bailout and the size of the bailout.[29] This is a timely question for bank regulators and academics alike, because of the public discontent arisen both in the US and in Europe with respect to the use of taxpayers' money to prop up illiquid banks. While recent academic papers have investigated the role of gender diversity in the executive board of German banks (Berger et al. 2014), there is currently no evidence about the impact of gender diversity in bank boards on the likelihood of a public bailout.

We bring to bear a unique hand-collected dataset on the presence of women on the board of directors of 105 listed banks in 15 European Union countries. Several recent papers have investigated the determinants of government bailouts in banks (among others, Bayazitova and Shivdasani, 2012, and Berger et al., 2016) but, to the best of our knowledge, this is the first study that seeks to determine the role of gender diversity.

Our main findings are as follows. First, Probit regressions and duration regressions indicate that an increase in gender diversity in bank boards leads to a lower probability of a public bailout. These

[29] In line with Dam and Koetter (2012) and Vallascas et al. (2017), we use the term "*public*" because the decision of rescuing banks usually requires the involvement of multiple public authorities (that is, public administrations, ministers of finance, central banks, and special entities).

findings are confirmed when we employ an instrumental-variables (IV) approach. Second, employing IV-Tobit and panel Tobit regressions to allow for left-censoring of the data, we find that banks entering the financial crisis with a more gender-diverse board need less public funds, in the form of capital injections and credit lines. However, we find mixed evidence that the proportion of female directors in bank board affects the amount of bailout funding granted in the form of guarantees.

We are also the first to document the mechanism through which board diversity may affect the probability of receiving a bailout. In particular, we focus on the following variables: bank profitability, bank risk, and bank dividend policy. Profitable banks, with a relatively low level of systemic risk are less likely to receive a bailout (Bayazitova and Shivdasani, 2012). Since previous literature suggests that gender diversity may affect dividend policy and share buybacks (Evgeniou and Vermaelen, 2017), and bank dividend policy also interacts with bank risk (Acharya et al., 2011; Onali, 2014) and monitoring incentives (Onali et al., 2016; Chen et al., 2017), we also investigate the relationship between gender diversity in bank boards and dividend payout ratios.

We find that gender diversity in bank board does not affect bank profitability as proxied by Tobin's Q, but it is positively related to ROA. We find evidence that gender diversity in bank boards affects bank risk, as proxied by the ratio of non-performing loans to total loans. In line with Chen et al. (2017), we find that more gender-diverse bank boards have higher payout ratios.

Our contribution to the previous literature is twofold.

First, we provide evidence that the economic impact of gender diversity on the probability of a bailout is substantial: considering the most conservative estimates from our regressions, an increase by one standard deviation in the fraction of female directors (10.01 percentage points)[30] leads to a reduction in the probability of a bailout by at least 4.80 percentage points (-0.0048 * 10.01 = 0.0481). As a comparison, an increase by one standard deviation in systemic risk (the main variable

[30] To clarify the magnitude of these effects further, it is useful to point out that the mean of board size is 13.9 (see Table 4). An additional woman on a board with 14 members increase in the fraction of women on the board by 1/14 = 0.0714 (that is, 7.14 percentage points). Therefore, an additional woman on board reduces the probability of a bailout by 0.0048 * 7.14 = 3.4 percentage points.

responsible for bailouts according to Bayazitova and Shivdasani, 2012) as proxied by Marginal Expected Shortfall (hereafter, *MES*), leads to an increase in the probability of a bailout by around 6 percentage points. Thus, in terms of economic magnitudes, gender diversity is less important than systemic risk for the probability of receiving a public bailout. However, it is more important than other variables such as bank capital adequacy, deposits, profitability, and growth opportunities.

Second, previous empirical studies focus on bailouts in the form of capital supports or capital injections,[31] overlooking that governments use different tools to restore financial stability (Philippon and Schnabl, 2013; Berger et al., 2016). However, public authorities used a variety of bailout measures to deal with generalised distress in the banking system (Dewatripoint, 2014). For instance, governments make use of guarantees, either on deposits to prevent market panic, or on debts to lower risk premia in capital markets. These alternative mechanisms are understudied, despite the fact that guarantees have been extensively used by governments. Importantly, the amount of bailout funding received by the banks in our sample is a staggering €2,073 million: €231 million for capital injections, €352 million for credit lines, and €1,490 million for guarantees.

We focus on European banks because of four reasons. First, the Eurozone crisis has protracted the period of financial instability in Europe started with the 2007-2008 financial crisis: we focus on a sample period going from 2007 to 2013, which includes the Euro Sovereign-Debt Crisis (started in late 2009), consistent with recent literature on policy interventions on banks (Fiordelisi and Ricci, 2016). This allows us to study a longer time series than for the US. Second, we are able to exploit information on a broad range of government bailouts (capitalizations, guarantees and credit lines), while studies based on US data consider only equity capital injections within the Trouble Asset Relief Program (TARP, Bayazitova and Shivdasani, 2012). Third, many EU-member states introduced both legal instruments and voluntary gender quotas to promote gender equality in decision-making positions (De Cabo et al. 2011, Ahern and Dittmar, 2012). However, it is unclear whether these

[31] Capital injections consist in capital supports at more favorable conditions in the effort of strengthening banks' capital. Capital injections have been at the core of rescue programs and they have been considered the most effective tool among a variety of rescue packages (Philippon and Schnabl, 2013).

reforms are binding and may lead to more stable banking systems. Finally, while the empirical literature on the impact of board diversity on bank profitability tends to focus on one country (Campbell and Minguez-Vera, 2008; Ahern and Dittmar, 2012; Berger et al., 2014; Liu et al., 2014), we examine a sample of banks located in 15 EU-countries. By investigating a cross-country sample, our study captures a higher degree of heterogeneity than previous literature (for example, Berger et al., 2016) in terms of institutional, socio-economic and cultural factors that may affect corporate governance in banks.

The remainder of the paper is structured as follows. Section 2 provides an overview about the institutional background for bank bailouts in the EU. Section 3 develops hypotheses that relate gender diversity in the boardroom to the probability of bank bailouts. Section 4 describes the dataset and the methodology. Section 5 reports the main results. Section 6 provides a discussion of the mechanism through which gender diversity affects the probability of a bailout. Section 7 concludes the paper.

2. Institutional Background

The recent financial crisis revealed drawbacks of the EU European Banking System both at the member-state level and at the aggregate level because of the absence of a comprehensive Pan-European regulatory and legal framework for the financial sector and, in particular, the absence of a single resolution mechanism and of a single supervisory mechanism (The Larosiére Group report, 2009).[32]

In response to the crisis, many European countries launched rescue measures to address funding problems in banks to restore confidence in the financial system and to limit negative externalities of

[32] These shortcomings led to the creation of the new European supervisory system, namely the Banking Union (BU). The BU is based on three pillars: the Single Supervisory Mechanism (SSM), the Single Resolution Mechanism (SRM), and the European Deposit Insurance Scheme (EDIS). The SSM confers to the European Central Bank (ECB) supervisory powers over banks deemed to be of "significant" importance for Euro-Area, while leaving the national supervisory agencies in charge of supervisory activities of banks outside of the SSM framework. The SRM manages the resolution process of banks in distress with the aim to reduce the cost of bank bailouts to the taxpayers by improving bank's incentives to operate prudently (De Haan et al., 2009). The EDIS, which was introduced in 2015 (outside of our sample period), is supposed to complement national deposit guarantee schemes (DGS). The main objective of EDIS is to reduce the extent to which national DGS are vulnerable to local shocks, and to mitigate two-way feedback effects between sovereign credit risk and banks (Acharya et al., 2014).

bank distress. The Member States allocated more than €30 billion to support financial institutions in accordance with the guidelines provided by the Economic and Financial Affairs Council (Ecofin).[33] European action plans consisted of three bailout measures: capital injections, credit lines, and guarantees. Each one of these rescue-packages had a specific aim. *Capital Injections*, the most common form of bailout packages in the aftermath of the last financial crisis (Philippon and Schnabl, 2013), aimed to strengthen banks' capital and to ensure the correct functioning and financing of the wider economy. *Guarantees* on deposits and debts had the objective to calm markets in an effort to lower risk premia. European governments used *Guarantees* extensively during the crisis period because they did not have to be recorded in the public budget, nor did they require any explicit legislative process. Finally, *Credit Lines* were employed in particular cases to enhance the liquidity position of impaired banks.

Although US and EU-member states rescue programs share many similarities in dealing with the financial crisis, there exist important institutional differences in both the supervisory approach to bank distress and in central banking features. For example, due to the widespread fragmentation and market-orientation of the US banking system, US supervisory agencies are generally inclined to enforce Prompt Corrective Actions (PCA), while European supervisors tend to exercise forbearance to avoid bank runs (Dermine and Schoenmaker, 2010). Moreover, the Federal Reserve supported financial institutions individually during the financial crisis, while Eurosystem's authorities, as we as the Bank of England, focussed on liquidity extension measures (Stolz and Wedow, 2010).

We report the main differences between the US and EU financial systems and approach to bank resolutions during our sample period in Table 1. In addition to the abovementioned discrepancies, the two frameworks diverge in terms of treatment of depositors in the resolution process (before 2015

[33] These principles require that:

i) the value of these rescue arrangements reflect their price in non-crisis market conditions;
ii) governments can enforce other conditions related to these arrangements, such as instructions for the financial institutions' management, restrictions on banking activities, and removal of management board members;
iii) the state aids be temporary, of a limited amount, and based on scrutiny of European Financial authorities to avoid any abuse onto taxpayers' money and disruptions to the *level-playing-field*.

only the US had national depositor preference) and approaches to address bank distress (supervisory actions and rescue measures). For example, EU authorities have to implement a concerted action plan for bank rescue measures, to avoid that national measures impair the functioning of the single market because of potential distortions in competition (Stolz and Wedow, 2010; Calderon and Schaeck, 2016).[34]

[INSERT TABLE 1]

3. Hypotheses Development: Gender diversity and Public Bailouts

Recent literature has investigated the factors affecting the likelihood to receive a public bailout (Faccio et al., 2006; Bayazitova and Shivdasani, 2012; Dam and Koetter, 2012; Berger et al., 2016) and, specifically, the effects of governance mechanisms on bailout probability (Vallascas et al., 2017). However, to the best of our knowledge, the literature has neglected gender diversity in bank boards as a factor that may impinge on the probability of a public bailout.

We argue that it is plausible that gender diversity may affect the probability that a bank receives a bailout. This hypothesis stems from previous literature which posits that gender diversity in boardrooms affects economic outcomes (i.e. Adams and Ferreira, 2009; Ahern and Dittmar, 2012). In particular, female directors may influence both bank profitability and risk (Matsa and Miller, 2013; Berger et al., 2014), and ultimately the probability that the bank receives a public bailout.

The risk-taking channel is important because the decision to rescue a bank depends mainly on a bank's financial distress costs and systemic risk (Bayazitova and Shivdasani, 2012), and female directors tend to be more risk averse and less confident than their male counterparts (Brody, 1993; Arch, 1993; Croson and Gneezy, 2009; Adams and Funk, 2012; Huang and Kisgen, 2013). Therefore, gender diversity may reduce bank risk-taking, and ultimately the probability that the bank needs a public bailout to avoid liquidation.

[34] As reported by Calderon and Schaeck (2016), government interventions during crises can affect banking competition.

A second channel through which gender diversity may reduce the probability of a public bailout is performance, because a key determinant for a public bailout is bank profitability (Dam and Koetter, 2012). Female directors are likely to exert stronger monitoring efforts, and gender diversity tends to improve the performance of firms with weak governance mechanisms (Adams and Ferreira, 2009). However, empirical contributions on the association between gender diversity in the board and firm profitability have provided mixed findings, both in the management literature (Kramer, 1991; Eisenhardt et al., 1997; Hillman et al., 2000; Hillman et al., 2002; Peterson and Philpot, 2007; Francoeur et al., 2008; Adams and Funk, 2012) and in the finance literature (Campbell and Minguez-Vera, 2008; Cheng, 2008; Adams and Ferreira, 2009; Ahern and Dittmar, 2012; Liu et al., 2014). probably due to discrepancies in the institutional and legal environments in different countries.[35] In particular, Campbell and Minguez-Vera (2008) find a positive impact of gender diversity on the profitability of Spanish firms. Similar results are provided by Francoeur et al. (2008) and Liu et al. (2014) for Canada and China, respectively. In contrast, Adams and Ferreira (2009) and Ahern and Dittmar (2012) provide evidence of a *negative* relationship between gender diversity and firm profitability.[36] Finally, Gregory-Smith et al. (2014) show that gender diversity in the board of UK companies does not affect firm performance.

In addition to the two channels above, the impact of gender diversity in boards on bank dividend policy may also play a role. Dividend payouts can be used as a monitoring device to decrease agency costs (Easterbrook, 1984; Abreu and Gulamhussen, 2013; Onali et al., 2016; Chen et al., 2017), because dividends decrease the amount of excess cash that insiders can invest in projects with a negative net present value (Jensen, 1986). Chen et al. (2017) report that gender diversity in corporate boards increases payout ratios for firms with weak governance structures, indicating that female

[35] There are also non-academic studies about gender diversity and corporate performance. A report by Credit Suisse (2012) about the impact of gender diversity on the performance of around 2,400 companies from 2005 to 2011 suggests that companies with at least one woman on the board tend to have better stock price performance than companies without women on the board. However, most of the outperformance occurred in the post-2008 period, suggesting that gender diversity on the board is particularly important in periods of falling stock prices and high volatility.

[36] Recent contributions provide two potential explanations for a negative relationship: women may exert stronger monitoring efforts than men, leading to higher monitoring costs and lower profitability (Adams and Ferreira, 2009); women may be less experienced, on average, than men (Ahern and Dittmar, 2012).

directors use dividends to decrease agency costs. However, Chen et al. (2017) focus on non-financial firms. Recent literature finds that the relationship between bank dividend policy and corporate governance variables is subject to dynamics which differ from those typical of non-financial firms (Abreu and Gulamhussen, 2013; Onali et al., 2016). In particular, banks may pay dividends to shift default risk to bank creditors and, in the case of bailouts, to the taxpayer (Acharya et al., 2011; Onali, 2014).

Empirical contributions on the relationship between gender diversity in boards and risk have provided conflicting findings (Matsa and Miller, 2013; Sila et al., 2016). For example, Berger et al. (2014) find a positive association between gender diversity in the executive board and bank risk in Germany, while Adams and Ragunathan (2015) and Sila et al. (2016) do not find any significant association between gender diversity and bank risk in the US. It is important to emphasise that the inconsistencies in these results may be due to different factors, such as: the proxy for risk used, the country under examination, and the type of banks examined. For example, Sila et al. (2016) focus on large listed companies (including Bank Holding Companies) in the US, while the sample used in Berger et al. (2014) consists mainly of unlisted German banks. Moreover, results from non-financial firms may not be valid for banks, because banks tend to have different governance arrangements (Adams and Mehran, 2003; Mulbert, 2010).[37]

The considerations above suggest that *ex-ante* the relationship between gender diversity in bank boards and the probability of a public bailout is unclear:

H1a: Banks with a more gender-diverse board are less likely to receive a public bailout.

H1b: Banks with a more gender-diverse board are more likely to receive a public bailout.

The hypotheses *H1a* and *H1b* are concerned with the probability of a bailout. However, we can also develop similar hypotheses about the size of the bailout received by a bank. Since bank size can

[37] Monitoring from a variety of stakeholders complicates the governance of financial institutions. For instance, bank regulators can act on behalf of depositors, and the government can actively seek to monitor bank conduct (Onali et al., 2016). Additionally, bank instability can lead to severe negative externalities (Adam and Mehran, 2003).

of course affect the overall amount of a bailout, we focus on the size of the bailout scaled by a bank's total assets. Consistent with *H1a* and *H1b* above, we put forward two additional hypotheses:

H2a: Gender diversity in bank boards reduces the amount public funds scaled by total assets.

H2b: Gender diversity in bank boards increases the amount public funds scaled by total assets.

4. Data and Methodology

This section describes the methodology and data. Section 4.1 describes our econometric strategy. Section 4.2 describes our dataset. Section 4.3 provides descriptive statistics.

4.1 Methodology

4.1.1 Estimating the probability of a bailout

To test our hypotheses, we first use a broad definition of "public bailout" which includes any kind of last-resort measures by public authorities to support ailing banks. To this end, we build the variable *Bailout*,[38] defined as a dummy variable takes on the value of one if the bank *i*'s receives a public bailout at time *t*, and zero otherwise.

To test *H1*, we rely on a Probit model, in line with previous literature on bank bailouts (Faccio et al., 2006; Bayazitova and Shivdasani, 2012):

$$E[Bailout_{i,t} | \, Gender\ Diversity, Controls\,] = \mathbf{\Phi}\ (Gender\ Diversity_{i,t-1}, Controls_{i,t-1}) \quad (1)$$

where $i = 1,2, \ldots N$ labels banks, while $t = 1, 2 \ldots T$ labels years. To reduce simultaneity concerns, we consider the first lag of the explanatory variables. We cluster standard errors on the bank-level to

[38] In further tests, we distinguish among different kinds of bailouts:

- *Capital injections*: a dummy variable that takes the value of one if the capital support for bank *i*'s at time *t* is provided and zero otherwise (Berger et al., 2016);
- *Guarantees*: a dummy variable that takes on the value one if one or more guarantees are provided for the bank *i*'s at time *t* and zero otherwise;
- *Credit lines*: a dummy that takes on the value one if the bank *i*'s at time *t* receives a favoured credit line from the government and zero otherwise.

Past studies document mainly the importance of capital injections (Philippon and Schnabl, 2013; Berger et al., 2016) as the core of rescue programs. However, in Europe guarantees played a very important role. In contrast with capital injections, guarantees require neither to be shown in public budgets nor to be allotted after an explicit legislative process. For these reasons, they were used extensively during the financial crisis and the Eurozone sovereign debt crisis.

correct for serial correlation in the errors within each bank and, in alternative specifications, on the country-level.[39] *Gender Diversity* is the percentage of female directors on the board of bank *i* at time *t* (Campbell and Mínguez-Vera, 2007; Gimeno and Nieto, 2012), and *Controls* is a vector of bank-specific variables and macroeconomic variables to allow for country-level time-varying factors that may affect bailout probability.[40]

We choose the variables to include in the vector *Controls* on the basis of previous literature on bank bailouts (Faccio et al. 2006; Bayazitova and Shivdasani, 2012; Dam and Koetter, 2012; Berger et al., 2014; Berger et al., 2016, Vallascas et al., 2017). In line with a *Too-Big-To-Fail* (TBTF) perspective (O'Hara and Shaw, 1990), we control for bank size, measured as the log of total assets (*Size*).[41] For robustness, we use as an alternative proxy for systemic risk the *Marginal Expected Shortfall* (hereafter, *MES*) (Vallascas et al., 2017).[42] We also control for the Market-to-Book Ratio (*MTB Ratio*), a common proxy for growth opportunities, and for bank profitability, proxied by *ROA* and *Tobin's Q*. The former is defined as the net income of the bank divided by total assets (Adams and Ferreira, 2009; Liu et al., 2014). The latter is measured as the ratio of market value of equity plus face value of debt divided by book value of equity plus the face value of the debt (Lindeberger and Ross, 1981; Adams and Ferreira, 2009; Onali et al., 2016).

We also allow for the potential impact of bank funding structure and asset composition: *Capital Ratio*, defined as bank equity capital to total assets (Gropp et al. 2011; Acharya and Thakor, 2016); *Tier 1 ratio*, defined as the Tier 1 regulatory capital to risk-weighted assets (Beltratti and Stulz, 2012);

[39] Since the bank clusters are nested within the country clusters, we cannot cluster on both levels at the same time. We consider clustering at the bank level in our baseline regressions because clustering at the country level may result in biased standard errors because the number of clusters is small (Cameron and Miller, 2015).

[40] We do not include fixed effects in our specifications because Probit models with fixed effects are inconsistent (Fernàndez-Val, 2009; Wooldridge, 2010; Brückner and Ciccone, 2010; Cole et al., 2017). Moreover, corporate governance variables are sticky (Zhou, 2001; Coles et al. 2012). However, we allow for the impact of bank fixed effects in further tests using panel tobit models (Honoré, 1992).

[41] As well as being a rough indicator of a bank's systemic relevance (Tarashev and Drehmann, 2013), *Size* is also a proxy for a bank's market power and a measure of diversification (Demsetz and Strahan, 1997; Gropp et al., 2011).

[42] *MES* is defined as the one-day loss expected if market returns are less than 2% and it is measured as at 31 December of a given year (Acharya et al., 2012).

Deposits Ratio, defined as the ratio of deposits divided by total assets;[43] *Liquid Assets Ratio*, calculated as the ratio of cash plus marketable securities to total assets (Wang et al., 2009); and the *Derivatives to Assets Ratio*, which is the amount of derivatives scaled by total assets (Bayazatova and Shivdasani, 2012). We control for ownership concentration, which may decrease bank risk according to some literature (Iannotta et al., 2007): we use the *Herfindahl-Hirschman Index* (hereafter, *HHI*), calculated as the sum of squared ownership shares for each recorded shareholder.[44]

We also consider an array of country-level variables commonly used in the banking literature as controls. This is necessary because bailout policies and bank performance could be influenced by institutional and macroeconomic factors (Faccio et al., 2006; Gropp et al., 2011). We control for the annual *GDP growth* (real), to allow for business cycle effects at the country level (Anginer et al., 2013). To capture changes in the probability of a bailout due to financial crises, we include two dummy variables: *US-Mortgage Crisis Dummy* takes on the value one for the years 2007 and 2008 (and zero otherwise); and *EU-Sovereign Debt Crisis Dummy* takes on the value one for the period from 2010 to 2012, and zero otherwise (Erkens et al., 2012; Arellano et al., 2012).

In further tests and consistent with the corporate governance literature, we also include controls on *Board size* (the log of the number of the board members) and *Board independence ratio* (the number of independent directors[45] divided by the number of board members) similar to previous literature (Erkens and et al., 2012; Vallascas et al., 2017). We also control for the presence of a female CEO (Faccio et al., 2016), using a dummy variable takes on value one if the CEO is female and zero otherwise (*Female CEO*).

[43] By scaling deposits by total assets, we measure the degree to which bank activities depend on deposits funding (Demsetz and Strahan, 1997; EBA, 2016).
[44] In the specifications related to the mechanism we also employ the dummy variable *Widely Held*, which is an indicator variable equal to one if there is no owner with more than 10% of bank share rights, and zero otherwise. This variable has been employed previously in the literature about bank risk taking (Laeven and Levine, 2009).
[45] To identify independent directors, we follow the same criteria followed by Onali et al. (2016).

4.1.2 Instrumental variables (IV) estimation

It may be argued that gender diversity is not exogenously determined, as may be the case for a number of corporate governance mechanisms (Coles et al., 2012). In our case, there could be a reverse causality problem between public bailouts and *Gender Diversity*: when a bank receives a bailout, dismissals of executives and board replacements may ensue (Berger et al., 2016). Moreover, in our specifications we may be omitting unobservable variables that are correlated with board composition.

For these reasons, in addition to a Probit model specified as described in section 4.1.1, we employ an IV-Probit model, based on a two-stage approach:

$$STAGE\ 1: Gender\ Diversity_{i,t} = f(IV_{i,t-1}, Controls_{i,t-1})$$

(2a)

$$STAGE\ 2: E[Bailout_{i,t} |\ Gender\ Diversity, Controls\ ] =$$

$$\boldsymbol{\Phi}\big(Gender\ Diversity_{i,t-1}, Controls_{i,t-1}\big) \quad (2b)$$

where *Bailout* is the probability that a bank receives a public bailout, and *Controls* is a vector of control variables (as discussed before).

IV-estimation methods rely on two assumptions: the relevance restriction requires that the instrument affects the potentially endogenous variable (*Gender Diversity*); and the exclusion restriction requires that the instrument is not directly correlated to the dependent variable (*Bailout*). To choose an appropriate instrument, we thus have to search for a source of exogenous variation in our main variable of interest, *Gender Diversity*. We borrow the idea for our instruments from Knyazeva et al. (2013) and Chen et al. (2017) who show that local labour market conditions affect board composition. We identify two instruments based on regional labour-market characteristics: *Female Participation Rate*, or the female labour force participation divided by the male labour force participation in the NUTS 2 region where the bank's headquarter is located; and *Female employment rate*, calculated as employment rate for women with tertiary education in the NUTS 2 where the bank's headquarter is located. Both of these instruments are likely to be positively correlated with

Gender Diversity, and therefore they satisfy the relevance restriction, a necessary condition for instrumental variables to be valid.

However, *Female Participation Rate* is based on the total number of women who are economically active in a particular region, and one may argue that this could be a weak instrument because board directors tend to be highly qualified individuals. For this reason, we also consider *Female employment rate*, which allows for the educational attainment of women, focusing on the regional employment rate of women with tertiary education only. We expect this instrument to have a larger coefficient than that of *Female Participation Rate* in the first-stage of our IV-regressions, because it is very likely that female board of directors have tertiary education.

The second necessary condition for the validity of our instruments is that they do not have any first-order effect on our dependent variable. Since the percentage of women in the local labour market is unlikely to bear a direct impact on the probability of financial distress of a specific bank, this variable also plausibly satisfies the exclusion restriction. In fact, the banks in our sample are large listed banks, for which geographical diversification occurs at the national (and possibly international level). For this reason, it is unlikely that local labour market conditions play an important role in the probability of distress of the bank (and *vice versa*). It may be argued, however, that the economic conditions of the country where the bank has its headquarters can affect the soundness of the bank, especially for countries for which there is a feedback effect between sovereign debt risk and the risk of the domestic financial sector (Acharya et al., 2014), and omitting such a variable from the analysis may generate omitted variable bias. For example, if economic growth is positively related to female labour participation and employment rates, then banks located in countries with higher-GDP growth rates may be more likely to have a higher value for *Gender Diversity*. For this reason, we allow for potential omitted variable bias by controlling for national GDP growth rate in our regressions (*GDP growth*).

Using regional labour market characteristics is also superior to using national labour market characteristics, because it reduces the probability that correlation between the instrument and the

endogenous variable depends on other national-level variables that are omitted from the analysis. In fact, one may argue that national-level labour market variables may be important factors in the decision making process of national governments when assigning bailouts to local banks. However, this last point is (in our view) rather weak, because a bailout cannot be granted without the approval of the European Commission (in particular, the Directorate General for Competition), which needs to consider potential distortions in competition resulting from a bailout (Dewatripoint, 2014).[46]

4.1.3 Duration models

As a robustness check, we also use survival data analysis to estimate the impact of gender diversity on the probability that a bank receives a bailout (Cox, 1972, Cleves et al., 2016, Chen et al., 2017). We employ both a Cox hazard model[47] and a parametric Weibull regression, and we estimate the probability that bank *i* receives a bailout since the start of the financial crisis.[48] More specifically, we implement the following regression setup:

$$\Pr\left(Bailout_t \middle| \mu[X_i = Gender\ Diversity_{i,precrisis}, Controls_{i,precrisis}]\right) =$$

$$= h_0(t) exp \sum_{i=1}^{n} \beta_i \mu(X_i) + Country\ FE + \varepsilon_i \quad (3)$$

We estimate the bank's probability of receiving a bailout as a function of the number of years starting from the beginning of the crisis to the end of the sample period as well the mean value of the variable of interest, *Gender Diversity* (and other control variables), across the pre-crisis period (2005-2006). Furthermore, to improve robustness, instead of using macroeconomic and institutional factors (see Section 4.1.1), we also consider in the specification country fixed-effects (*Country FE*). In

[46] It may be argued that national programs on gender-quotas in boards mandated by EU-15 governments (or other authorities) could be exploited as exogenous shocks that could be used as instrumental variables or for a difference-in-differences approach. However, as we show in Supplementary Appendix C, in most cases these quotas were for state-owned companies or companies with state ownership, therefore they were not binding for listed banks. Moreover, since the implementation periods of these regulations tend to fall after the end of our sample period (or before the start of our sample period) such an econometric strategy is infeasible. Finally, in some cases there were no specific sanctions for non-compliance. Italy is the only country for which the gender quotas apply to listed banks, are implemented between the start and end date of our sample period, and there are specific sanctions for non-compliance. In this case, we do observe an increase in the number of sample banks that comply with the quota from 1 (pre-quotas period) to 7 (post-quotas period).

[47] The Cox proportional hazard model (1972) is less restrictive than full parametric Probit regression since it requires fewer assumptions (that is fixing any distribution on the failure event) and fits better smaller samples (Cleves et al., 2016; Chen et al., 2017).

[48] If a bank receives more than a public bailout during the crisis, we consider the date of the first bailout.

further tests, we also estimate the bank's probability of receiving a bailout as a function of the number of days starting from the beginning of the crisis to the end of the sample period.

4.1.4 Tobit regressions for the size of the public bailout

Gender Diversity may not only affect the probability to receive a public bailout, but also the amount of funding granted to the bank. In particular, consider for each specific type of public bailout the total amount of funding scaled by total assets (*Public Funds*). Clearly, this is a censored variable, since

$$Public\ Funds^{*}_{j,i,t} = f(Gender\_Diversity_{j,i,t-1}, Controls_{j,i,t-1})$$

$$\text{where} \quad Public\ Funds^{*}_{j,i,t} = \begin{cases} Public\ Funds_{j,i,t} & \textbf{if } Public\ Funds_{j,i,t} > 0 \\ \mathbf{0} & \textbf{otherwise} \end{cases} \tag{4}$$

where j = 1,2, 3 labels the specific type of public bailout (*Capital Injections*, *Credit Lines* or *Guarantees*), i = 1,2, …N labels banks, and t = 1, 2…T labels years. The vector *Controls* is defined as before.

To test whether this is the case, we employ IV-Tobit models, with the same instruments as for the IV-Probit regressions above, as well as panel censored regression models (Honoré, 1992; Arena and Kutner, 2015), which allow for the estimation of limited dependent variables in presence of panel fixed effects.

4.2 Data and sample selection

To test our hypotheses, we build a new and unique hand-collected dataset with information on all public bailouts and board composition for listed banks in 15 EU-countries during the period from 2007 through 2013. Concentrating the analysis on listed EU banks is useful to improve the within-sample comparability of the banks from different countries, because these banks have to comply with IFRS and the market for their shares tends to be liquid.[49] Choosing 2013 as the final year of our

[49] These considerations are consistent with those put forward by Laeven and Levine (2009), who select an international sample of large banks because "*Focusing on the largest banks enhances comparability because they tend to comply with international accounting standards and have more liquid shares, reducing concerns that accounting or liquidity differences drive the results*." (p. 261).

sample period allows us to avoid potential distortions in the analysis caused by the Capital Requirements Directives (CRD) IV, which took effect on January 1, 2014. Since this directive implements the new rules introduced in Basel 2 and Basel 3 regulations on capital requirements, and because it is hard to disentangle the effect of this new regulation from other determinants of public bailouts, it is likely from 2014 onwards the data may contain noise due to the implementation of this reform. Our choice also allows for consistency with recent literature on policy actions on banks (Fiordelisi and Ricci, 2016).

Our sample selection steps are as follows. In the same vein as Onali et al. (2016), we select all banks defined by Bankscope as commercial banks, Bank Holding Companies (BHC), or cooperative banks. Second, we consider only listed banks, which adopt International Financial Reporting Standards (IFRS), to avoid confounding effects from differences in national accounting standards. Next, we select all banks for which information on total assets is available for at least one of the sampled years (resulting in 118 banks). Finally, we exclude financial institutions for which data on regulatory and other financial ratios are unavailable (13 banks) over the sample period. The final sample consists of 105 banks and covers the largest banks in EU-15.

Table 2 summarises the main steps of our sample construction. In the multivariate regressions below, some of the 105 banks exit the sample, and the exact number of banks entering each regression depends on the specification employed.

[INSERT TABLE 2]

Table 3 provides an analysis of the number of banks for each country and the sample representativeness in relation to the population of listed banks in the EU-15 over the sample period. While we select only a sub-sample of banks in the EU-15, our sample covers more than 90% of the whole European Banking System in terms of total assets, deposits or total lending.

[INSERT TABLE 3]

For our econometric analysis, we match data collected from multiple data sources. The data on public bailouts is from the document "*Public Support Measures in Europe and in the United States*",

available on Mediobanca's website (http://www.mbres.it/en/)[50] and the European Commission Database.[51] Bank-specific variables are collected from either Bankscope (balance sheet and income statement items) or V-Stern-lab (Marginal Expected Shortfall, *MES*). Information on macroeconomic and institutional factors variables is taken from AMECO database of the European Commission and the World Bank Database.

4.3 Descriptive Statistics

In this section, we discuss the distribution of bailouts across the sample period and we provide summary statistics for the main variables under examination. The total number of bailouts during the period from 2007 to 2013 was 140: 38 capital injections, 23 credit lines, and 79 guarantees. Figure 1 reports the distribution of public bailouts during the sample period. No bailout event occurred in 2007, and the majority of public bailouts took place in 2008 and 2009 (25 and 43 bailouts, respectively).

[INSERT FIGURE 1]

Table 4 reports summary statistics (mean, median, minimum and maximum) for each variable used in the subsequent multivariate analysis. We also report the statistics for proxies of bank performance, risk, and dividend payout ratios, and a short explanation for each of them (we will provide a more detailed explanation in Section 6). The mean and standard deviation for *Gender Diversity* are 11.84% and 10%, respectively. *Female Participation Rate* ranges between 69.98% and 100%, while *Female employment rate* goes from 65.50% to 88%, suggesting substantial variation in the extent to which women are involved in the social and economic environments in Europe (European Commission, 2012).

[INSERT TABLE 4]

Additionally, we also report further statistics focusing on the distribution of our main explanatory variable, *Gender Diversity*. Panel A reports the distribution of *Gender Diversity* by country, while

[50] This document can be found at the link: https://www.mbres.it/sites/default/files/resources/download_it/rs_Piani%20di%20stabilizzazione%20finanziaria.pdf
[51] http://ec.europa.eu/competition.html

Panel B report the distribution of our key variable by year. Panel A of Table 5 suggest that there are eleven countries in our sample – Austria, Belgium, Denmark, Finland, France, Germany, Ireland, Netherlands, Spain, Sweden and United Kingdom – where female directors account for at least 10% in average of total number of board members, while countries, such as Greece, Italy, Luxembourg, and Portugal, presents a fraction of female directors below the aforementioned threshold of 10%.

[INSERT FIGURE 2]

[INSERT TABLE 5]

Furthermore, in line with Figure 2, Panel B shows a remarkable increase in the percentage of female directors on bank boards over the sample period. In fact, the percentage of female directors changed from 8.67% to 16.57% in only 7 years reaching peak of 50% in the number of female directors in 2013. This is line with the initiatives of the European Commission and Member States to boost and ensure a better gender equality in companies' boards in terms of female representations.[52] In fact, the share of female directors rose from 8.67% to 16.57%, meaning an increase of around 7.9 percentage points (pp) over the sample period or an average increase of 1.12 pp per year.

Do rescued banks differ from non-rescued banks? Table 6 provides the results of two-sided *t*-tests[53] for differences in means of a set of variables that may be related to the probability of receiving a public bailout. We also provide the results separately for the pre-crisis period and the crisis period, and for capital injections, credit lines, and guarantees.

[INSERT TABLE 6]

Our results suggest that non-rescued banks had on average a higher value for *Gender Diversity* than rescued banks in the post-crisis period (for the pre-crisis period, the difference in means is statistically insignificant). This result suggests that more gender-diverse boards are less likely to need a public bailout during the crisis. The results tend to change slightly, however, once different types

[52] For instance, in 2011 the European Commission introduced legislation to improve gender balance in EU-listed companies: http://ec.europa.eu/newsroom/document.cfm?doc_id=46280.

[53] In addition to the *t*-tests reported above, we also conduct Wilcoxon-test to allow for the possibility that the Normality assumption does not hold in our sample. The results shown in Supplementary Appendix B reiterate the results for the *t*-tests.

of bailout are considered. In particular, banks bailed out by means of guarantees have a lower fraction of female directors both in the crisis-period and the pre-crisis period.

Consistent with TBTF considerations, rescued banks are significantly larger than non-rescued banks in both periods. These results are line with the argument that larger banks are more likely to attract public support (Dam and Koetter, 2012) because of their stronger spill-over effects in case of liquidation (Bayazitova and Shivdasani, 2012). As expected, this result is also confirmed by the differences-in-means regarding the *MES*, but only for the post-crisis period.

Our results also show that non-rescued banks have a higher *MTB Ratio* both in pre-crisis period and in the post-crisis period. Furthermore, rescued banks tend to have a lower *Deposits Ratio* than rescued peers, consistent with the view that deposits provide a stable source of funding for banks (Bruno et al., 2018). Unsurprisingly, non-rescued banks have, on average, better profitability (proxied by *Tobin's Q*) and lower riskiness (proxied by the *Z-score* and *NPL Ratio*) than rescued banks, although for the *Z-score* the results are significant only for the crisis period. Comparing the results for the post-crisis period with those for the pre-crisis period, we notice that the 2007-financial crisis weakened the profitability and growth opportunities of both rescued and non-rescued banks, but affected rescued banks more severely. Similar results are confirmed in Brei and Gadanecz (2012). Since dividend payout ratios may be related to risk-shifting incentives (Acharya et al., 2011), we also report the results for *t*-tests based on the dividends to equity ratio (*DPE*). On average, non-rescued banks have higher *DPE* than rescued banks during the crisis. A possible explanation for this result is that rescued banks are subject to higher monitoring intensity from public authorities, resulting in lower payout ratios (Onali et al., 2016).

5. Results

5.1 Probit regressions: Results

Table 7 presents the results for the probit regressions for the likelihood that a bank receives a public bailout. To improve robustness, we present the results with different sets of controls, different

levels of clustering for the standard errors, with and without year fixed effects, and in the last column we also present the results collapsed at the bank level, to reduce the possibility that our results depend on within-bank time trends in both the dependent and independent variables.

We find that banks with a higher fraction of female directors are less likely to receive a bailout, with the coefficient on *Gender Diversity* statistically significant at the 5% level or 1% level for all ten specifications. The magnitude of the marginal effects suggests that an increase by one percent in *Gender Diversity* decreases the probability of a bailout by around 0.36%-2.09%, depending on the specification chosen.

The coefficient on *Size* is statistically insignificant in all regressions. This result is not unexpected, since our sample is mainly composed by larger EU-banks and it is also line with the previous literature arguing that *Size* is a rough indicator of bank systemic importance (Drehmann and Tarashev, 2013), because it is unable to capture the potential distress costs and negative externalities associated with bank default. Systemic risk, proxied by *MES*, increases the probability of a public bailout, consistent with the view that banks that are systemically important are more likely to be rescued by the government if they are in distress.

In line with Bayazatova and Shivdasani (2012), we find that higher profitability (proxied by *ROA*) reduces the probability of a public bailout, in most specifications. *Capital Ratio* is negatively related to the probability of obtaining a bailout. The coefficients for *Tier 1 Ratio* are also negative and significant in the specifications where *Capital Ratio* is excluded. The fact that *Tier 1 Ratio* loses significance when *Capital Ratio* is included in the regressions indicates that authorities may consider *Capital Ratio* as a more informative variable when deciding which bank should be bailed out.

The coefficients on *HHI* are negative and statistically significant at the 5% level in six specifications out of nine, consistent with the view that ownership concentration decreases bank risk (Iannotta et al., 2007).

In Columns (7) and (8) of Table 7 we present the results after replacing the *Tier 1 Ratio* with either the *Liquid Assets Ratio* (Column (7)) or the *Derivatives to Assets Ratio* (Column (8)). The coefficient on the former is negative and significant at the 10% level, consistent with the view that a higher degree of short-term liquidity reduces the probability of financial distress. The coefficient on *Derivatives to Assets Ratio* is insignificant. The results for the other variables remain substantially unaltered.

The results for the control variables are, therefore, consistent with our expectations: better-capitalised and profitable banks, with low systemic risk, are less likely to obtain a public bailout. However, gender diversity on the board also plays a key role.

[INSERT TABLE 7]

5.2 IV-Probit Regressions: Results

Table 8 reports the results of the IV-Probit regressions: Panel A shows the results for the second-stage regressions, where the dependent variable is *Bailout*; and Panel B reports the results of the first-stage regressions, where the dependent variable is *Gender Diversity*. We report the results using two instrumental variables: *Female Participation Rate* and *Female employment rate*.

Consistently with Table 7, the results for the second-stage regressions reported in Panel A indicate that banks with a higher fraction of female directors on the board are less likely to receive a public bailout. The coefficient on *Gender Diversity* is statistically significant at the 1% level in five specifications and at the 5% in one specification. The economic magnitude of the impact of *Gender Diversity* is also significant: an increase by 1% in *Gender Diversity* decreases the probability of receiving a bailout by around 1.69%-4.68%, depending on the specification. Thus, the economic magnitude is larger than for the Probit regressions (see Table 7). Therefore, neglecting to use IV models leads to an underestimation of the magnitude of the negative effect of *Gender Diversity*.[54]

[54] To provide further evidence for the validity of our instruments, we run our IV-models again using *Female Participation Rate* at the country level (the data are collected from the World Bank database). This IV is less likely to satisfy the

The results reported in Panel B suggest that our instruments are strongly and positively correlated with the potentially endogenous regressor in all specifications, in line with our predictions. The *z*-statistics for both instruments are higher than 4 in all cases, suggesting that our instruments are unlikely to be weak. Moreover, the coefficients on *Female employment rate* are larger than those on *Female Participation Rate*, consistent with our expectations.

Larger and better-capitalised banks are more likely to have a more diverse board, consistent with previous literature (De Cabo et al., 2012), and banks located in countries with higher-*GDP growth* rates are more likely to have a higher fraction of female directors in the board.[55]

At the bottom of Panel B, we report the results for the Wald Test under the null hypothesis of no endogeneity of *Gender Diversity*. The *p*-value is lower than 5% in four specifications out of six, suggesting that the null hypothesis of no endogeneity of *Gender Diversity* can be rejected. Thus, the coefficient estimates for these four specifications are inconsistent for the probit regressions without IVs. The instruments employed are also strong: for example, the Kleibergen-Paap rank test statistics range between 19.25 and 30.44.

[INSERT TABLE 8]

5.3 Duration Models

In this section, we test our main hypotheses by using survival data analysis. As before, we expect that banks with a higher proportion of women on the board are less likely to receive a public bailout from 2007 until the end of the sample period.

exclusion restriction than the one at the regional level, in particular because of the feedback effect between sovereign risk and the risk of the domestic financial sector (Acharya et al., 2014). We re-estimate the regressions as per Columns (1)-(2) and (5)-(6) of Table 8. The IV at the national level enters the first-stage regressions with a positive and significant sign (t-stats > 5). In the second-stage regressions, we find that the coefficient on *Gender Diversity* is between the one for the corresponding Probit model the one for the IV-Probit model using the regional instruments. This finding confirms that our IV at the regional level is correcting endogeneity to a greater extent than the one at the national level.

[55] In unreported results, we also re-run the analysis by replacing the GDP growth at the country-level with the GDP growth at the NUTS2-level to allow for differences in economic development across regions. The results remain virtually unaltered.

Table 9 complements the results in Tables 7 and 8. The coefficient on the *hazard ratio* for *Gender Diversity* is less than one and statistically significant in all specifications, suggesting that banks with a higher value of *Gender Diversity* in the pre-crisis period are less likely to receive a bailout during the financial crisis.[56] In column (2), we control for the presence of female CEO in the bank, while in Column (3) we control for bank's board characteristics. The results for these tests remain unaltered.

In Column (4) and (5) we employ a duration model estimating the probability of receiving a bailout as a function of the number of calendar days from the beginning of the crisis to the end of the sample period.[57] In Column (5), we implement a parametric survival model, whose baseline hazard function has the *Weibull* form because the proportional-hazards assumption[58] does not hold when we consider the probability of receiving a bailout as a function of the number of calendar days. The results are qualitatively and quantitatively similar across specifications.

[INSERT TABLE 9]

In Figure 3 we report graphs of the estimated survival functions. In particular, we show the graphs separately for countries which experienced sovereign debt problems during the period 2009-2013 (Greece, Ireland, Italy, Portugal and Spain), and for the whole sample. From the graphs, it is clear that for Greek banks the estimated survival function starts from a lower value (around 0.2) and decades more rapidly than for the whole sample. This finding suggests that Greek banks were likely to receive a bailout earlier than banks from other countries.

[INSERT FIGURE 3]

5.4. Amount of Public Bailouts: Tobit Models

Table 10 shows the results of IV-Tobit regressions (Panel A) and panel Tobit regressions (Panel B). For Panel A, the coefficients on *Gender Diversity* are negative and significant at the 5% level in

[56] For the sake of brevity, we do not tabulate the results for the bank-specific control variables. However, as reported in Table 8, we have included these variables in our regressions.
[57] For the scope of this analysis we define the starting day of the crisis as 1st January 2007, following Erkens et al. (2012) and Ryan (2008).
[58] We check the proportional-hazards assumption using Schoenfeld's (1982) residuals test.

five cases out of six (and at the 10% level in the remaining case), indicating that banks with a higher fraction of female directors tend to receive a smaller amount of capital injections, credit lines and guarantees as a percentage of total assets. For Panel B, the coefficient on *Gender Diversity* in the regressions on *Guarantees*, reported in Column (3) is statistically insignificant, but the results for *Capital Injections* and *Credit Lines* are consistent with those reported in Panel A.

[INSERT TABLE 10]

6. The mechanism: Bank Profitability, Risk and Dividend Payout Ratios

In this section, we aim to identify the channels through which gender diversity in bank boards influences the probability of a public bailout during the financial crisis. We identify three potential channels: bank profitability, bank soundness, and bank dividend policy. As before, we rely on an IV setup for our inferences.

6.1 Instrumental Variables (IV) Regressions

To test the profitability-channel, we use two measures widely employed in the finance literature: *Tobin's Q* and *ROA*. To investigate the risk-channel, we employ backward-looking and forward-looking proxies for bank risk (see results in Supplementary Appendix F). First, following Dam and Koetter (2012), we consider a proxy for credit risk, the non-performing loans ratio, calculated as non-performing loans to total loans (*NPL Ratio*). Second, consistent with recent literature on risk-shifting (Onali, 2014), we employ two distance-to-default measures: (i) the *Z-score*, which is an accounting-based and backward-looking proxy for bank soundness, is calculated as the ratio of the *ROA* plus the ratio of equity to total assets, divided by the standard deviation of the *ROA*; and (ii) its log transformation (*Z-score (ln)*). Because of the Z-score is positively skewed, using its log transformation is more common (Onali, 2014). As additional market-based measure of risk, we also consider the standard deviation of monthly stock returns (*Volatility*).

To test the dividend-policy channel, we employ dividends to equity ratio in logs, *DPE (ln)*, in the main specifications as the dependent variable. We use the log transformation because dividend payout ratios are highly skewed to right (Onali et al., 2016).

To explore the mechanism behind the relation between gender diversity in the bank boards and probability of receiving a bailout, we rely on an IV framework. More precisely, we run three sets of regressions based on:

$$Y_{i,t} = f\left(Gender\ Diversity_{i,t-1}, Controls_{i,t-1}\right)$$

$$Gender\ Diversity_{i,t-1} = f(IV_{i,t-1}, Controls_{i,t-1}) \qquad (5)$$

where $Y_{i,t}$ is the variable of interest of our hypotheses (profitability, risk, dividends),[59] and *Controls* is a vector of bank-level and macroeconomic control variables. As before, we cluster the standard errors on the bank-level.

We employ the same instruments used in the previous section: *Female Participation Rate* and *Female employment rate*. We choose to do so for three reasons. First, reverse causality could drive our results due to the so-called *sorting-effect*: better-performing banks are more likely to hire female directors on their board (Adams and Ferreira, 2009). This effect is likely to affect the regressions on profitability proxies as well as those on proxies for risk and dividend policy, because these three variables are strongly associated with each other (for example, more profitable banks are likely to have higher payout ratios). Second, provided that women are indeed more risk averse than men, it is plausible that women can self-select in boards of less risky banks. Finally, there may be factors that are unobservable to the econometrician and correlated with *Gender Diversity*, engendering an omitted variable bias problem (Coles et al., 2012).[60]

[59] In robustness checks, we use the dividends-to-equity ratio without any log-adjustment. The results are virtually the same.

[60] Other previous studies (Sila et al., 2006; Chhaochharia and Laeven, 2009; Faccio et al, 2016), employ a dynamic panel data model using Generalized Method of Moments (GMM) estimation (Arellano and Bond, 1991; Blundell and Bond, 1998). We obtain similar results using these models: *Gender Diversity* is positively related to *Tobin's Q* and the *ROA*, and negative related to the *NPL Ratio.* However, this approach can lead to bias in presence of time-varying omitted variables (Wintoki et al., 2012).

6.2 Main Results

The results reported in Table 11 confirm that our instruments are significant and enter the first-stage regressions with the predicted sign.

The results for the second-stage regressions are shown in Table 11, Panel A. Our results related to the profitability channel provide mixed evidence that *Gender Diversity* affects bank performance: the coefficients on *Tobin's Q* (reported in Columns (1) and (2)) are positive but statistically insignificant; however, the coefficients on *ROA* are positive and statistically significant. An increase by 1 percentage point in *Gender Diversity* increases *ROA* by 0.0724 percentage points, and because *ROA* has a mean of 0.4331 percentage points, the increase is economically significant: around 16.72% of *ROA*'s average.[61] These findings contradict management theories arguing that a more diverse board might be more likely to disagree in the decision-making process, resulting in lower profitability (Eisenhardt et al., 1997). In contrast, they support the hypothesis that female directors can help their firm by attracting valuable resources and producing better profitability (Hillman et al., 2002), and they also corroborate the findings reported by Berger et al. (2014).[62]

The results for the *NPL Ratio* (Columns (5) and (6)) support the hypothesis that *Gender Diversity* has a negative and statistically significant impact on credit risk. However, we find that if Gender increases by 1 percentage point, *NPL Ratio* decreases by 0.5386 percentage points. Considering that the average *NPL Ratio* is around 5.27 percentage points, the economic magnitude of the impact of *Gender Diversity* is moderate, but not negligible (around 10.22% of *NPL Ratio*'s mean).

The negative impact of *Gender Diversity* on bank risk is confirmed when we replace *NPL Ratio* with the *Z-score (ln)* and *Volatility*: *Gender Diversity* correlates positively with the former (which is a proxy for distance-to-default Laeven and Levine, 2009), and negatively with the latter. We report

[61] The results remain unaltered when we control for the presence of a *Female CEO* (Faccio et al., 2016), the *Board Independence Ratio*, and *Board Size* (Erkens et al., 2012; Vallascas et al., 2017), as reported in Supplementary Appendix E.

[62] Berger et al. (2014) suggest that, although female directors represent a minority in banks' boards (European Commission, 2012), they are not marginalised in male-dominated boards.

these results in Supplementary Appendix F.[63] These findings may be interpreted as evidence of stronger monitoring efforts by female directors relative to their male counterparts (Adams and Ferreira, 2009; Chen et al., 2017). An alternative view could be that women tend to be more risk-averse (Croson and Gneezy, 2009), leading to stricter bank-lending policies.

In Columns (7) and (8) of Table 11, we analyse the results for *DPE* (ln). The coefficient of *Gender Diversity* is positive and statistically significant for Column (8), but not for Column (7). The economic magnitude of the impact for the results reported in Column (8) suggest that if *Gender Diversity* increases by 1 percentage point, *DPE (ln)* increases by 0.0568. Considering that *DPE (ln)* has a mean of 0.505, the increase is moderate but not economically insignificant (around 11.25% of its mean). This finding confirms those reported by Chen et al. (2017) with respect to non-financial firms in the US: a larger representation of female directors in boards is associated with higher dividend payout ratios. In Supplementary Appendix H, we re-estimate the results for dividend policy channel by replacing *DPE (ln)* with *DPE* (without using a log transformation for the dividend payout ratio) and *DPE/TA*, which is the ratio between dividends and total assets instead of equity (in line with Abreu and Gulamhussen, 2013).[64] Except for column 1 of Supplementary Appendix H, we reported similar results in line with Table 11. As a further robustness check (reported in Supplementary Appendix I), we provide some evidence that the positive relationship between *DPE* (ln) and *Gender Diversity* remains statistically and economically significant after controlling for other board characteristics, such as the presence of a female CEO, board size, the fraction of independent directors. Particularly, they remain statistically significant in all specifications, where we use *Female employment rate* as instrument for *Gender Diversity*.

[INSERT TABLE 11]

[63] As a further robustness check for the risk-channel, we re-estimate the results reported in Table 11 (Columns (5) and (6)) by allowing for other corporate governance variables. The results, which we report in Supplementary Appendix G, remain statistically and economically similar to those reported in Table 11.

[64] Similar to Evgeniou and Vermaelen (2017), we also examine the impact of *Gender Diversity* on the probability of share buybacks, using probit and logit models. However, the coefficients on *Gender Diversity* are insignificant.

To sum up, our findings show that *Gender Diversity* has a negative effect on bank risk, as proxied by the *NPL Ratio* and *Volatility*, a positive effect on *ROA*, and we also provide some evidence that *Gender Diversity* increases dividend payout ratios. Consistent with findings reported by Berger et al. (2014), our results suggest that, although female directors represent a minority in banks' boards (European Commission, 2012), they are not marginalised in male-dominated boards.

6.2 Robustness tests: 3SLS regressions

One may argue that if *Gender Diversity* increases payout ratios and decreases the probability of a bailout, then higher dividend payout ratios should decrease the probability of a bailout. In section 6.1 we argued that the channel through which a higher dividend payout ratio decreases the probability of a bailout is a decrease in agency costs. However, it may be pointed out that this is counterintuitive because dividends reduce, *ceteris paribus*, the capital ratio of the bank.

To explore this alternative mechanism, we investigate in more depth the channel through which *Gender Diversity* leads to higher payout ratios. In particular, *Gender Diversity* increases *ROA* and decreases the *NPL Ratio*, and both of these variables may influence payout ratios: banks with a higher profitability and lower credit risk may have higher payout ratios. Following these considerations, and in a similar vein as Bhagat and Bolton (2008, 2013) and Onali et al. (2016), we employ a 3-Stage Least Squares (3SLS) framework to examine the interlinkages across the following variables: *Public Bailout*, *ROAA*, *NPL Ratio*, *DPE (ln)*, and *Gender Diversity*. In particular, we implement the following econometric strategy:[65]

$$\begin{cases} Public\ Bailout_{it} = \beta_1 + \beta_2 ROA_{it-1} + \beta_3 C_{it-1} + \varepsilon_{1it} \\ ROA_{it-1} = \beta_4 + \beta_5 Gender\ Diversity_{it-1} + \beta_6 C_{it-1} + \varepsilon_{2it} \\ Gender\ Diversity_{it-1} = \beta_7 + \beta_8 Female\ Participation\ Rate_{it-1} + \beta_9 Female\ Employment\ Rate_{it-1} + \\ \qquad\qquad + \beta_{10} C_{it-1} + \varepsilon_{2it} \end{cases} \quad (6)$$

[65] We also run 3SLS regressions similar to equations (6), where *DPE* (ln) replaces *ROA*. The results are consistent with those reported in section 6.2, in that *DPE* $(\ln)_{t-1}$ has a positive and significant coefficient in the regression where *Public Bailout*$_t$ is the dependent variable, *Gender Diversity*$_{t-1}$ has a positive and significant coefficient in the regression on *DPE* $(\ln)_{t-1}$, and *Female Participation Rate*$_{t-1}$ and *Female Employment Rate*$_{t-1}$ have positive and significant coefficients in the regression where *Gender Diversity*$_{t-1}$ is the dependent variable.

$$\begin{cases} Public\ Bailout_{it} = \beta_1 + \beta_2 NPL\ Ratio_{it-1} + \beta_3 C_{it-1} + \varepsilon_{1it} \\ NPL\ Ratio_{it-1} = \beta_4 + \beta_5 Gender\ Diversity_{it-1} + \beta_6 C_{it-1} + \varepsilon_{2it} \\ Gender\ Diversity_{it-1} = \beta_7 + \beta_8 Female\ Participation\ Rate_{it-1} + \beta_9 Female\ Employment\ Rate_{it-1} + \\ \qquad\qquad + \beta_{10} C_{it-1} + \varepsilon_{2it} \end{cases} \quad (7)$$

$$\begin{cases} DPE(\ln)_{it} = \beta_1 + \beta_2 ROA_{it-1} + \beta_3 C_{it-1} + \varepsilon_{1it} \\ ROA_{it-1} = \beta_4 + \beta_5 Gender\ Diversity_{it-1} + \beta_6 C_{it-1} + \varepsilon_{2it} \\ Gender\ Diversity_{it-1} = \beta_7 + \beta_8 Female\ Participation\ Rate_{it-1} + \beta_9 Female\ Employment\ Rate_{it-1} + \\ \qquad\qquad + \beta_{10} C_{it-1} + \varepsilon_{2it} \end{cases} \quad (8)$$

$$\begin{cases} DPE(\ln)_{it} = \beta_1 + \beta_2 NPL\ Ratio_{it-1} + \beta_3 C_{it-1} + \varepsilon_{1it} \\ NPL\ Ratio_{it-1} = \beta_4 + \beta_5 Gender\ Diversity_{it-1} + \beta_6 C_{it-1} + \varepsilon_{2it} \\ Gender\ Diversity_{it-1} = \beta_7 + \beta_8 Female\ Participation\ Rate_{it-1} + \beta_9 Female\ Employment\ Rate_{it-1} + \\ \qquad\qquad + \beta_{10} C_{it-1} + \varepsilon_{2it} \end{cases} \quad (9)$$

In equations (6) and (7), *Public Bailout* is a function of either profitability (proxied by *ROA*) or credit risk (proxied by the *NPL Ratio*), which depend, in turn, on *Gender Diversity*. In equations (8) and (9), *DPE* (ln) is a function of profitability or credit risk.

To improve the robustness of our results in section 6.2, for the equation on *Gender Diversity* we use both of our instruments to be able to run Hansen tests for over-identifying restrictions (using 2SLS regressions). In all cases, we obtain Hansen tests greater than 0.10.[66]

[INSERT TABLE 12]

The results reported in Table 12 confirm that: profitability (proxied by the *ROA*) decreases the probability of a bailout and increases dividend payout ratios (proxied by *DPE* (ln)); credit risk (proxied by the *NPL Ratio*) increases the probability of a bailout and decreases dividend payout ratios (proxied by *DPE* (ln)); *Gender Diversity* increase profitability (proxied by the *ROA*) and decreases credit risk (proxied by the *NPL Ratio*); *Female Participation Rate* and *Female Employment Rate* increase *Gender Diversity*.

[66] These results are available upon request from the authors. Using only one instruments does not alter our results.

7. Conclusions and recommendations

This paper is the first attempt to estimate the impact of gender diversity in bank boards on the probability that a bank needs a public bailout. Leveraging a painstakingly hand-collected dataset on a large sample of European banks, we have shown that gender diversity reduces the probability of a public bailout, although this effect is economically moderate in comparison with the impact of the overall degree of systemic risk of an institution. Moreover, conditional on a public bailout happening, the amount of public funding received, as a percentage of bank assets, decreases as the fraction of women on the board increases.

An investigation of the drivers of such a phenomenon suggests that gender diversity bears a positive impact on bank profitability (proxied by the ROA) and decreases the non-performing loans ratio. Consistent with our expectations, banks with higher ROA have a lower probability of a bailout, as do banks with a lower non-performing loans ratio.

Moreover, gender diversity correlates positively with dividend payout ratios, suggesting a decrease in agency costs, which consequently leads to a lower probability of a bailout. We also investigate an alternative channel: gender diversity increases payout ratios because it increases profitability and it decreases the non-performing ratio, and payout ratios tend to be higher in more profitable banks with a lower non-performing loans ratio.

In light of recent reforms in several EU countries regarding gender quotas and the current debate about the need to understand and enhance corporate governance mechanisms in banks (de Larosière Group, 2009; Principles for Enhancing Corporate Governance, BCBS, 2010), our results provide important insights on the role of female directors for bank conduct: our findings may be interpreted as evidence that female directors exert stronger monitoring efforts than their male counterparts (Adams and Ferreira, 2009; Chen et al., 2016, Evgeniou and Vermaelen, 2017), leading to stricter bank lending policies and lower agency costs.

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Tables

Table 1.

Panel A summarises briefly the main differences between the US Banking Market and the EU Banking Market. Panel B provides a numerical comparison between the two rescue programs launched in both markets.

Panel A: A comparison between the US Banking Market and the EU Banking Market		
Features	*US Banking Market*	*EU-Banking Market*
Type of financial system	*Market-based System*: Securities markets satisfy firms' funding needs in the credit allocation by exerting control over firms' managers. Generally, this kind of system requires no direct government intervention or ownership.	*Bank-based System*: Banks play a key role in the credit allocation both by mobilizing savings and by monitoring the decision of investments undertaken by firms' managers (particularly, in Continental Europe).
Banking market structure	*US banking system*: Widely-fragmented and characterized by a large number of small financial intermediaries.	*EU banking system*: Systemically Important Financial Institutions (SIFIs) representing the 65% of the whole banking market.
Supervisory Authorities' Reaction	*Prompt Corrective Actions*: The supervisory agency intervenes and arranges the liquidation or unconventional measures once the ailing institution does not meet the minimum regulatory standards. In the case of a small bank's distress, the FDIC may easily arrange the closure or the takeover of the ailing financial institutions.	*Forbearance*: Supervisory agency tolerates that the ailing bank continues operating even if it does not satisfy minimum regulatory standards in order to avoid bank runs.
Rescue schemes	*TARP*: Banks submit their application for the rescue-program. The US Treasury decides on the approvals of bank's applications. As a result, the US Treasury approved injections in banks with better asset quality ("*Healthy Banks"*).	*EU-Member States Rescue Programs*: Governments and other specific public authorities arrange the national schemes and *ad-hoc measures* for ailing banks. The European Commission (*DG-Competition*) approves the national scheme or the *ad-hoc measures* on the premise that the measures do not distort the level playing field both within the local market and across UE-Member States markets.
Approval Decision for rescue schemes	U.S. Treasury	European Commission (DG-Competition)
Approach to Globally Systemically Important Banks (G-SIBs)	Privileged Treatment	Privileged Treatment
Other provision(s)	*National Depositor Preference(s)*: In case of bank liquidation, this law confers priority to depositors relatively to general creditors.	*EU-depositor preference.* EU-directive in force since 2014. EU-member states have to enforce the directive into national laws after one year.
Central Banking features	FED carries out its functions independently and discretionally over monetary policy, even by supporting banks at individual basis.	The European Central Bank (ECB) refinances financial intermediaries mainly through liquidity extensions. The ECB reduced the *corridor of the standing facilities* in 2009, that is, the difference between the interest rate of the marginal lending facility and that of the deposit facility.

Panel B: A comparison between the US-TARP and EU-Member States Rescue Schemes (31/12/2013)		
Features	*US-TARP (€ billion)*	*EU-Rescue Schemes (€ billion)*
Injections	408.3	472.3
Guarantees	1,356. 0	2,442.6
Others	305.9	250.7
Overall Amount	**2,070.2**	**3,165.6**

Sources: Bordo et al. (1994); Stiroh and Strahan (2003); Dermine and Schoenmaker (2010); Stolz and Wedow (2010); Bayazitova and Shivdasani (2012); Woll (2014); Danisewicz et al. (2017); *Bulletin of Mediobanca.*.

Table 2. Sample Selection

	Search criteria	Number of banks
Step 1	Universe of European publicly quoted banks listed on Bankscope	2,662
Step 2	World region: European Union (15)	232
Step 3	Accounting Standards: International Financial Reporting Standards	185
Step 4	Specialization: Bank Holdings & Holding Companies, Commercial Banks, Cooperative Banks	118
Step 5	Total Assets: All banks with a known value for at least one of the selected periods	115
Step 6	Information availability: regulatory data and other financial ratios	105

Table 3. Sample Composition and Representativeness

Panel A: Overview			
Country Name	Banks	Sample %	Observations
Austria	7	6.67	49
Belgium	3	2.86	16
Denmark	11	10.48	77
Finland	3	2.86	26
France	8	7.62	56
Germany	9	10.48	63
Greece	11	9.35	63
Ireland	2	1.90	14
Italy	20	19.05	151
Luxembourg	2	1.90	14
Netherlands	4	3.81	33
Portugal	4	3.81	27
Spain	8	7.62	55
Sweden	4	3.81	28
United Kingdom	9	8.41	63
Total	105	100.00	735
Panel B: Sample Representativeness			
Sample Banks in 2013			
Total Assets %		0.94	
Deposits %		0.95	
Loans %		0.94	

Table 4.

The table reports summary statistics for all the variables used in our empirical analysis. We also report a short description of the variables. All ratios are shown in percentage terms. The sample period is from 2007 to 2013. For each variable, we report the following statistics: number of observations ("Obs"), mean ("Mean"), standard deviation ("SD"), minimum value ("Min") and maximum value ("Max"). The last column of the table reports the source of the data for each variable. All variables are winsorised at the 1^{th} and 99^{th} percentiles.

	Description	Obs	Mean	SD.	Min	Max	Source
Dependent Variable for the key hypothesis							
Public Bailout	1 if the bank was bailed out during the crisis period, and 0 otherwise.	735	0.1537	0.3609	0.0000	1.0000	Mediobanca
Capital injections	1 if the bank received a public capital injection during the crisis period, and 0 otherwise.	735	0.0517	0.2216	0.0000	1.0000	Mediobanca
Credit Lines	1 if the bank received a credit line from the government during the crisis period.	735	0.0327	0.1778	0.0000	1.0000	Mediobanca
Guarantees	1 if the bank received a guarantee from the government during the crisis period.	735	0.1075	0.3099	0.0000	1.0000	Mediobanca
Public funds (Capital Injections)	Amount of the capital injection received by the bank scaled by total assets.	705	0.1627	1.3848	0.0000	33.3800	Authors' calculation
Public funds (Credit lines)	Amount of the credit line received by the bank scaled by total assets.	705	0.1656	2.3490	0.0000	59.6533	Authors' calculation
Public funds (Guarantees)	Amount of the guarantee received by the bank scaled by total assets.	705	0.6864	2.9181	0.0000	30.2263	Authors' calculation
Dependent Variables used to explore the mechanism							
Tobin	Market Value of equity plus the face value of debt divided by the book value of equity plus the face value of debt.	674	0.9936	0.8957	0.0375	6.3000	Authors' calculation
NPL Ratio (%)	Non-performing loans to total loans.	714	5.2693	6.6500	0.0000	33.9530	Bankscope
Z-score (ln)	Natural log of the sum of return on assets (ROA) and the capital assets ratio divided by standard deviation of ROA.	664	3.0694	1.2249	-0.1677	5.7596	Authors' calculation
DPE (ln)	Natural log of dividends paid for a given year divided by bank equity.	705	0.5050	0.9415	-2.7558	2.9548	Authors' calculation
Potentially Endogenous Explanatory Variable							
Gender Diversity	The percentage of female directors on the board.	724	11.8404	10.0067	0.0000	40.0000	Annual Reports
Instruments							
Female Participation Rate (%)	Female labour force participation (unit: thousands of people) divided by male labour force participation (unit: thousands of people) in the NUTS 2 region where the bank's headquarter is located.	666	84.3809	6.9806	69.9805	100.6332	Eurostat
Female employment rate (%)	Employment rate for women with tertiary education in the NUTS 2 region where the bank's headquarter is located.	663	79.1751	4.7391	65.5000	88.0000	Eurostat
Other corporate governance variables							
Female CEO	1 if the bank CEO is female, 0 otherwise.	726	0.0262	0.1598	0.0000	1.0000	Annual Reports
Board Size	Number of board members.	731	13.9207	5.7960	0.0000	34.0000	Annual Reports
Board Size (ln)	Number of board members (ln).	724	2.5622	0.4086	1.3863	3.5264	Authors' calculation
Board Independence Ratio (%)	Proportion of independent directors on the board.	724	50.2464	28.8695	0.0000	100.0000	Annual Reports
Controls							
Size	Logarithm of total assets.	705	17.3016	2.3847	12.0816	21.4275	Bankscope
Marginal Expected Shortfall	Marginal contribution of the bank to the expected shortfall of the financial system in a left-tail scenario.	565	3.0801	1.2920	0.5400	6.3700	V-Stern Lab
Market-to-Book Ratio	Market value of equity divided by book value of equity.	679	0.9906	0.9080	0.0128	6.3408	Authors' calculation
ROA	Net-income to total assets.	708	0.4331	2.2527	-7.2410	13.7400	Bankscope
Capital Ratio (%)	Equity capital to total assets.	705	9.5237	10.9667	1.4490	66.8950	Bankscope
Tier 1 Ratio (%)	Tier 1 regulatory capital divided by risk-weighted assets.	705	9.7148	6.0960	0.0306	34.9000	Bankscope
Deposits Ratio	Deposits divided by total assets.	674	1.0879	1.3968	0.0296	10.3198	Bankscope
Widely Held	1 if there is no owner with more than 10% of bank share rights, and zero otherwise.	731	0.2408	0.4278	0	1	Authors' calculation/FactSet
HHI	Sum of squared ownership shares for all recorded shareholders of the bank.	694	0.3678	0.3182	0.0167	1.0000	Authors' calculation/FactSet
GDP growth	Gross domestic product annual growth rate.	735	-0.2587	2.9132	-8.2690	5.6767	AMECO

Table 5. Distribution for Gender Diversity

The table presents the distribution of female directors. Panel A shows the distribution of female directors by country. Panel B reports the distribution of female directors by year. Each panel reports the average number of female directors on board (*Number of female directors*), the maximum number of female directors on board (*Max)*, the average percentage of female directors on the board (*%*), the maximum percentage of female directors on board by country (Panel A) and by year (Panel B).

Panel A: Distribution of *Gender Diversity* by country

Country	*Number of female directors*	*Max*	*%*	*% Max*
Austria	3	7	13.2458	33.3333
Belgium	2	4	8.9619	22.2222
Denmark	2	5	15.7289	41.6666
Finland	2	4	25.2350	50.0000
France	3	6	19.1741	45.4545
Germany	2	7	14.7249	35.0000
Greece	1	3	7.9831	25.0000
Ireland	2	3	11.2832	20.0000
Italy	1	4	5.1705	27.2727
Luxemburg	0	0	0.0000	0.0000
Netherlands	1	4	13.8965	33.3333
Portugal	1	2	4.1363	20.0000
Spain	1	4	9.5643	25.0000
Sweden	3	8	25.4536	47.0588
United Kingdom	2	3	12.3475	27.2727

Panel B: Distribution of *Gender Diversity* by year

Year(s)	*Number of female directors*	*Max*	*%*	*% Max*
2007	1	6	8.6698	37.5000
2008	1	7	9.8901	41.6666
2009	1	6	9.7962	36.3636
2010	2	7	11.5482	45.4545
2011	2	7	12.2151	41.1764
2012	2	8	14.6839	47.0588
2013	2	8	16.5704	50.0000

Table 6. *T*-tests for subsamples of rescued and non-rescued banks.

We report summary statistics of EU 105 listed banks: mean differences between rescued banks (that is, those that received a bailout) and non-rescued banks (that is, those that did not receive a bailout) for the pre-crisis period and post-crisis period. Panel A reports results for the pre-crisis period. Panel B presents these statistics for the post-crisis period. Both panels make a distinction among different kinds of public bailouts – *Capital injections*, *Guarantees*, and *Credit lines*. Variances between groups are assumed to be unequal. All variables are winsorised at the 1th and 99th percentiles. *** p<0.01, ** p<0.05, * p<0.1.

Panel A: Pre-Crisis Period

Variables	Non-rescued Banks	Rescued Banks	Significance	No Capital Injections	Capital Injections	Significance	No Credit Lines	Credit lines	Significance	No Guarantee	Guarantee	Significance
Gender Diversity	9.4980	8.2851		8.1791	10.6359	**	8.8183	8.7879		9.6753	7.7573	*
Size	16.5667	17.7618	***	16.7676	18.6562	***	16.9487	18.4954	***	17.0522	17.4831	
MES	1.9670	1.9663		1.8958	2.1361	*	1.9366	2.0807		2.0997	1.7968	***
MTB Ratio	2.0540	1.6839	**	1.8635	1.8079		1.8625	1.7966		2.0121	1.6351	***
Tobin's Q	2.0420	1.6663	**	1.8526	1.7813		1.8509	1.7683		1.9991	1.6167	***
Deposits Ratio	1.5246	0.7661	***	1.1766	0.7833	***	1.1423	0.8066	***	1.4293	0.6936	***
NPL Ratio	1.3941	2.3976	**	1.6403	2.9243	***	1.9473	2.0366		1.3987	2.6268	***
Z-score (ln)	3.0844	3.0909		3.1878	2.7906	**	3.0788	3.1259		3.0436	3.1409	
DPE	3.5669	3.7531		3.5924	3.9092		3.3018	5.1971	***	3.9660	3.3362	
DPE (ln)	0.9111	1.0609		0.9786	1.0503		0.9056	1.3715	***	0.9909	1.0041	

Panel A: Post-Crisis Period

Variables	Non-rescued Banks	Rescued Banks	Significance	No Capital Injections	Capital Injections	Significance	No Credit Lines	Credit lines	Significance	No Guarantee	Guarantee	Significance
Gender Diversity	12.7925	10.3925	***	12.4416	11.1114		12.4684	9.6671	*	12.7464	9.6676	***
Size	17.0887	18.2647	***	17.2025	18.8646	***	17.2252	19.1570	***	17.1943	18.0361	***
MES	3.0563	3.8409	***	3.1332	4.2609	***	3.1739	3.9429	***	3.1258	3.7368	***
MTB Ratio	0.9376	0.6016	***	0.8921	0.6626	**	0.8900	0.5977	**	0.9205	0.5788	***
Tobin's Q	0.9435	0.6104	***	0.8980	0.6757	**	0.8960	0.6080	**	0.9266	0.5862	***
Deposits Ratio	1.1876	0.6924	***	1.1167	0.7295	***	1.1090	0.7133	***	1.1592	0.6651	***
NPL Ratio	5.4168	7.5160	***	5.6836	7.6171		5.7992	5.6640		5.4691	8.0522	***
Z-score (ln)	3.1967	2.6206	***	3.1573	2.0539	***	3.1306	2.2528	**	3.1373	2.7843	**
DPE	2.0830	1.3409	**	2.0830	1.3409		1.9634	1.6241		2.0713	1.0971	***
DPE (ln)	0.4637	0.2014	***	0.4357	0.1102		0.4185	0.3761		0.4542	0.1536	***

Table 7. Gender Diversity and Public Bailouts

This table shows results of Probit regressions. The dependent variable is an indicator variable equal to one if bank *i* receives a bailout during the sample period (2007-2013) and zero otherwise. *Gender Diversity* is the percentage of female directors on the board of bank *i* at time *t*. *Female Participation Rate* is defined as the female labour force participation divided by male labour force participation in the NUTS 2 region where the bank's headquarter is located. *Female employment rate* is defined as the employment rate for women with tertiary education in the NUTS 2 region where the bank's headquarter is located. *Size* is the log of total assets. *MES* is the marginal expected shortfall of a stock given that the market return is below its 5th percentile. *MTB Ratio* is the market value of equity divided by the book value of equity. *ROA* is net income scaled by total assets. *Tobin's Q* is the market value of equity plus the face value of debt divided by the book value of equity plus the face value of debt. *Capital Ratio* is the ratio of bank equity capital over total assets. *Tier 1 Ratio* is the ratio of Tier 1 regulatory capital divided by risk-weighted assets. *Deposits Ratio* is the ratio of bank customer deposits to total assets. *Liquid Assets Ratio* is calculated as cash plus marketable securities to total assets. *Derivatives to Assets Ratio* is the amount of bank's derivatives scaled by total assets. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. *US-Mortgage Crisis dummy* is a dummy takes the value on one if the observation refers to the years 2007 and 2008. *EU-Sovereign Debt Crisis* a dummy takes the value on one if the observation refers to the years from 2010 and 2012. Constant included but not reported. All variables are winsorised at the 1th and 99th percentiles. Robust z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

	(1) With ROA, without Crises	*(2) With Tobin, without ROA*	*(3) Cluster S.E. by Country*	*(4) With MES*	*(5) With MES and HHI*	*(6) With MES, HHI and Tobin'Q*	*(7) With Liquid Assets Ratio*	*(8) With Derivatives Ratio*	*(9) With Year Fixed Effects*	*(10) Collapsed at the bank level*
***Gender Diversity*$_{t-1}$**	**-0.0304*** (-3.7165)**	**-0.0282*** (-3.3555)**	**-0.0299*** (-3.5635)**	**-0.0223** (-2.4695)**	**-0.0269*** (-2.7902)**	**-0.0243** (-2.5327)**	**-0.0249*** (-3.0351)**	**-0.0301*** (-3.2066)**	**-0.0273*** (-3.2031)**	**-0.0548** (-2.1731)**
Marginal effects	**-0.0060**	**-0.0057**	**0.0059**	**-0.0048**	**-0.0058**	**-0.0052**	**-0.0036**	**-0.0066**	**-0.0050**	**-0.0209**
Size$_{t-1}$	-0.0231	-0.0444	-0.0255				0.0282	0.0223	-0.0130	-0.0470
	(-0.5662)	(-1.0491)	(-0.5709)				(0.5942)	(0.3412)	(-0.2995)	(-0.4934)
MES$_{t-1}$				0.2213***	0.1695**	0.1940**				
				(2.9970)	(2.2076)	(2.4372)				
MTB Ratio$_{t-1}$	-0.1089	-5.7644	-0.1498	0.0403	0.0561	-2.2750	-0.3613*	-0.2381	-0.1435	-0.1135
	(-0.8880)	(-0.7951)	(-1.2458)	(0.2476)	(0.3495)	(-0.2870)	(-1.8436)	(-0.9872)	(-0.9931)	(-0.3188)
ROA$_{t-1}$	-0.1349**		-0.1374	-0.1395**	-0.1705**		-0.3071***	-0.3481***	-0.1691**	-0.1199
	(-2.0929)		(-1.3848)	(-2.0009)	(-2.4086)		(-3.4654)	(-3.7232)	(-1.9786)	(-0.4167)
Tobin's Q$_{t-1}$		5.6360				2.3162				
		(0.7675)				(0.2900)				
Capital Ratio$_{t-1}$	-0.0809***	-0.0954**	-0.0831***				-0.0827***	-0.0789***	-0.0843***	-0.1501*
	(-2.7207)	(-2.2752)	(-3.5931)				(-2.9823)	(-2.6331)	(-2.7599)	(-1.8258)
Tier 1 Ratio$_{t-1}$	-0.0193	-0.0247	-0.0178	-0.0566**	-0.0629**	-0.0746**			0.0020	0.1004*
	(-0.7878)	(-0.9222)	(-0.9075)	(-2.4215)	(-2.2108)	(-2.4136)			(0.0776)	(1.6475)
Deposits Ratio $_{t-1}$	-0.6340***	-0.5942***	-0.6095***	-0.9004***	-0.8888***	-0.9674***	-0.6365**	-0.5494*	-0.5855**	-0.6977*
	(-2.6793)	(-2.6757)	(-2.6854)	(-3.0343)	(-2.9580)	(-3.3056)	(-2.1559)	(-1.7794)	(-2.4464)	(-1.8509)
Liquid Assets Ratio$_{t-1}$							-0.0096*			
							(-1.9012)			
Derivatives Ratio$_{t-1}$								-1.8049		
								(-1.1302)		
HHI$_{t-1}$	-0.7632***	-0.6739**	-0.7629***		-0.7250**	-0.5221*	-0.5721*	-0.9710***	-0.7818***	-0.9788
	(-2.8519)	(-2.5725)	(-2.5867)		(-2.3368)	(-1.6744)	(-1.6716)	(-2.7186)	(-2.7158)	(-1.5209)
GDP growth $_{t-1}$	0.0101	-0.0029	0.0057	0.0151	0.0224	0.0090	-0.0222	0.0128	-0.0562	-0.2800
	(0.3146)	(-0.0864)	(0.0860)	(0.3509)	(0.5379)	(0.2286)	(-0.6103)	(0.3168)	(-1.1121)	(-1.6166)
Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	514	519	514	433	420	420	400	333	514	92
Banks	96	96	96	78	76	76	76	67	96	92
US-Mortgage Crisis	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
EU-Sovereign Crisis	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes
Year FEs	No	No	No	No	No	No	No	No	Yes	No
Cluster S.E.	Bank	Bank	Country	Bank	Bank	Bank	Bank	Bank	Bank	N/A

Table 8. Gender Diversity and Public Bailouts: IV-Probit regressions

This table shows results of IV Probit regressions used to predict bank bailouts. The dependent variable is an indicator variable equal to one if bank *i* receives a bailout during the sample period (2007-2013) and zero otherwise. *Gender Diversity* is the percentage of female directors on the board of bank *i* at time *t*. *Female Participation Rate* is defined as the female labour force participation divided by male labour force participation in the NUTS 2 region where the bank's headquarter is located. *Female employment rate* is defined as the employment rate for women with tertiary education in the NUTS 2 region where the bank's headquarter is located. *Size* is the log of total assets. *MES* is the marginal expected shortfall of a stock given that the market return is below its 5th percentile. *MTB Ratio* is the market value of equity divided by the book value of equity. *ROA* is net income scaled by total assets. *Tobin's Q* is the market value of equity plus the face value of debt divided by the book value of equity plus the face value of debt. *Capital Ratio* is the ratio of bank equity capital over total assets. *Tier 1 Ratio* is the ratio of Tier 1 regulatory capital divided by risk-weighted assets. *Deposits Ratio* is the ratio of bank customer deposits to total assets. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. *US-Mortgage Crisis dummy* is a dummy takes the value on one if the observation refers to the years 2007 and 2008. *EU-Sovereign Debt Crisis* a dummy takes the value on one if the observation refers to the years from 2010 and 2012. Constant included but not reported. Cragg-Donald test refers to the Cragg-Donald Wald F statistic. Kleibergen-Paap test refers to the Kleibergen-Paap Wald rank F statistic. All variables are winsorised at the 1th and 99th percentiles. Standard errors are clustered at bank-level. Robust z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panel A: Second Stage

Variables	Baseline IV-1	Baseline IV-2	Alternative IV-1	Alternative IV-2	Collapsed IV-1	Collapsed IV-2
	(1)	(2)	(3)	(4)	(5)	(6)
Gender Diversity$_{t-1}$	**-0.0790*** **	**-0.0700*** **	**-0.0753*** **	**-0.0762*** **	**-0.0989** **	**-0.1202*** **
	(-5.2355)	**(-4.0700)**	**(-4.1761)**	**(-3.6735)**	**(-2.3707)**	**(-3.0756)**
Marginal effects	**-0.0169**	**-0.0150**	**-0.0182**	**-0.0188**	**-0.0383**	**-0.0468**
Size$_{t-1}$	0.0653	0.0580			-0.0358	-0.0246
	(1.4162)	(1.1758)			(-0.3409)	(-0.2433)
MES$_{t-1}$			0.2106***	0.2141**		
			(2.5823)	(2.5258)		
MTB Ratio$_{t-1}$	-0.0873	-0.0775	0.9237	1.1302	0.0034	0.0385
	(-0.6169)	(-0.5504)	(0.1093)	(0.1337)	(0.0096)	(0.1160)
ROA$_{t-1}$	-0.0143	-0.0073			0.0818	0.1610
	(-0.2086)	(-0.1059)			(0.2619)	(0.5454)
Tobin's Q$_{t-1}$			-0.8524	-1.0593		
			(-0.0998)	(-0.1243)		
Capital Ratio$_{t-1}$	-0.1266***	-0.1106***			-0.1742*	-0.1706**
	(-3.5014)	(-3.2087)			(-1.9420)	(-2.0044)
Tier 1 Ratio$_{t-1}$	-0.0137	-0.0256	-0.0438	-0.0497*	0.0815	0.0720
	(-0.5807)	(-1.0792)	(-1.5426)	(-1.7385)	(1.1794)	(1.0992)
Deposits Ratio$_{t-1}$	-0.5159**	-0.5069**	-0.9334***	-0.8818***	-0.7436**	-0.7048**
	(-2.5401)	(-2.4618)	(-3.6017)	(-3.3907)	(-2.0124)	(-2.0734)
HHI$_{t-1}$			-0.7710**	-0.8006**	-0.7288	-0.6803
			(-2.2115)	(-2.2998)	(-0.9987)	(-0.9753)
GDP growth$_{t-1}$	0.0329	0.0300	0.0381	0.0385	-0.2070	-0.1447
	(0.9523)	(0.8020)	(1.0699)	(1.0161)	(-1.0776)	(-0.7519)
Observations	482	479	384	381	82	82
Banks	90	90	70	70	82	82
US-Mortgage Crisis	Yes	Yes	Yes	Yes	No	No
EU-Sovereign Crisis	Yes	Yes	Yes	Yes	No	No
Cluster	Bank	Bank	Bank	Bank	N/A	N/A

Panel B: First Stage

	Baseline IV-1	Baseline IV-2	Alternative IV-1	Alternative IV-2	Collapsed IV-1	Collapsed IV-2
Female Participation Rate$_{t-1}$	**0.5713*** **		**0.5604*** **		**0.5572*** **	
	(4.9045)		**(4.2700)**		**(4.9408)**	
Female employment rate$_{t-1}$		**0.7538*** **		**0.7259*** **		**0.8856*** **
		(5.3291)		**(4.2341)**		**(4.1959)**
Size$_{t-1}$	0.8424***	1.2777***			0.7091*	1.2853***
	(2.6773)	(3.4289)			(1.7213)	(2.7768)
MES$_{t-1}$			0.7055	1.6889***		
			(1.3258)	(2.9135)		
MTB Ratio$_{t-1}$	1.2884**	1.3298**	53.1960*	55.1526*	1.6160	1.6883
	(2.3593)	(2.2605)	(1.9052)	(1.8678)	(1.5361)	(1.5498)
ROA$_{t-1}$	-0.0902	-0.4576			0.8212	1.4064*
	(-0.2773)	(-1.1537)			(0.9680)	(1.6470)
Tobin's Q$_{t-1}$			-52.7997*	-54.6916*		
			(-1.8447)	(-1.8117)		
Capital Ratio$_{t-1}$	-0.0915	0.0180			-0.0461	-0.0277
	(-0.6991)	(0.1067)			(-0.3018)	(-0.1723)
Tier 1 Ratio$_{t-1}$	0.2259***	0.2735***	0.2687**	0.2958**	0.1353	0.1341
	(2.7708)	(2.7958)	(2.4292)	(2.1206)	(0.8187)	(0.7822)
Deposits Ratio$_{t-1}$	-0.3870	-0.3800	-0.3697	-0.5855**	-0.5339	-0.6432
	(-0.9877)	(-0.9711)	(-1.2201)	(-2.0023)	(-1.0720)	(-1.2514)
HHI$_{t-1}$			-6.8429***	-5.0022*	0.4186	2.9235
			(-2.7988)	(-1.9361)	(0.1544)	(1.0157)
GDP growth$_{t-1}$	0.3169**	0.3856***	0.3080**	0.3604***	0.2815	-0.0430
	(2.5473)	(3.5891)	(2.2352)	(3.0126)	(0.4280)	(-0.0587)
US-Mortgage Crisis	Yes	Yes	Yes	Yes	No	No
EU-Sovereign Crisis	Yes	Yes	Yes	Yes	No	No
Wald exogeneity test	9.903	6.092	7.806	5.420	0.864	1.873
(Prob>Chi-Squared)	0.00165	0.0136	0.00521	0.0199	0.353	0.171
Cragg-Donald test	122.6	73.36	101.3	53.44	21.43	15.46
Kleibergen-Paap test	30.44	27.24	27.81	19.25	N/A	N/A

Table 9. Timing of Public Bailout and Gender Diversity

The table shows the results of Cox (1972) and Weibull regressions (Column 5) where the dependent variable is the probability that a bank receives a bailout since the start of the financial crisis (2007). Predictors are expressed in average and calculated across the pre-crisis period. The variable of our interest is *Gender Diversity*. The controls are *Size*, *Capital Ratio*, *Tier 1 Ratio*, *Deposits Ratio, CEO female Dummy, Board Independence Ratio*, and *Board Size*. *CEO female Dummy* is an indicator variable that takes the value of one if the CEO is a woman, and zero otherwise. *Board Independence Ratio* is the proportion of independent directors on the board. *Board Size (ln)* is the natural logarithm of the number of board members. In Column 5 and in Column 6, we estimate the Cox hazard model (1972) using a duration based on the number of days. Regressions include also country fixed-effects (*Country FE*). We report the *Hazard Ratio* for ease of the interpretation. PH test stands for the Schoenfeld residuals test (Schoenfeld, 1982). Robust z-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Proportional Hazard Models					
Variables	*Public Bailout (1)*	*Public Bailout (2)*	*Public Bailout (3)*	*Public Bailout (4)*	*Public Bailout (5)*
Gender Diversity*precrisis*	**0.9487*** (-3.1067)**	**0.9487*** (-3.1100)**	**0.9537*** (-2.7380)**	**0.9002** (-2.5538)**	**0.9806** (-2.3058)**
Bank-specific controls	Yes	Yes	Yes	Yes	Yes
Country FE	Yes	Yes	Yes	Yes	Yes
CEO female Dummy	No	Yes	No	No	No
Board size (ln) – Board Independence Ratio	No	No	Yes	No	No
Proportional Hazard Model	Semi-Parametric	Semi-parametric	Semi-Parametric	Semi-Parametric	Parametric
Intercept	No	No	No	No	Yes
PH-test (Chi-Squared)	8.56	8.56	8.61	38.45***	(N/A)
Rescued banks	47	47	47	50	50
Banks	105	105	105	105	105
Duration	Years	Years	Years	Days	Days
Log-Likelihood	-133.10	-133.10	-132.54	-116.90	-51.71

Table 18. Censored Regression Models: Amount of Public Bailouts and Gender Diversity.

This table shows results of IV-Tobit models (Panel A) and Panel Data Censored Regression Models (Panel B) with bank fixed effects (Honorè, 1992). The dependent variables are: *Capital Injections*, *Credit Lines*, *Guarantees*. *Capital Injections* is the amount of equity capital injections for bank *i* in year *t*, scaled by total assets. *Credit Lines* is the amount of credit lines for bank *i* in year *t*, scaled by total assets. *Guarantees* is the amount of guarantees for bank *i* in year *t*, scaled by total assets. *Gender Diversity is* the percentage of female directors on the board of the bank *i*'s at time *t*. The control variables are: *MES*, *Tobin's Q*, *Capital Ratio*, *Tier 1 Ratio*, *Deposits Ratio*, *HHI*, *GDP growth*, *US-Mortgage Crisis*, and *Sovereign Debt Crisis*. *MES* is the marginal expected shortfall of a stock given that the market return is below its 5th percentile. *Tobin's Q* is calculated as the Market Value of equity plus the face value of debt divided by the book value of equity plus the face value of debt. *Capital Ratio* is the ratio of bank equity capital over total assets. *Tier 1* is the ratio between the regulatory capital and the risk-weighted assets. *Deposits Ratio* is the proportion of the bank customer deposits to total assets. *GDP growth* is annual percentage growth rate of GDP at market prices based on constant local currency. *US-Mortgage Crisis dummy* is a dummy takes the value on one if the observation refers to the years 2007 and 2008. *EU-Sovereign Debt Crisis* a dummy takes the value on one if the observation refers to the years from 2010 and 2012. For Panel A, all control variables are lagged by one year. For Panel B, the variables are not lagged, because this would be inconsistent with the assumptions of the model. Constant included but not reported. All variables are winsorised at the 1th and 99th percentiles. Standard errors are clustered at bank-level. Robust *z*-statistics in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panel A: IV Tobit Regressions

Variables	*Capital Injections (1)*	*Capital Injections (2)*	*Credit Lines (3)*	*Credit Lines (4)*	*Guarantees (5)*	*Guarantees (6)*
Gender Diversity$_{t-1}$	**-0.3237****	**-0.2998****	**-0.1199***	**-0.2004*****	**-0.9458*****	**-0.8922****
	(-2.3625)	**(-2.3608)**	**(-1.7083)**	**(-3.0464)**	**(-3.4701)**	**(-2.4856)**
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	378	375	378	375	378	375
Banks	70	70	70	70	70	70
	First stage results					
Female Participation Rate$_{t-1}$	**0.5348*****		**0.5348*****		**0.5348*****	
	(3.9044)		**(3.9044)**		**(3.9044)**	
Female employment rate$_{t-1}$		**0.7069*****		**0.7069*****		**0.7069*****
		(4.3279)		**(4.3279)**		**(4.3279)**
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	378	375	378	375	378	375
Banks	70	70	70	70	70	70

Panel B: Panel Tobit Regressions (Honorè, 1992)

Variables	*Capital Injections (1)*	*Credit Lines (2)*	*Guarantees (3)*
Gender Diversity	**-0.1039****	**-0.1056****	**-0.3855**
	(-2.1044)	**(-2.5187)**	**(-0.8367)**
Controls	YES	YES	YES
Observations	428	428	428
Bank FE	Yes	Yes	Yes
Banks	77	77	77
Chi-Squared	69.22	669.81	51.12
Fraction Censored	0.08	0.05	0.14

Table 11. The mechanism

This table shows results of IV regressions where the dependent variables are proxies for bank profitability, bank's risk and, dividend payout ratios. *Gender Diversity* is the percentage of female directors on the board of bank *i* at time *t*. *Female Participation Rate* is defined as the female labour force participation divided by male labour force participation in the NUTS 2 region where the bank's headquarter is located. *Female employment rate* is defined as the employment rate for women with tertiary education in the NUTS 2 region where the bank's headquarter is located. *Size* is the log of Total Assets. *MES* is the marginal expected shortfall of a stock given that the market return is below its 5th percentile. *Capital Ratio* is the ratio of bank equity capital over total assets. *Tier 1 Ratio* is the ratio of Tier 1 regulatory capital divided by risk-weighted assets. *Deposits Ratio* is the ratio of bank customer deposits to total assets. *Widely Held* is a dummy equal to one if there is no owner with more than 10% of bank share rights and zero otherwise. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. *US-Mortgage Crisis dummy* is a dummy takes the value on one if the observation refers to the years 2007 and 2008. *EU-Sovereign Debt Crisis* a dummy takes the value on one if the observation refers to the years from 2010 and 2012. Cragg-Donald test refers to the Cragg-Donald Wald F statistic. Kleibergen-Paap test refers to the Kleibergen-Paap Wald rank F statistic. Constant included but not reported. All variables are wisorised at the 1th and 99th percentiles. Standard errors are clustered at bank-level. Robust z-statistics are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panel A: Second Stage								
Variables	*Tobin's Q* (1)	*Tobin's Q* (2)	*ROA* (3)	*ROA* (4)	*NPL Ratio* (5)	*NPL Ratio* (6)	*DPE (ln)* (7)	*DPE (ln)* (8)
Gender Diversity$_{t-1}$	**0.0208**	**0.0308**	**0.0724****	**0.0792***	**-0.5386*****	**-0.8526*****	**0.0287**	**0.0568****
	(0.9260)	**(1.0838)**	**(2.1391)**	**(1.8222)**	**(-3.0627)**	**(-4.0373)**	**(1.2668)**	**(2.2233)**
Size$_{t-1}$					0.5200*	0.7276**		
					(1.9418)	(2.1634)		
MES $_{t-1}$	-0.0552	-0.0696	-0.1452*	-0.1590*			-0.0306	-0.0606
	(-1.1187)	(-1.2298)	(-1.8776)	(-1.9013)			(-0.5982)	(-0.9092)
Capital Ratio$_{t-1}$	0.0044	0.0087	0.1211***	0.1238***	-0.2682*	-0.3929**	0.0373***	0.0502***
	(0.2944)	(0.6004)	(3.1069)	(2.9187)	(-1.8635)	(-1.9704)	(2.7537)	(3.3425)
Tier 1 Ratio$_{t-1}$	-0.0395	-0.0434	-0.0262	-0.0305	0.1954**	0.2760**	-0.0195	-0.0281
	(-1.1596)	(-1.1915)	(-1.2957)	(-1.5423)	(2.1056)	(2.0992)	(-0.8226)	(-1.1573)
Deposits Ratio$_{t-1}$	0.2438*	0.2399*	0.0971*	0.0940	-0.6326**	-0.5412	0.0351	0.0255
	(1.8746)	(1.8826)	(1.6899)	(1.6240)	(-2.3207)	(-1.4576)	(0.6011)	(0.4854)
Widely Held$_{t-1}$	-0.2229	-0.1689	0.1157	0.1744	0.4295	-0.6776	-0.1310	0.0068
	(-1.6402)	(-1.1875)	(0.4992)	(0.5500)	(0.3430)	(-0.4239)	(-0.8165)	(0.0323)
HHI$_{t-1}$	-0.1433	-0.0229	-0.1512	-0.0593	3.0877	0.8338	-0.4763	-0.1483
	(-0.3900)	(-0.0640)	(-0.2543)	(-0.0845)	(1.1167)	(0.2574)	(-1.5066)	(-0.3873)
GDP growth$_{t-1}$	-0.0100	-0.0127	0.0564	0.0563	-0.0324	0.1240	0.0075	-0.0039
	(-0.8370)	(-0.9617)	(1.5079)	(1.4887)	(-0.2092)	(0.8261)	(0.5334)	(-0.2464)
Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	429	425	441	437	532	528	440	436
Banks	71	71	72	72	88	88	72	72
R-squared	0.238	0.224	0.005	-0.031	-0.173	-0.871	0.165	0.055
Cluster	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank
US-Mortgage Crisis	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
EU-Sovereign Debt Crisis	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: First Stage								
Female Participation Rate$_{t-1}$	**0.4620*****		**0.4312*****		**0.4613*****		**0.4343*****	
	(3.7600)		**(3.4800)**		**(3.9700)**		**(3.4900)**	
Female employment rate$_{t-1}$		**0.6701*****		**0.6313*****		**0.6936*****		**0.6405*****
		(4.4200)		**(4.2200)**		**(5.2900)**		**(4.2900)**
Size$_{t-1}$					0.5204	0.9883***		
					(1.6200)	(2.8000)		
MES$_{t-1}$	0.4333	1.3211**	0.5897	1.3504**			0.5812***	1.3493**
	(0.8000)	(2.2100)	(1.0600)	(2.2800)			(1.0400)	(2.2800)
Capital Ratio$_{t-1}$	-0.3022	-0.4136*	-0.3143	-0.4216*	-0.2691	-0.2972*	-0.3086	-0.4155*
	(-1.3800)	(-1.8500)	(-1.4000)	(-1.8400)	(-1.6400)	(-1.8400)	(-1.3700)	(-1.8200)
Tier 1 Ratio$_{t-1}$	0.2545**	0.3066**	0.2634**	0.3101	0.2581**	0.3237**	0.2599**	0.3060**
	(2.1700)	(2.1000)	(2.2000)	(2.1200)	(2.1700)	(2.5400)	(2.1700)	(2.0900)
Deposits Ratio$_{t-1}$	0.2265	0.0581	0.2094	0.0632	0.1553	0.1904	0.2130	0.0645
	(0.5800)	(0.1600)	(0.5300)	(0.1700)	(0.4000)	(0.4800)	(0.5300)	(0.1800)
Widely Held$_{t-1}$	-1.1760	-2.5443	-1.7527	-2.9972	-1.3759	-2.6093*	-1.6955	-2.9259
	(-0.7100)	(-1.3300)	(-1.0700)	(-1.6300)	(-1.0500)	(-1.7900)	(-1.0400)	(-1.5900)
HHI$_{t-1}$	-8.6242***	-8.0487**	-8.2856***	-8.0040***	-5.0270**	-4.3470*	-8.2059***	-7.8800***
	(-2.9800)	(-2.6100)	(-2.9500)	(-2.7100)	(-2.3200)	(3.0600)	(2.9100)	(-2.6600)
GDP growth$_{t-1}$	0.3650***	0.3417***	0.3486**	0.3284***	0.3438***	0.3395*	0.3428**	0.3206***
	(2.6500)	(2.8600)	(2.5700)	(2.7200)	(2.7400)	(3.0600)	(2.5100)	(2.6400)
Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	429	425	441	437	528	528	440	436
Banks	71	71	72	72	88	88	72	72
Cluster	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank
Cragg-Donald test	61.55	48.92	54.76	44.88	78.49	74.49	55.26	45.71
Kleibergen-Paap test	14.11	19.53	12.11	17.85	15.80	27.93	12.20	18.41

Table 12. 3SLS regressions

This table reports the results for 3SLS regressions investigating the mechanism underlying the relationship between *Gender Diversity* and public bailouts. The controls include: *Widely Held*, *MES*, *Capital Ratio*, *Tier 1 Ratio*, *HHI*, *GDP growth*, *US-Mortgage Crisis Dummy*, and *EU-Sovereign Debt Crisis*. Except for *Bailout* and *Widely Held*, all controls are wisorised at 1st and 99th percentiles. Robust z-statistics are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Variables	*Public Bailout$_t$* (1)	*ROA$_{t-1}$* (2)	*Gender Diversity$_{t-1}$* (3)	*Public Bailout$_t$* (4)	*NPL Ratio$_{t-1}$* (5)	*Gender Diversity$_{t-1}$* (6)	*DPE(ln)* (7)	*ROA $_{t-1}$* (8)	*Gender Diversity$_{t-1}$* (9)	*DPE(ln)* (10)	*NPL Ratio$_{t-1}$* (11)	*Gender Diversity$_{t-1}$* (12)
ROA$_{t-1}$	-0.6065***						0.8154***					
	(-4.3285)						(3.0766)					
NPL Ratio$_{t-1}$				0.0699***						-0.0910***		
				(4.7609)						(-3.3721)		
Gender Diversity$_{t-1}$		0.0545***			-0.4718***			0.0541***			-0.4826***	
		(3.5393)			(-5.2115)			(3.5052)			(-5.2375)	
Female Participation Rate$_{t-1}$			0.2058***			0.1705***			0.2211***			0.1716***
			(3.5599)			(3.3893)			(3.7848)			(3.4062)
Female employment rate$_{t-1}$			0.4823***			0.5362***			0.4618***			0.5400***
			(5.4334)			(6.9222)			(5.0291)			(6.8284)
Observations	486	486	486	486	486	486	480	480	480	480	480	480
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Figure 2. Public bailouts over the sample period.

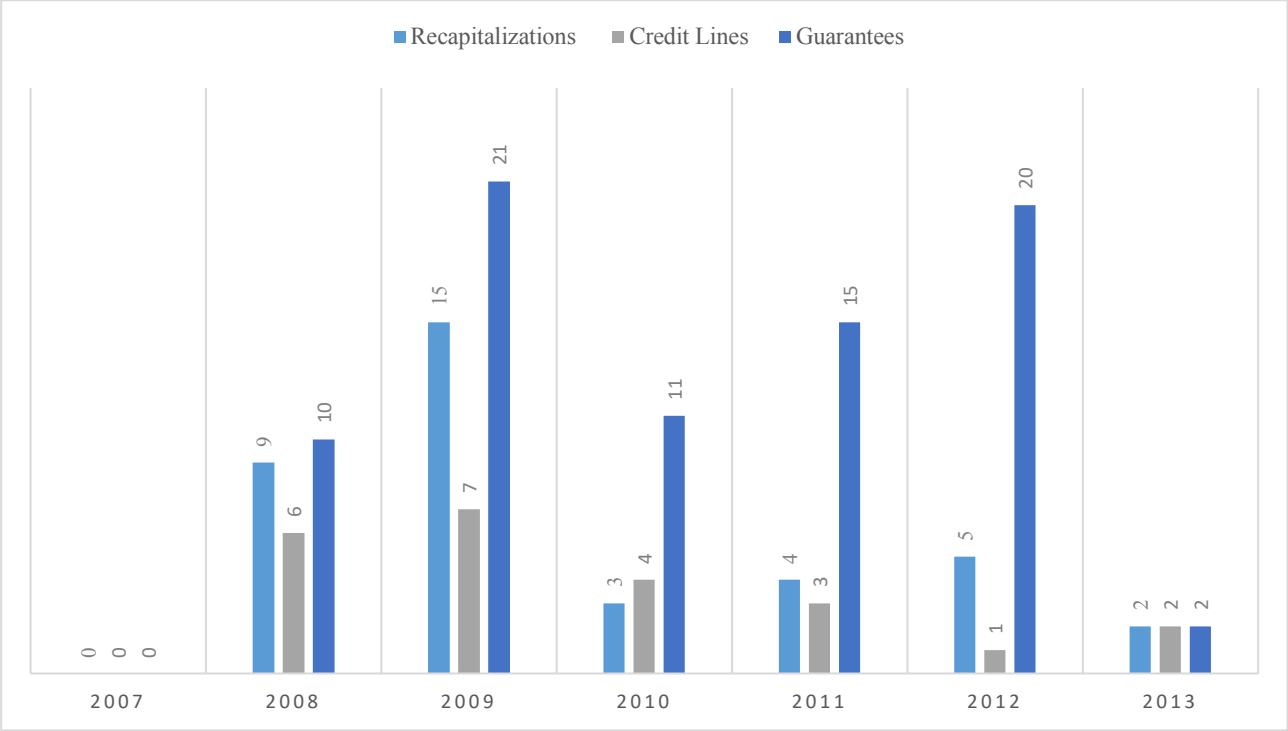


Figure 3. Average Gender Diversity over the sample period.

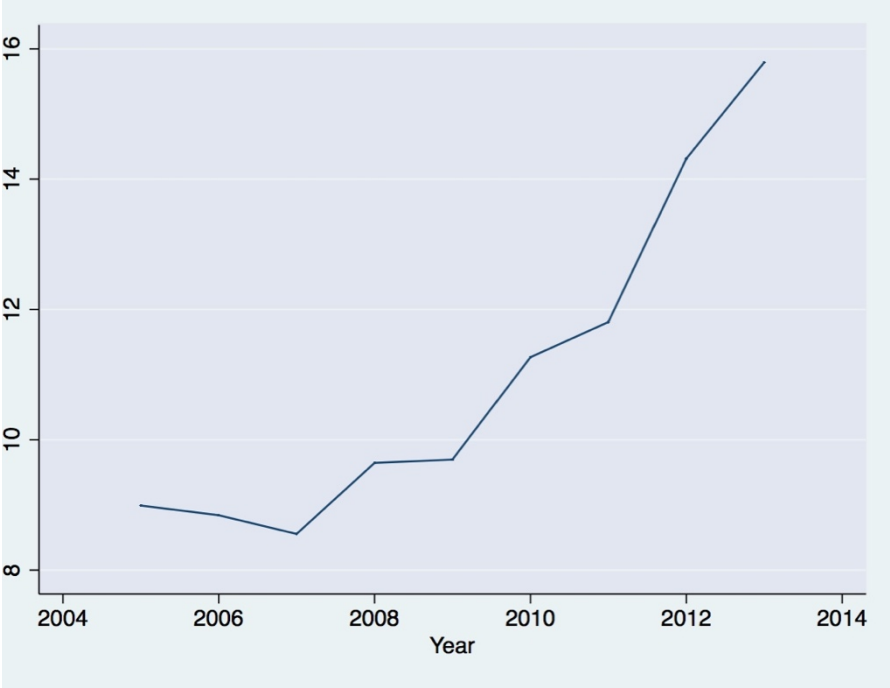
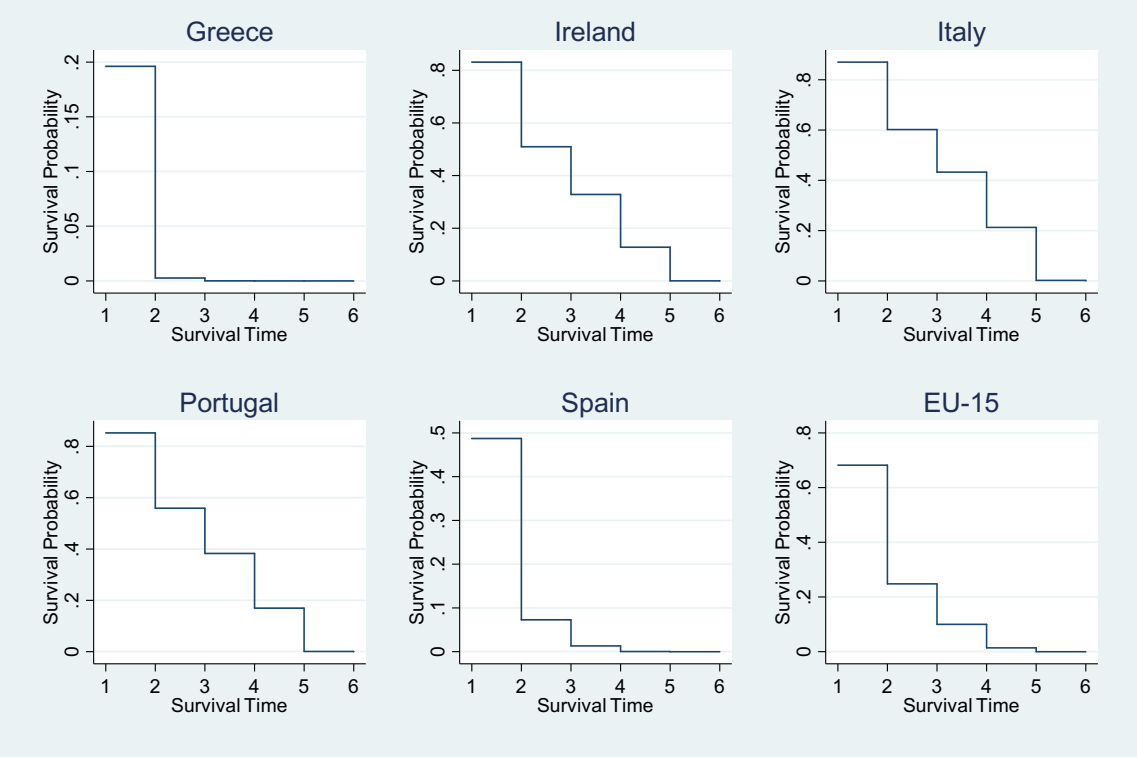


Figure 3. Proportional Cox hazard models: Estimated survival functions.



Appendix

Supplementary Appendix A. Correlations

The table shows pairwise correlations among the main explanatory variables.

Pairwise correlations												
Variables		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
Gender Diversity	(1)	1										
Size	(2)	0.1953***	1									
MES	(3)	0.1033**	0.5001***	1								
MTB Ratio	(4)	0.0626	-0.268***	-0.2121***	1							
ROA	(5)	0.1009***	-0.2096***	-0.2451***	0.3108***	1						
Tobin	(6)	0.0662*	-0.2727***	-0.2105***	0.9999***	0.3140***	1					
Capital Ratio	(7)	-0.0602	-0.5459***	-0.1951***	0.1224***	0.4945***	0.1247***	1				
Deposits Ratio	(8)	-0.0599	-0.2835***	-0.0061	0.3124***	0.0872**	0.3117***	0.1033***	1			
Tier 1 Ratio	(9)	0.0951**	-0.0249	0.0436	-0.1479***	-0.0807**	-0.1470***	-0.1466***	-0.0772**	1		
HHI	(10)	-0.1318***	-0.2244***	-0.2478***	-0.0452	-0.0162	-0.0437	0.0314	0.1506***	0.0553	1	
GDP growth	(11)	0.1233***	0.0789**	-0.0829***	0.1544***	0.2142***	0.1543***	-0.0118	0.071**	-0.0473	-0.0625*	1

Supplementary Appendix B. Wilcoxon Tests

This table reports Wilcoxon-Test for rescued banks and non-rescued banks. Panel A reports results for the pre-crisis period and Panel B for the post-crisis period. *** p<0.01, ** p<0.05, * p<0.1.

Rescued and Non-rescued banks: An overview

Panel A: Pre-Crisis Period

	Public Bailouts							
	Bailout		Capital Injections		Credit Lines		Guarantees	
Variables	Z-statistic	Significance	Z-statistic	Significance	Z-statistic	Significance	Z-statistic	Significance
Gender Diversity	0.9242		-2.4435	**	-0.5046		1.7654	*
Size	-3.6983	***	-5.5732	***	-4.0545	***	-1.1170	
Deposits (%TA)	2.5278	**	0.6893		0.5157		4.5847	***
NPL Ratio	-5.4208	***	-4.4377	***	-2.5489	**	-5.0455	***
Z-score (ln)	-0.1400		2.4657	**	-0.1094		-0.9385	
Tobin's Q	1.4993		-0.6718		-0.2343		2.0721	**
MES	-0.1168		-2.0783	**	-1.3244		2.5870	***
DPE	-1.1159		-0.6862		-3.1442	***	0.0328	
DPE (ln)	-1.2550		-0.6637		-3.2267	***	-0.0394	
MTB Ratio	1.4248		-0.8305		0.3931		1.9955	**

Panel B: Post-Crisis Period

	Public Bailouts							
	Bailout		Capital Injections		Credit Lines		Guaranteess	
Variables	Z-statistic	Significance	Z-statistic	Significance	Z-statistic	Significance	Z-statistic	Significance
Gender Diversity	1.8645	*	0.6231		1.0799		2.1842	**
Size	-4.6945	***	-4.110674	***	-3.837331	***	-2.908283	***
Deposits (%TL)	4.6287	***	0.9122		1.3173		4.8121	***
NPL Ratio	4.0988	***	4.3770	***	2.5534	**	2.5250	**
Z-score (ln)	4.2992	***	1.2603		2.3045	**	3.8869	***
Tobin's Q	-5.2207	***	-4.7754	***	-2.9363	***	-3.4732	***
MES	3.0659	***	1.5162		1.2229		3.2586	***
DPE	2.7038	***	1.3821		0.4547		2.9522	***
DPE (ln)	4.2665	***	1.2829		2.3110	**	3.8425	***
MTB Ratio	1.8645	*	0.6231		1.0799		2.1842	**

Supplementary Appendix C. Impact of gender-quotas programs

The table shows the change in the number of sample banks that satisfy the gender-quota (if any) before and after the implementation of gender-quotas programs in EU-15 countries. In most cases, the rules are applicable only to state-owned companies. In some cases, listed companies are considered, or large firms. For more details, see: *Legal Instruments for Gender Quotas in Management Boards.*[67] For cases where the implementation stage evolves over two phases, we consider only the phases that end within our sample period. If the implementation started before the start of our sample period, we report the number of banks above the quota as "Banks above quota post-program".

Country	*Gender Quotas*	*Implementation Year*	*Targeted organisations*	*Banks above quota pre-program*	*Banks above quota post-program*	*Δ no.*
Austria	25% (phase 1) 35% (phase 2)	2013 2018	Only state-owned companies	1	1	0
Belgium	33%	2012 (state-owned companies) 2016 (listed companies)	State-owned and listed companies	0	0	0
Denmark	30%	2000	Only state-owned companies	-	3	-
Finland	20%	2005	Only state-owned companies	-	1	-
France	20% (phase 1) 40% (phase 2)	2013 2016	Listed companies; companies with 500+ employees or turnover/asset >€50m	7	7	0
Ireland	40%	2004	Only state-owned companies	-	0	-
Italy	20% 33%	2012 2015	Listed companies; companies with public participation / state-ownership	1	7	6
Netherlands	30%	2016	All firms with >250 employees (and turnover criteria).	1	-	-
Spain	40%	2015	Public limited companies with > 250 employees.	0	-	-

[67] This document can be found at: http://www.europarl.europa.eu/RegData/etudes/workshop/join/2013/474413/IPOL-FEMM_AT(2013)474413_EN.pdf

Supplementary Appendix D. Main studies on the impact of gender diversity on performance, risk, and dividend policy.

Selected literature					
Authors	*Sample*	*Method*	*Dependent Variable*	*Main independent Variable*	*Main findings*
			Panel A: Performance		
Adams and Ferreira (2009)	US sample of 1,939 listed non-financial firms (1006-2003)	OLS, IV estimation, GMM estimation	Tobin's Q (ln)	Proportion of female directors	Proportion of female directors is negatively related to firm profitability.
Ahern and Dittmar (2012)	All public limited Norwegian firms traded on the Oslo Stock Exchange (2001-2009)	DID estimator	Tobin's Q	Proportion of female directors	Introduction of the gender-quota in Norway in 2003 determined both younger and less experienced board and a deterioration of firm's profitability
Liu et al. (2014)	Chinese sample of listed firms (199-2011)	OLS, Panel estimation, IV(s), Arellano-Bond	ROA, ROS	Proportion of female directors	Positive relationship between the proportion of female directors and firm profitability.
Adams and Ragunathan (2015)	US-listed BHC companies and commercial banks (2006-2009)	OLS, IV(s)	Tobin's Q, ROA	Proportion of female directors	Banks with a higher proportion of female directors perform better (for Tobin's Q).
			Panel B: Risk		
Berger et al. (2014)	German sample of 2,490 small and medium-sized banks (1994-2010)	DID estimation	Risk Weighted Assets to total assets/Total Assets, Herfindahl–Hirschman Index for loan portfolio	Proportion of female executives	Female executives have less expertise than their male-peers. More gender-diverse executive teams increase bank portfolio risk.
Sila et al. (2016)	i) 1960 firms; ii) 138 BHC (1996-2010)	GMM estimation	Proxies for equity risk, systematic risk, and idiosyncratic risk	Proportion of female directors	There exists no relationship between female boardroom representation and equity risk. Similar evidences are reported for BHCs.
			Panel C: Dividend Policy		
Chen et al. (2017)	US sample of 1,691 firms (1997-2011)	IV estimation	Dividends/Equity, Dividends/Total Assets	Proportion of female directors	Positive effect of board gender composition on dividend payout ratio.

Supplementary Appendix E. Gender diversity, corporate governance mechanisms, and bank profitability

This table shows results of IV regressions where the dependent variables are proxies for bank profitability. *Gender Diversity* is the percentage of female directors on the board of bank *i* at time *t*. *Female participation rate* is defined as the female labour force participation divided by male labour force participation in the NUTS 2 region where the bank's headquarter is located. *Female employment rate* is defined as the employment rate for women with tertiary education in the NUTS 2 region where the bank's headquarter is located. *Female CEO* is a dummy variable takes on value 1 whether the CEO is female, and 0 otherwise. *Board size* is the logarithm of board members. *Board Independence ratio* is measured as the proportion of independent directors on the total board. *Size* is the log of total assets. *MES* is the marginal expected shortfall of a stock given that the market return is below its 5th percentile. *Capital Ratio* is the ratio of bank equity capital over total assets. *Tier 1 Ratio* is the ratio of Tier 1 regulatory capital divided by risk-weighted assets. *Deposits Ratio* is the ratio of bank customer deposits to total assets. *Widely Held* is a dummy variable equal to one if there is no owner with more than 10% of bank share rights, and zero otherwise. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. *US-Mortgage Crisis dummy* is a dummy takes the value on one if the observation refers to the years 2007 and 2008. *EU-Sovereign Debt Crisis* a dummy takes the value on one if the observation refers to the years from 2010 and 2012. Cragg-Donald test refers to the Cragg-Donald Wald F statistic. Kleibergen-Paap test refers to the Kleibergen-Paap Wald rank F statistic. Constant included but not reported. All variables are winsorised at the 1th and 99th percentiles. Standard errors are clustered at the bank level. Robust z-statistics are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Panel A: Second Stage								
	Tobin's	*Tobin's*	*ROA*	*ROA*	*Tobin*	*Tobin*	*ROA*	*ROA*
VARIABLES	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Gender Diversity$_{t-1}$	**0.0212**	**0.0326**	**0.0760****	**0.0864***	**0.0119**	**0.0125**	**0.0763****	**0.0864**
	(0.8887)	**(1.0295)**	**(2.0885)**	**(1.7706)**	**(0.5174)**	**(0.4762)**	**(2.0211)**	**(1.5900)**
Female CEO$_{t-1}$	-0.0660	-0.1619	-0.5689	-0.6493				
	(-0.2619)	(-0.5036)	(-1.5601)	(-1.4497)				
Board Size (ln)$_{t-1}$					-0.4467*	-0.4970*	-0.1017	-0.1278
					(-1.7832)	(-1.9129)	(-0.4337)	(-0.4736)
Board Independence Ratio$_{t-1}$					0.0007	0.0010	-0.0026	-0.0030
					(0.3127)	(0.4447)	(-0.6838)	(-0.6475)
MES$_{t-1}$	-0.0552	-0.0702	-0.1458*	-0.1625*	-0.0507	-0.0644	-0.1469*	-0.1633*
	(-1.1166)	(-1.2167)	(-1.8606)	(-1.8775)	(-0.9563)	(-1.1541)	(-1.7888)	(-1.7509)
Capital Ratio$_{t-1}$	0.0044	0.0090	0.1212***	0.1254***	-0.0083	-0.0100	0.1201***	0.1237***
	(0.2943)	(0.6241)	(3.0513)	(2.8137)	(-0.4556)	(-0.5325)	(3.0461)	(2.7564)
Tier 1 Ratio$_{t-1}$	-0.0392	-0.0430	-0.0242	-0.0291	-0.0390	-0.0418	-0.0280	-0.0333
	(-1.1778)	(-1.2036)	(-1.2123)	(-1.4650)	(-1.1736)	(-1.1798)	(-1.3120)	(-1.5421)
Deposits Ratio$_{t-1}$	0.2435*	0.2390*	0.0951	0.0906	0.2079*	0.2024*	0.0854	0.0787
	(1.8798)	(1.8917)	(1.6345)	(1.5332)	(1.7229)	(1.6958)	(1.4124)	(1.2743)
Widely Held$_{t-1}$	-0.2250	-0.1707	0.1004	0.1714	-0.2381	-0.2092	0.1522	0.2296
	(-1.6391)	(-1.1912)	(0.4338)	(0.5260)	(-1.4891)	(-1.3720)	(0.6422)	(0.6411)
HHI$_{t-1}$	-0.1449	-0.0174	-0.1619	-0.0346	-0.2312	-0.2161	-0.1740	-0.0510
	(-0.3947)	(-0.0483)	(-0.2708)	(-0.0477)	(-0.5804)	(-0.5785)	(-0.2824)	(-0.0684)
GDP growth$_{t-1}$	-0.0100	-0.0133	0.0557	0.0540	-0.0085	-0.0054	0.0594	0.0583
	(-0.8304)	(-0.9449)	(1.4793)	(1.4075)	(-0.8297)	(-0.5083)	(1.5862)	(1.5008)
Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	429	425	441	437	429	425	441	437
R-squared	0.238	0.220	-0.010	-0.070	0.271	0.278	-0.013	-0.071
Cluster	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank
US-Mortgage Crisis	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
EU-Sovereign Debt Crisis	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: First Stage								
Female participation rate$_{t-1}$	**0.4445*****		**0.4134*****		**0.4156*****		**0.3857*****	
	(3.6032)		**(3.3199)**		**(3.4142)**		**(3.1324)**	
Female employment rate$_{t-1}$		**0.6318*****		**0.5925*****		**0.5855*****		**0.5490*****
		(4.0440)		**(3.8492)**		**(3.3041)**		**(3.1692)**
Female CEO$_{t-1}$	6.3850**	5.3127**	6.5202**	5.5030**				
	(2.4193)	(2.2808)	(2.4992)	(2.3611)				
Board Size (ln)$_{t-1}$					-1.2245	-0.6952	-0.9097	-0.4320
					(-0.5749)	(-0.3346)	(-0.4287)	(-0.2074)
Board Independence Ratio$_{t-1}$					0.0383	0.0296	0.0403	0.0310
					(1.5549)	(1.0739)	(1.6512)	(1.1456)
MES$_{t-1}$	0.4185	1.2673**	0.5731	1.2975**	0.4350	1.2050*	0.5928	1.2481**
	(0.7714)	(2.0992)	(1.0349)	(2.1745)	(0.7641)	(1.9620)	(1.0305)	(2.0667)
Capital Ratio$_{t-1}$	-0.2901	-0.4017*	-0.3024	-0.4096*	-0.3302	-0.4269*	-0.3349	-0.4284*
	(-1.3261)	(-1.7865)	(-1.3475)	(-1.7785)	(-1.5319)	(-1.9694)	(-1.5180)	(-1.9270)
Tier 1 Ratio$_{t-1}$	0.2206*	0.2762*	0.2294*	0.2792*	0.2537**	0.2974*	0.2637**	0.3028**
	(1.8998)	(1.8847)	(1.9448)	(1.9017)	(2.1024)	(1.9905)	(2.1576)	(2.0222)
Deposits Ratio $_{t-1}$	0.2398	0.0818	0.2239	0.0876	0.1539	0.0493	0.1619	0.0738
	(0.6026)	(0.2223)	(0.5563)	(0.2365)	(0.3539)	(0.1181)	(0.3663)	(0.1746)
Widely Held$_{t-1}$	-0.9312	-2.3411	-1.5049	-2.7874	-1.6332	-2.8451	-2.1994	-3.2954*
	(-0.5648)	(-1.2138)	(-0.9267)	(-1.4989)	(-0.9787)	(-1.4566)	(-1.3547)	(-1.7695)
HHI$_{t-1}$	-8.1399***	-7.7674**	-7.8205***	-7.7210**	-8.0127**	-7.8195**	-7.5472**	-7.6480**
	(-2.8302)	(-2.5037)	(-2.8028)	(-2.5982)	(-2.4589)	(-2.4577)	(-2.3624)	(-2.4998)
GDP growth$_{t-1}$	0.3579**	0.3402***	0.3425**	0.3272***	0.2982**	0.3071**	0.2775**	0.2890**
	(2.6300)	(2.8239)	(2.5528)	(2.6918)	(2.2889)	(2.6279)	(2.1753)	(2.4393)
Intercept	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	429	425	441	437	429	425	441	437
Cluster	Bank	Bank	Bank	Bank	Bank	Bank	Bank	Bank
Cragg-Donald test	56.93	42.25	50.31	38.44	47.67	31.79	41.97	28.93
Kleibergen-Paap test	12.98	16.35	11.02	14.82	11.66	10.92	9.812	10.04

Supplementary Appendix F. Gender diversity and alternative measures of bank risk

This table shows results of the relation between gender diversity and bank risk. *Gender Diversity* is the percentage of female directors on the board of bank *i* at time *t*. *Female participation rate* is defined as the female labour force participation divided by male labour force participation in the NUTS 2 region where the bank's headquarter is located. *Female employment rate* is defined as the employment rate for women with tertiary education in the NUTS 2 region where the bank's headquarter is located. *Size* is the log of total assets. *Capital Ratio* is the ratio of bank equity capital over total assets. *Tier 1 Ratio* is the ratio of Tier 1 regulatory capital divided by risk-weighted assets. *Deposits Ratio* is the ratio of bank customer deposits to total assets. *Widely Held* is a dummy variable equal to one if there is no owner with more than 10% of bank share rights, and zero otherwise. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. *US-Mortgage Crisis dummy* is a dummy takes the value on one if the observation refers to the years 2007 and 2008. *EU-Sovereign Debt Crisis* a dummy takes the value on one if the observation refers to the years from 2010 and 2012. Cragg-Donald test refers to the Cragg-Donald Wald F statistic. Kleibergen-Paap test refers to the Kleibergen-Paap Wald rank F statistic. Constant included but not reported. All variables are winsorised at the 1^{th} and 99^{th} percentiles. Standard errors are clustered at the bank level. Robust z-statistics are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Panel A: Second Stage						
Variables	Z-score	Z-score	Z-score (ln)	Z-score (ln)	Volatility	Volatility
	(1)	(2)	(3)	(4)	(5)	(6)
Gender Diversity$_{t-1}$	-0.0317	2.3467*	0.0184	0.0525*	-0.0023**	-0.0049**
	(-0.0389)	(1.7228)	(0.8085)	(1.8088)	(-2.0685)	(-2.5649)
Size $_{t-1}$	-1.1555	-2.7708	-0.0012	-0.0224	0.0050**	0.0067**
	(-0.5132)	(-0.9710)	(-0.0225)	(-0.3645)	(2.2150)	(2.2898)
Capital Ratio$_{t-1}$	0.7212	1.6040	0.0314	0.0441*	-0.0018*	-0.0027**
	(0.9224)	(1.4635)	(1.4630)	(1.7049)	(-1.7410)	(-1.9744)
Tier 1 Ratio$_{t-1}$	0.2843	-0.2385	-0.0102	-0.0173	-0.0003	0.0002
	(0.4677)	(-0.2919)	(-0.5742)	(-0.8313)	(-0.3362)	(0.2610)
Deposits Ratio$_{t-1}$	-0.9819	-1.6694	-0.0096	-0.0184	-0.0005	0.0001
	(-0.4880)	(-0.6190)	(-0.2103)	(-0.3279)	(-0.3978)	(0.0306)
Widely Held$_{t-1}$	-17.6006**	-9.7159	-0.1363	-0.0293	0.0059	-0.0018
	(-2.4149)	(-1.1603)	(-0.6820)	(-0.1267)	(0.5483)	(-0.1261)
HHI$_{t-1}$	-26.9677*	-10.1990	-0.2260	0.0187	-0.0139	-0.0320
	(-1.8299)	(-0.5973)	(-0.5705)	(0.0402)	(-0.9980)	(-1.6403)
GDP growth$_{t-1}$	1.2695	0.1460	0.0232	0.0044	0.0009	0.0023*
	(1.2695)	(0.1440)	(1.0397)	(0.1965)	(0.7881)	(1.7312)
Intercept	Yes	Yes	Yes	Yes	Yes	Yes
Observations	512	508	502	498	507	503
R-squared	0.067	-0.090	0.029	-0.090	0.040	-0.209
Cluster	Bank	Bank	Bank	Bank	Bank	Bank
US-Mortgage Crisis	Yes	Yes	Yes	Yes	Yes	Yes
EU-Sovereign Debt Crisis	Yes	Yes	Yes	Yes	Yes	Yes
Panel B: First Stage						
Female participation rate$_{t-1}$	0.4552***		0.4721***		0.4414***	
	(3.8418)		(3.9659)		(3.6982)	
Female employment rate$_{t-1}$		0.7042***		0.7523***		0.6570***
		(5.1437)		(5.5975)		(4.8213)
Size$_{t-1}$	0.4986	0.9851***	0.5231	1.0491***	0.5927*	1.0628***
	(1.5506)	(2.7723)	(1.6142)	(2.9428)	(1.8353)	(3.0005)
Capital Ratio$_{t-1}$	-0.2631	-0.2787*	-0.2450	-0.2554	-0.2475	-0.2544
	(-1.6020)	(-1.7367)	(-1.4948)	(-1.6058)	(-1.5588)	(-1.6545)
Tier 1 Ratio$_{t-1}$	0.2353*	0.3064**	0.2405*	0.3209**	0.2395**	0.2917**
	(1.9315)	(2.3462)	(1.9728)	(2.4667)	(2.0859)	(2.3516)
Deposits Ratio$_{t-1}$	0.1225	0.1970	0.1264	0.2102	0.1648	0.1848
	(0.3153)	(0.5017)	(0.3289)	(0.5386)	(0.4251)	(0.4753)
Widely Held$_{t-1}$	-1.2758	-2.4417	-1.2095	-2.3909	-1.3885	-2.4955
	(-0.9574)	(-1.6461)	(-0.9064)	(-1.6189)	(-1.0216)	(-1.6479)
HHI$_{t-1}$	-4.9109**	-4.4243*	-4.9614**	-4.3418*	-5.0609**	-4.0099*
	(-2.0966)	(-1.8669)	(-2.1000)	(-1.8290)	(-2.2783)	(-1.7265)
GDP growth$_{t-1}$	0.3629***	0.3361***	0.4191***	0.3975***	0.3480**	0.3402***
	(2.7922)	(2.8974)	(3.2035)	(3.5387)	(2.5958)	(2.8641)
Intercept	Yes	Yes	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes	Yes	Yes
Observations	512	508	502	498	507	503
Cluster	Bank	Bank	Bank	Bank	Bank	Bank
Cragg-Donald test	72.91	72.39	77.81	80.78	66.70	63.13
Kleibergen-Paap test	14.76	26.46	15.73	31.33	13.68	23.24

Supplementary Appendix G. Gender diversity, corporate governance mechanisms, and bank risk.

This table shows results of the relation between gender diversity and bank's risk, considering control variables related to the corporate governance mechanism. *Gender Diversity* is the percentage of female directors on the board of bank *i* at time *t*. *Female participation rate* is defined as the female labour force participation divided by male labour force participation in the NUTS 2 region where the bank's headquarter is located. *Female employment rate* is defined as the employment rate for women with tertiary education in the NUTS 2 region where the bank's headquarter is located. *Female CEO* is a dummy variable takes on value 1 whether the CEO is female, and 0 otherwise. *Board size* is the logarithm of board members. *Board Independence ratio* is measured as the proportion of independent directors on the total board. *Size* is the log of total assets. *Capital Ratio* is the ratio of bank equity capital over total assets. *Tier 1 Ratio* is the ratio of Tier 1 regulatory capital divided by risk-weighted assets. *Deposits Ratio* is the ratio of bank customer deposits to total assets. *Widely Held* is a dummy variable equal to one if there is no owner with more than 10% of bank share rights, and zero otherwise. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. *US-Mortgage Crisis dummy* is a dummy takes the value on one if the observation refers to the years 2007 and 2008. *EU-Sovereign Debt Crisis* a dummy takes the value on one if the observation refers to the years from 2010 and 2012. Cragg-Donald test refers to the Cragg-Donald Wald F statistic. Kleibergen-Paap test refers to the Kleibergen-Paap Wald rank F statistic. Constant included but not reported. All variables are winsorised at the 1^{th} and 99^{th} percentiles. Standard errors are clustered at the bank level. Robust z-statistics are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Panel A: Second Stage				
	NPL Ratio	*NPL Ratio*	*NPL Ratio*	*NPL Ratio*
Gender Diversity$_{t-1}$	**-0.5627*** **	**-0.9137*** **	**-0.5890*** **	**-1.0346*** **
	(-2.9458)	**(-3.9238)**	**(-2.6843)**	**(-3.3746)**
Female CEO$_{t-1}$	4.1984*	7.5954***		
	(1.8921)	(2.7385)		
Board Size (ln)$_{t-1}$			-1.3590	-3.2751
			(-0.6197)	(-1.1469)
Board Independence Ratio$_{t-1}$			0.0065	0.0274
			(0.3513)	(0.9597)
Size $_{t-1}$	0.5375**	0.7739**	0.6708*	1.1035**
	(1.9718)	(2.1851)	(1.7800)	(2.3575)
Capital Ratio$_{t-1}$	-0.2641*	-0.3919*	-0.2878*	-0.4664**
	(-1.8187)	(-1.9026)	(-1.8435)	(-1.9908)
Tier 1 Ratio$_{t-1}$	0.1865**	0.2648**	0.2191*	0.3548**
	(2.0151)	(1.9640)	(1.9295)	(2.0911)
Deposits Ratio$_{t-1}$	-0.6270**	-0.5247	-0.7023**	-0.6996
	(-2.2476)	(-1.3434)	(-2.2726)	(-1.4807)
Widely Held$_{t-1}$	0.5131	-0.5925	0.2003	-1.4653
	(0.4094)	(-0.3567)	(0.1441)	(-0.7288)
HHI$_{t-1}$	3.2412	0.9911	2.9565	0.2479
	(1.1726)	(0.2989)	(1.0208)	(0.0673)
GDP growth $_{t-1}$	-0.0293	0.1369	-0.0328	0.1365
	(-0.1864)	(0.8769)	(-0.2096)	(0.8164)
Intercept	Yes	Yes	Yes	Yes
Observations	532	528	532	528
R-squared	-0.196	-1.021	-0.244	-1.379
Cluster	Bank	Bank	Bank	Bank
US-Mortgage Crisis	Yes	Yes	Yes	Yes
EU-Sovereign Debt Crisis	Yes	Yes	Yes	Yes
Panel B: First Stage				
Female participation rate$_{t-1}$	0.4425***		0.3921***	
	(3.7687)		(3.4944)	
Female employment rate$_{t-}$		0.6593***		0.5905***
		(4.9621)		(4.2040)
Female CEO$_{t-1}$	7.0747***	6.1545***		
	(2.9422)	(3.1226)		
Board Size (ln)$_{t-1}$			-3.3681	-3.3927
			(-1.5076)	(-1.6564)
Board Independence Ratio$_{t-1}$			0.0243	0.0176
			(1.1999)	(0.8151)
Size$_{t-1}$	0.5289	0.9769***	0.8225**	1.2199***
	(1.6403)	(2.7607)	(2.4355)	(3.5392)
Capital Ratio$_{t-1}$	-0.2513	-0.2816*	-0.2873*	-0.3131*
	(-1.5561)	(-1.7558)	(-1.7781)	(-1.9826)
Tier 1 Ratio$_{t-1}$	0.2327**	0.2986**	0.2903**	0.3400**
	(1.9883)	(2.3542)	(2.3274)	(2.5550)
Deposits Ratio $_{t-1}$	0.1584	0.1943	-0.0346	-0.0106
	(0.4066)	(0.4954)	(-0.0815)	(-0.0250)
Widely Held$_{t-1}$	-1.1791	-2.4111	-1.8588	-2.8588**
	(-0.9052)	(-1.6452)	(-1.4880)	(-2.0241)
HHI$_{t-1}$	-4.5644**	-4.0042*	-4.6490**	-4.1859*
	(-2.1152)	(-1.7586)	(-2.0009)	(-1.8137)
GDP growth $_{t-1}$	0.3351***	0.3332***	0.2882**	0.3015***
	(2.7172)	(3.0128)	(2.5178)	(2.7598)
Intercept	Yes	Yes	Yes	Yes
Controls	Yes	Yes	Yes	Yes
Observations	532	528	532	528
Cluster	Bank	Bank	Bank	Bank
Cragg-Donald test	72.02	65.85	52.07	46.82
Kleibergen-Paap test	14.20	24.62	12.21	17.67

Supplementary Appendix H. Gender diversity and alternative measures of bank dividend policy.

This table shows results of IV regressions used to analyse the relation between gender diversity and bank dividend policy. We use two alternative dependent variables, namely *DPE* and *Dividend to total Assets Ratio*. *DPE* is the dividend to equity ratio. *DPE*/*TA* is the ratio of dividends to total assets *Gender Diversity* is the percentage of female directors on the board of bank *i* at time *t*. *Female participation rate* is defined as the female labour force participation divided by male labour force participation in the NUTS 2 region where the bank's headquarter is located. *Female employment rate* is defined as the employment rate for women with tertiary education in the NUTS 2 region where the bank's headquarter is located. *MES* is the marginal expected shortfall of a stock given that the market return is below its 5th percentile. *Tier 1 Ratio* is the ratio of Tier 1 regulatory capital divided by risk-weighted assets. *Deposits Ratio* is the ratio of bank customer deposits to total assets. *Widely* Held is a dummy variable equal to one if there is no owner with more than 10% of bank share rights, and zero otherwise. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. *US-Mortgage Crisis dummy* is a dummy takes the value on one if the observation refers to the years 2007 and 2008. *EU-Sovereign Debt Crisis* a dummy takes the value on one if the observation refers to the years from 2010 and 2012. Cragg-Donald test refers to the Cragg-Donald Wald F statistic. Kleibergen-Paap test refers to the Kleibergen-Paap Wald rank F statistic. Constant included but not reported. All variables are winsorised at the 1th and 99th percentiles. Standard errors are clustered at the bank level. Robust z-statistics are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Panel A: Second Stage				
	DPE	*DPE*	*DPE/TA*	*DPE/TA*
Gender Diversity$_{t-1}$	**0.1325**	**0.2699****	**0.0186****	**0.0174***
	(1.2886)	**(2.1480)**	**(1.9973)**	**(1.8662)**
MES$_{t-1}$	-0.2222	-0.3616	-0.0349	-0.0343
	(-1.1031)	(-1.2660)	(-1.3374)	(-1.2391)
Capital Ratio$_{t-1}$	0.1104	0.1746***	0.0692***	0.0681***
	(1.5862)	(2.7933)	(3.2284)	(3.2668)
Tier 1 Ratio$_{t-1}$	-0.1116	-0.1540	0.0074	0.0086
	(-0.8398)	(-1.1080)	(0.7004)	(0.7876)
Deposits Ratio$_{t-1}$	0.2976	0.2504	0.1418**	0.1476***
	(0.7698)	(0.7110)	(2.5264)	(2.9085)
Widely Held$_{t-1}$	0.0254	0.6865	0.0746	0.0678
	(0.0404)	(0.8184)	(0.8059)	(0.6796)
HHI$_{t-1}$	-1.9968	-0.3897	0.1102	0.0915
	(-1.6037)	(-0.2576)	(0.7382)	(0.5861)
GDP growth$_{t-1}$	0.0365	-0.0210	0.0062	0.0070
	(0.6836)	(-0.3326)	(1.0109)	(1.1585)
Intercept	Yes	Yes	Yes	Yes
Observations	440	436	283	281
R-squared	0.175	-0.003	0.491	0.508
Cluster	Bank	Bank	Bank	Bank
US-Mortgage Crisis	Yes	Yes	Yes	Yes
EU-Sovereign Debt Crisis	Yes	Yes	Yes	Yes
cdf	55.26	45.71	34.66	36.34
widstat	12.20	18.41	7.708	15.20
Panel B: First Stage				
Female participation rate$_{t-1}$	**0.4343*****		**0.4512*****	
	(3.4931)		**(2.7764)**	
Female employment rate$_{t-1}$		**0.6405*****		**0.7002*****
		(4.2906)		**(3.8982)**
Size $_{t-1}$	0.5813	1.3493**	0.7961	1.7107**
	(1.0443)	(2.2826)	(1.1175)	(2.4497)
Capital Ratio$_{t-1}$	-0.3086	-0.4155*	-0.5494**	-0.6397***
	(-1.3747)	(-1.8234)	(-2.4427)	(-3.3185)
Tier 1 Ratio$_{t-1}$	0.2599**	0.3060**	0.6855***	0.7784***
	(2.1704)	(2.0907)	(3.5136)	(4.0603)
Deposits Ratio$_{t-1}$	0.2130	0.0646	3.1366*	3.0281*
	(0.5334)	(0.1754)	(1.6762)	(1.6866)
Widely Held$_{t-1}$	-1.6956	-2.9259	-2.5410	-3.7202*
	(-1.0361)	(-1.5866)	(-1.2745)	(-1.8311)
HHI$_{t-1}$	-8.2059***	-7.8800***	-10.1509**	-10.4179***
	(-2.9108)	(-2.6610)	(-2.5918)	(-2.9620)
GDP growth $_{t-1}$	0.3428**	0.3206**	0.3943**	0.4038**
	(2.5080)	(2.6365)	(2.4331)	(2.6417)
Observations	440	436	283	281
Cluster	Bank	Bank	Bank	Bank
US-Mortgage Crisis	Yes	Yes	Yes	Yes
EU-Sovereign Debt Crisis	Yes	Yes	Yes	Yes
Cragg-Donald test	55.26	45.71	34.66	36.34
Kleibergen-Paap test	12.20	18.41	7.708	15.20

Supplementary Appendix I. Gender diversity, corporate governance mechanisms, and bank dividend policy.

This table shows results of the relation between gender diversity and bank's dividend policy. The dependent variable is *DPE* in log. *Gender Diversity* is measured as the percentage of female directors on the board of the bank *i*'s at time *t*. *Female participation rate* is defined as the female labour force participation divided by male labour force participation in the NUTS 2 region where the bank's headquarter is located. *Female employment rate* is defined as the employment rate for women with tertiary education in the NUTS 2 region where the bank's headquarter is located. Our regressions include bank-specific variables and macroeconomic variables. *Female CEO* is a dummy variable takes on value 1 whether the CEO is female, and 0 otherwise. *Board size* is the logarithm of board members. *Board Independence ratio* is measured as the proportion of independent directors on the total board. *MES* is the marginal expected shortfall of a stock given that the market return is below its 5th percentile. *Tier 1 Ratio* is the ratio of Tier 1 regulatory capital divided by risk-weighted assets. *Deposits Ratio* is the ratio of bank customer deposits to total assets. *Widely* Held is a dummy variable equal to one if there is no owner with more than 10% of bank share rights, and zero otherwise. *HHI* stands for Herfindahl–Hirschman Index and is calculated as the sum of the squared ownership shares for all recorded shareholders of the bank. *GDP growth* is annual percentage growth rate of GDP. *US-Mortgage Crisis dummy* is a dummy takes the value on one if the observation refers to the years 2007 and 2008. *EU-Sovereign Debt Crisis* a dummy takes the value on one if the observation refers to the years from 2010 and 2012. Cragg-Donald test refers to the Cragg-Donald Wald F statistic. Kleibergen-Paap test refers to the Kleibergen-Paap Wald rank F statistic. Constant included but not reported. All variables are winsorised at the 1th and 99th percentiles. Standard errors are clustered at the bank level. Robust z-statistics are reported in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Panel A: Second Stage				
Variables	DPE (ln) (1)	DPE (ln) (2)	DPE (ln) (3)	DPE (ln) (4)
Gender Diversity$_{t-1}$	0.0312	0.0643**	0.0300	0.0675**
	(1.3043)	(2.2484)	(1.1214)	(2.2275)
Female CEO$_{t-1}$	-0.4006	-0.6836		
	(-0.4473)	(-0.8119)		
Board Size (ln)$_{t-1}$			-0.0597	-0.0327
			(-0.2861)	(-0.1287)
Board Independence Ratio$_{t-1}$			-0.0011	-0.0032
			(-0.3403)	(-0.8504)
MES$_{t-1}$	-0.0310	-0.0641	-0.0310	-0.0667
	(-0.6022)	(-0.9285)	(-0.6108)	(-0.9577)
Capital Ratio$_{t-1}$	0.0373***	0.0518***	0.0363**	0.0536***
	(2.7057)	(3.1466)	(2.1822)	(2.8758)
Tier 1 Ratio$_{t-1}$	-0.0180	-0.0266	-0.0202	-0.0312
	(-0.7925)	(-1.1386)	(-0.8387)	(-1.2716)
Deposits Ratio$_{t-1}$	0.0336	0.0219	0.0287	0.0174
	(0.5841)	(0.4303)	(0.5396)	(0.3473)
Widely Held$_{t-1}$	-0.1423	0.0023	-0.1162	0.0707
	(-0.8673)	(0.0104)	(-0.6884)	(0.3016)
HHI$_{t-1}$	-0.4849	-0.1251	-0.4898	-0.1075
	(-1.5236)	(-0.3108)	(-1.4544)	(-0.2541)
GDP growth$_{t-1}$	0.0070	-0.0061	0.0089	-0.0030
	(0.4929)	(-0.3675)	(0.6794)	(-0.1900)
Intercept	Yes	Yes	Yes	Yes
Observations	440	436	440	436
R-squared	0.164	0.018	0.163	-0.011
Cluster	Bank	Bank	Bank	Bank
US-Mortgage Crisis	Yes	Yes	Yes	Yes
EU-Sovereign Debt Crisis	Yes	Yes	Yes	Yes
Panel B: First Stage				
Female participation rate$_{t-1}$	0.4166***		0.3888***	
	(3.3379)		(3.1517)	
Female employment rate$_{t-1}$		0.6017***		0.5581***
		(3.9188)		(3.2259)
Female CEO$_{t-1}$	6.5759**	5.5410**		
	(2.5143)	(2.3793)		
Board Size (ln)$_{t-1}$			-0.9064	-0.4205
			(-0.4268)	(-0.2018)
Board Independence Ratio$_{t-1}$			0.0408	0.0312
			(1.6641)	(1.1517)
Size$_{t-1}$	0.5638	1.2959**	0.5833	1.2466**
	(1.0162)	(2.1721)	(1.0123)	(2.0642)
Capital Ratio$_{t-1}$	-0.2962	-0.4030*	-0.3284	-0.4216*
	(-1.3234)	(-1.7601)	(-1.4922)	(-1.9078)
Tier 1 Ratio$_{t-1}$	0.2253*	0.2748*	0.2598**	0.2987**
	(1.9074)	(1.8743)	(2.1234)	(1.9964)
Deposits Ratio$_{t-1}$	0.2278	0.0892	0.1666	0.0765
	(0.5618)	(0.2388)	(0.3743)	(0.1798)
Widely Held$_{t-1}$	-1.4408	-2.7122	-2.1401	-3.2250*
	(-0.8857)	(-1.4543)	(-1.3159)	(-1.7270)
HHI$_{t-1}$	-7.7300***	-7.5908**	-7.4488**	-7.5168**
	(-2.7627)	(-2.5448)	(-2.3202)	(-2.4474)
GDP growth$_{t-1}$	0.3362**	0.3192**	0.2703**	0.2807**
	(2.4869)	(2.6107)	(2.0959)	(2.3507)
Cluster	Bank	Bank	Bank	Bank
US-Mortgage Crisis	Yes	Yes	Yes	Yes
EU-Sovereign Debt Crisis	Yes	Yes	Yes	Yes
Cragg-Donald test	50.86	39.28	42.49	29.65
Kleibergen-Paap test	11.14	15.36	9.933	10.41