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Interconnectedness and Systemic Risk of European Banks over the Recent Crises

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This version: 29 July 2014

Abstract

The recent financial turmoil has stimulated a rich debate in the banking and financial literature on the identification of the determinants of systemic risk, as well as of devices to forecast and prevent crises. In this paper, we explore the contribution of corporate variables on the systemic risk in a CoVar approach, as recently proposed by Adrian and Brunnermeier (2011, 2014). Using a sample of 141 European banks belonging to 24 European countries, continuously listed from 2006Q1 to 2012Q4, we investigate the impact of these variables over several regimes that characterised the European context in recent years, namely the subprime crisis (2007Q3-2008Q3), the European Great Financial Depression (2008Q4-2010Q2) and the sovereign debt crisis (2010Q3-2012Q4). We find evidence that while size has not played a significant role in spreading systemic risk, the contrary has been true for maturity mismatch. However, the nature and the intensity of these two determinants vary across the different crisis periods.

Keywords: Systemic Risk, Financial Crises, Sovereign Debt Crisis, Value at Risk, CoVar.
J.E.L. Classifications: G01, G021, C23.

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1. Introduction

Following the recent financial crises, national and international monetary authorities have devoted an increasing attention to the efficacy and stability of the banking system. Reinhart and Rogoff (2009) provide a bulk of historical evidences about the existence of similar crises in the past, and about the related behaviours of political and monetary authorities, deeply involved in the bailouts of banks and financial institutions on the edge of bankruptcy. This has brought a substantial reconsideration of the role of the supervision system for the banking and financial industries.

The extremely tight structural banking supervision that featured the European banking system, from the late Thirties to the Nineties, aimed at providing stability to the financial systems, could be seen as the main legacy of the Great Depression. Between the end of the Great Depression and early 1980s, no relevant bank failures occurred in countries that adopted severe structural regulations. Banking supervision authorities focused their attention on measures of micro-prudential regulation, like the different capital requirements of the Basel I, Basel II and then Basel III Agreements[1]. More recently, this approach was integrated by a macro-prudential perspective (Borio, 2003)[2]. In particular, the recent financial crisis and the increasing degree of interconnectedness of the economic and financial systems showed the substantial failure of the different measure of risks previously adopted by both the single intermediaries and by the financial authorities. This is due to the existence of a systemic risk that is independent from the soundness of individual bank balance sheets. In these respects, previous risk measures, and in particular the Value-at-Risk (VaR), were targeted to the risk of a single financial institution, and were therefore used in order to determine the optimal capital

[1] Basel I Agreement, signed in 1988, obliges banks to keep as reserve the 8% of their loans, without considering the level of risk of loans. To this purpose, Basel II Agreement, published in 2004, has a more complex system of evaluation of credit riskiness, known as the three Basel's pillars based on several banks' features. The break-up of the recent financial crises forced the European monetary authorities (Basel Committee on Banking Supervision) to agree in 2010-2011 the Basel III to improve the quantity and quality of the banking capital and the introduction of two innovative indicators such as the liquidity coverage and the net stable funding ratios.

[2] These very tight regulations have contributed to the development of the so-called "shadow banking system" (Adrian and Ashcraft, 2012)

requirements. Nevertheless, nor the VaR or the other traditional measures capture the systemic risk: this implies that effective capital requirements might not be effectively evaluated by banking authorities.

The challenges of the recent financial crises have pushed financial literature to devote much effort in understanding and describing the different features of systemic risk (Hansen, 2013) and systemic risk leading factors (Weiss et al., 2014a), as well as in implementing reliable interventions to overcome this phenomenon (Benoit at al., 2013, Rodriguez-Moreno and Pena, 2013). Several authors investigate this issue from different perspectives, either related to the connection between bank size and systemic risk (Pais and Stork, 2103) in a cross-country perspective (Slijkerman et al., 2013, Weiss et al., 2014b) or in its connection with financial contagion and financial fragility (Martinez-Jaramillo et al., 2010).

Currently, several measures of systemic risk are available in banking literature. In addition to the traditional measures of risk, often criticised because mainly limited to balance sheet information (Huang et al., 2009), more recent studies (Acharya et al., 2010; Black et al., 2013) focus on new corporate variables related to the mismatch between assets and liabilities.

Following the CoVaR measure of systemic risk proposed by Adrian and Brunnermeier (2011, 2014), in this paper we analyse the impact of corporate variables, such as size, maturity mismatch and leverage, on systemic risk during the recent crises. We do this by using a sample of 141 European banks, continuously listed in the stock markets of 24 European countries, both belonging to the Euro and non-Euro area, from the first quarter of 2006 (2006Q1) to the last quarter of 2012 (2012Q4). The CoVar methodology allows taking advantage of both market high frequency data and quarterly data available from the balance sheets, which express the fundamentals of any corporations, as highlighted by corporate finance literature. Moreover the quarterly balance-sheet data, as argued by Adrian and

Brunnermeier (2011, 2014), represent optimal devices to forecast bank contribution to systemic risk, observing each single institution from inside in an *ex ante* perspective.

Our results challenge a traditional assumption in the analysis of the European system, linking the *"too big to fail"* issue to an higher contribution of large banks to the systemic risk factor. In fact, our analyses show that, if we consider the whole period of analysis, size is likely to act as a shield against systemic risk, rather than boosting the phenomenon. By contrast, other corporate variables and financial ratios (maturity mismatch, market to book value and market volatility) are more likely to affect systemic risk.

The remainder of the paper is organised as follows. Section 2 provides a short review of the literature on systemic risk analytics. Section 3 presents a description of the sample period, the CoVaR methodology, and a description of the variables. In Section 4, we report the alternative model specifications and the empirical findings. Section 5 concludes.

2. Overview of the Literature on Systemic Risk

In order to identify the main determinants of the systemic risk, and to allow regulators to implement optimal banking supervision policy, much effort has been dedicated in the attempt to measure risk. In particular, specific attention has been devoted to cross sectional measures, in order to examine the co-dependence between institutions (Bisias et al. 2012, and Benoit et al. 2013 for an overview on the topics).

2.1 Definitions of systemic risk

The European Central Bank (2010) defines systemic risk as a threat of financial instability so widespread that it impairs the functioning of a financial system to the point where economic growth and welfare suffer materially. In the financial literature, Billio et al. (2012) define systemic risk as any set of circumstances that threatens the stability of or public confidence in the financial system, while Black et al. (2013) refer to a sovereign default in

late 2011 as a failure of a systematically important European bank leading to a disastrous financial instability. Acharya et al. (2011) argue that systemic risk of an individual institution has not yet been measured or quantified by regulators in a systematic way, though systemic risk has always been one of the justifications of the elaborate regulatory apparatus. Therefore, if the bankruptcy of an institution is not related to the general economic condition, the liquidation of its assets may be straightforward; but when institutions' asset risk is correlated with that of the economy, they are likely to fail when the rest of the financial sector is under stress at the same time. Their liquidations may be difficult and potentially destabilizing for other players if fire-sale assets price lead to externalities.

Interestingly, the interconnections among financial institutions, which have progressively characterized the more and more integrated financial system, may be extremely beneficial during normal market conditions (Yellen, 2013). By contrast, in the turmoil of a financial crisis, deeply interconnected financial institutions may behave as devices for propagating risks and losses through other financial institutions, as it happened in the aftermath of the collapse of Lehman Brothers in September 2008 or during the crisis of the European sovereign debts in the dramatic summer of 2011.

Thus, conventional wisdom and recent institutional and academic debate have devoted relevant effort in identifying the systemically important financial institutions (SIFIs), because the bailouts of some of them during the years 2007-2009, involved high costs that were posed entirely on the shoulders of the taxpayers. These bailouts contributed to renew the *"too big to fail"* rhetoric idea. AIG bailout by the US government on September 16th 2008 may be considered as one of the most distinguishing example of this theory.

Other recent studies (Acharya et al., 2010; Black et al., 2013) develop the idea that size is only one of the factors determining systemic risk, while other features, such as an excessive mismatching of assets and liabilities (Lopez-Espinosa et al., 2012) also play a

significant role. Some financial institutions are extremely interconnected, and therefore become instruments of risk's propagation, although they are not very large or large at all (Acharya et al., 2011). With specific reference to this point, according to Yellen (2013) the difficult task that market participants, policymakers and regulators need to deal with consists in finding ways to preserve the benefits of interconnectedness in financial markets while managing the potentially harmful side effects.

2.2 Measures of systemic risk

Huang et al. (2009) criticize the traditional measures of risk focused on balance sheet information, because of their low frequency (they are generally quarterly available), and suggest the use of alternative information directly deriving from the financial markets. In particular, an operational systemic risk measure can be constructed as an hypothetical insurance premium against catastrophic losses in a banking system. The two factors that would determine the risk of a portfolio, i.e. the probability of default (PDs) and the asset return correlation, are estimated from credit default swap spread and stock return co-movements. The indicator of systemic risk consists in the price of insurance against large losses of the banking sector, based on the forward looking PDs and correlations in the next period (a quarter). Huang at al. (2009) analyse the link between default risk factors and a number of macro-financial factors using 12 major banks in the United States[3] over the period January 2000-May 2008. This indicator, denominated Distressed Insurance Premium (DIP), that can be implemented with the Monte Carlo technique, represents an hypothetical insurance premium against a systemic financial distress defined as the total losses that exceed a given threshold of total bank liabilities.

[3] The banks are: Bank of America, Bank of New York, Bear Sterns, Citibank, Goldman Sachs, JP Morgan Chase, Lehman Brothers, Merrill Lynch, Morgan Stanley, State Street Corporation, Wachovia and Wells Fargo.

This methodology has been recently used by Black et al. (2013) in examining individual contributions of 58 major European banks to the systemic risk measure, over the period January 2005-January 2013. This study highlights a different degree and timing of contribution of each nation and single bank to the aggregate risk. More specifically the authors find that French banks contributed the most to systemic risk. Interestingly, the systemic contribution of banks in Germany and UK increased the most dramatically in 2006, just prior to the onset of the financial crisis. However, in 2008, the relative contribution of German and UK banks decreased substantially Thus, the systemic risk contribution of Italian and Spanish banks increased during the sovereign debts crisis, while the two countries played a very minor role during the global financial crisis.

Acharya et al. (2010) present an alternative indicator of systemic risk, denominated systemic expected shortfall (SES), representing the propensity to be undercapitalized when the system as a whole is undercapitalized (2010). To determine a measure of the true leverage, the authors apply the standard approximation of leverage defining the "quasi market value of assets" as the difference between book assets and the sum of book equity and market equity. The paper suggests that the marginal expected shortfall (MES), and leverage estimated in the year prior to the crisis (June 2006 till June 2007), explain the cross sectional variation in equity performance during the crisis (July 2007 till December 2008). According to the authors, the combination of MES and leverage gives a better understanding of financial risks since financial distress costs of leveraged firms can be large in a crisis.

Other authors (Brownless and Engle, 2012; Acharya et al., 2012) propose the capital shortfall during a systemic crisis as measure of systemic risk, denominated SRISK. The measure of capital shortfall is determined by the difference between a prudential equity asset ratio and the equity endowment for each single institution. The contribution of each single

institution SRISK to the aggregate one is defined by the ratio between the two previously mentioned balance sheet items.

Adrian and Brunnermeier (2011, 2014) propose the CoVaR method, representing an important alternative to the DIP approach, because it allows for a countercyclical implementation of macro prudential policy by predicting systemic risk using current institutional characteristics such as size, leverage and maturity mismatch. The CoVar approach introduces two valuable advances in the systemic risk research. First, it captures the most relevant corporate variables affecting systemic risk, and the nature of all financial institutions producing negative spillover effects on the others institutions, either they are *"too big to fail"* or not too large, but extremely interconnected, i.e. *"too interconnected to fail"*. Moreover, the CoVar approach contrasts the changes in market value of total assets, based on weekly frequencies, with other balance sheets variables measured only quarterly. These latter variables are fundamentals in the CoVar's method because any approach that relies on contemporaneous risk measure would be unnecessarily tight after adverse events and unnecessarily loose in periods of stability, amplifying respectively good and bad shocks.

Adrian and Brunnermeier (2011, 2014) report an empirical analysis on United States data from 1986Q1 to 2010Q1, covering the three recessions, i.e. 1991, 2001 and 2007-2009 and the financial crisis of 1987, 1998, 2000 and 2007-2008. The sample contains 1,269 financial institutions with an average length of 624 weeks. Their results suggest that corporations with higher leverage, more maturity mismatch and larger size tend to be involved in larger systemic risk contributions at different level of lagged effects. The links between the nature of liabilities and the presence of more stable source of financing is further developed by Lopez-Espinosa et al. (2012). They use a CoVar approach on a sample of 54 large firms belonging to 18 different countries[4] over the period July 2001-December 2009 and

[4] The countries are: Austria, Australia, Belgium, Britain, Canada, Denmark, France, Germany, Ireland, Italy, Japan, Netherlands, Norway, South Africa, Spain, Sweden, Switzerland and United States.

find no evidence that a larger size increases the systemic risk, but short term wholesale is the most relevant balance sheet variable in determining each single institution's contribution to aggregate systemic risk

3. Data and variables

3.1 Stylized facts

Over the period 2006-2012 considered in this study, the European banking system was affected by three different regimes of financial turmoil: the subprime crisis (2007Q3-2008Q3), the great financial depression (2008Q4-2010Q2) and the sovereign debt crisis (2010Q3-2012Q4). An important step is to evaluate both the institutional context and the policies put into place by the European Central Banks (the European Central Bank and the Bank of England). Starting from August 2007, the first rumors of the arising subprime crisis had some impact on the French, German and British banking systems, and this impact was very strong in the aftermath of the bankruptcy of Lehman Brothers.

In the wake of the remarkable consequences of the bankruptcy of Lehman Brothers, the institutional debate mainly focused on the "*too big to fail*" issue, implying the identification of a certain number of Systemically Important Financial Institutions (SIFI) to avoid their collapse, given this would jeopardized the whole financial system.

At the beginning of October 2008, just few weeks after Lehman Brothers collapse, the British Government launched a rescue package in order to bailout British banks such Northern Rock, RBS, HBOS, Lloyds and to calm the collapsing of the stock market. Black et al (2013) document the relevant impact on the overall systemic risk of the banks belonging to the above-mentioned nations, with specific regard to the years prior to the breakup of the Great Financial Depression. By its nature, systemic risk may reveal a procyclical aspect, arising up unexpectedly in quiet times.

Until the end of the Great Financial Depression, South European banking systems were only marginally affected by the crisis. Things changed dramatically starting from the Spring 2010, when Greece disclosed to be on the edge of bankruptcy. Since then, the crisis progressively undermined the outstanding sovereign debt of almost all the Mediterranean countries, seriously jeopardizing the stability of their banking systems. This new disguise of the financial crisis forced European Central Banks to heavily intervene supplying liquidity to the systems, following the "whatever it takes" approach of the ECB' s Governor Draghi, being not only a single bank but the whole system of these countries very weak and unable to have a stable funding on the market.

The evaluation of the European banking system over the recent years is thus very relevant in terms of policy implications. In fact, the European system was the most affected by the recent crisis, and thus can provide valuable information on the dynamics and determinants of systemic risk.

In Table 1, we report a short description of the 141 continuously listed banks belonging to 24 different countries over the period from 2006Q1 to 2012Q4, while the full list of banks is provided as Supplementary Material.

[INSERT SOMEWHERE HERE TABLE 1]

The capitalization of the European banking system swings between a maximum of 15.21% of the total market capitalization in 2006 and 10.61% in 2012, becoming less important both in absolute and in relative terms, because of the decrease in market values due to the financial crisis. Our sample represents roughly 70% of the market capitalization of the European banking system, though in our sample, some countries have a low representation in terms of numbers of continuously listed banks. For example in the Euro area, only a Dutch

and a Luxembourg bank is included in our sample. The same occurs for Bulgaria, Czech Republic and Hungary among the countries not belonging to the non-Euro area.

3.2 Time-Varying VaR, CoVar, and Market Variables

Our paper makes use of the CoVaR measure as introduced by Adrian and Brunnermeier, (2011, 2014). The most common measure of risk used by financial institutions is the value-at-risk (VaR), that focuses on the risk of an individual institution in isolation. The q%-VaR is the maximum dollar loss within the q%-confidence interval. Formally, the q-VaR for an institution *i* can be defined as:

$$\Pr ob(X_i \leq VaR_i^q) = q \tag{1}$$

where X_i is the variable of institution i for which the VaR_i is defined: following Adrian and Brunnermeier (2011, 2014) we set X_i to be the growth rates of market-valued total financial assets. Note that VaR_i is typically a negative number and, while in practice the sign is often switched, we will not follow this convention, in accordance to Adrian and Brunnermeier (2011, 2014).

The indicator of systemic risk CoVaR analyses the VaR of the market portfolio conditional to the VaR of an individual institution and is defined as:

$$\Pr ob(r_m \leq CoVar_i^{q,p} \left| r_i = VaR_i^p \right.) = q \tag{2}$$

where r_i is the market-valued asset return of institution *i*, and r_m is the return of the portfolio, computed as the average of the r_i's weighted by the lagged market value assets of the institutions in the portfolio. Adrian and Brunnermeier (2011, 2014) measure the contribution of each single institution to the systemic risk by the ΔCoVar, namely the difference between CoVar conditional on the institution being in distress and CoVar in the median state of the institution.

In order to estimate the time-varying $CoVar_t$ and VaR_t, we include a set of state variables to capture the time variation in conditional moments of asset returns. With references to these specific market's factors, we also follow the implementation adopted by Lopez-Espinosa et al. (2012) to take into account the peculiarities of the European institutional environment. In practice, in our analysis we use the following variables:

a) the weekly price of the FTSE Stock Market volatility index $(FTSEVol_t)$
b) the liquidity spread $(LiqSpread_t)$ calculated as the difference between the three months UK repo rate and the three months UK T bill
c) the change in French T-bill secondary market 3 month rate (Lopez-Espinosa et al. (2012) $(\Delta Tbill_t)$
d) the change in slope of the yield curve represented by French 5-year minus three-months interest rate on government bonds $(\Delta Slope_t)$
e) the change in credit spread, represented by the difference between Baa seasoned Moody's corporate bonds and the 10-year German government bonds $(\Delta CredSpread_t)$
f) the weekly equity returns from the FTSE European Stock Market Index $(FTSE\,\mathrm{Re}turns_t)$.

Table 2 reports the summary statistics for the market equity losses (X_i) and 95% risk measures X(i), Var, CoVar, and ΔCoVar of the 141 banks for weekly data from 2006Q1-2012Q3.

[INSERT SOMEWHERE HERE TABLE 2]

Recall that $\Delta CoVaR_i$ measures the marginal contribution of institution i to overall systemic risk and reflects the difference between the value at risk of the financial universe conditional on the stressed and the median state of institution i. We have 141 institutions in the sample, all equally observed for 28 quartiles. The table shows that the financial firms in the sample

were observed over a very turbulent period. During the years from 2006Q1 to 2012Q4, the average value of the VaR was almost equal to -9%, while the CoVaR was -5%, and the ΔCoVaR was -3.2%.

Table 3 provides summary statistics for the estimated risk measures of ΔCoVaR by single countries. The average value of ΔCoVaR ranges from a minimum of -0.561 for Greece to a maximum of -0.345 for Sweden. The major European countries register similar ΔCoVaR measures, ranging from the French value of -0.438, to the -0.446 for Italy and the -0.456 for Germany.

[INSERT SOMEWHERE HERE TABLE 3]

Table 4 provides summary statistics for the market variables employed in our analysis for the calculation of the CoVaR measures[5].

[INSERT SOMEWHERE HERE TABLE 4]

3.3 Corporate Variables

In this study, we make use of following corporate variables, collected from the quarterly balance sheets of all the European banks included in the sample:

1) $Leverage_{i,t-1}$ is calculated as the total assets to equity ratio of bank *i* at quarter *(t-1)*;
2) $MM_{i,t-1}$ is the maturity mismatch, namely the relative level of short term funding, calculated as the ratio between total short term debt minus cash and total liabilities, for bank *i* at quarter *(t-1)*. This ratio is as a proxy of the interconnectivity between financial institutions;
3) $Size_{i,t-1}$, as the total assets of bank *i* at quarter *(t-1)*;
4) $MBV_{i,t-1}$ is the market to book ratio, namely the ration between market value of

[5] Summary statistics by year are reported as Supplementary Material.

equity and book value of equity, for bank *i* at quarter *(t-1)*;

5) ERV_t is the equity return volatility for bank *i* at quarter *(t-1)*, computed from daily equity returns data within each quarter;

6) $Beta_t$ is the equity market beta for bank *i* at quarter *(t-1)*, computed from daily equity returns data within each quarter.

Table 5 reports summary statistics for the above-listed corporate variables[6]. The average leverage of the European banks in the sample suggests that only roughly 6% of banks' assets are financed by equity. This measure represents, in broad terms, a proxy of Core Tier 1 index[7]. The average size of the bank's total assets is roughly 53 billion of Euro. Market to book values exceed 1. We observe a low level of the beta coefficient during the crisis and a limited percentage of a maturity mismatch measure on the total liabilities of the banks.

[INSERT SOMEWHERE HERE TABLE 5]

4. Model Specifications and Empirical Results

In this section, we consider the following predictive regression model with fixed effects:

$$\Delta CoVaR_{it} = \beta_{i0} + \beta_1 \Delta CoVaR_{it-1} + \beta_2 VaR_{it-1} + \beta_3 Leverage_{it-1} + \beta_4 MM_{it-1} + \beta_5 Size_{it-1} + \beta_6 MBV_{it-1} + \sum_{j=1}^{n-1} Country_j + \sum_{z=1}^{p-1} Bank_z + \sum_{k=1}^{m-1} Time_k + \varepsilon_{it} \quad (3)$$

We run several model specifications and report the results in Table 6. In column (i), we have the benchmark specification that makes use of the above-mentioned quarterly

[6] Detailed statistics by country and by year are reported as Supplementary Material.
[7] Note that the value exceeds the minimum threshold of 5.5% Core Tier 1 set in February 2014 by the European Banking Authority as benchmark for times of crisis.

corporate variables and quarter time dummies. Specification (ii) adds three additional crisis dummies, with Crisis 1 capturing the features of the Subprime Crisis, running from the start of the real estate subprime loans crisis in 2007Q3 to 2008Q3, Crisis 2 is supposed to characterise the great financial depression running from 2008Q4 (the bankruptcy of Lehman Brothers) to 2010Q2, and Crisis 3 deals with the sovereign debt crisis running from 2010Q3 (in correspondence of emerging news about Greece's default) to 2012Q4. In specification (iii) we have the crisis dummies only. In specification (iv) we add the interaction of corporate variables with the three crisis dummies to capture the potential marginal effects of institutional features over the three sub-periods. In specification (v) we include the interactions of crisis variables with country dummies. Lastly, in specification (vi), we replace time dummies with the market variables used for the estimation of CoVar variables.

[INSERT SOMEWHERE HERE TABLE 6]

In order to interpret the results, we recall that our measure of systemic risk is defined in negative terms, so that negative coefficients are related to increase in systemic risk, and viceversa. Based on both goodness of fit indicators and information criteria, our preferred model is specification (iv), which shows a higher level of explained variance and allows investigating the relations among corporate variables and dummies of crisis, while the other three specifications allow us to understand the participation of the different determinants in explaining $\Delta CoVaR_{it}$. In particular, when looking at the overall period, disregarding the specific behaviour of corporate variables during the crisis, we learn from specifications (i) and (ii) that equity return volatility is a determinant of an increase in systemic risk. However the statistical significant coefficients of equity return volatility disappear in specifications (iii) and (iv), namely when we consider the specific effects during the sub-periods. Futher, by

comparing specifications (ii) and (iii), we appreciate the large share of variance explained by time dummies, that are indeed included in specification (iv) as well.

The results from specification (iv) allow to consider the interactions between corporate variables and the crisis dummies. If we consider the whole period, size is correlated with an increase of systemic risk. Two other corporate variables, i.e. beta coefficient and maturity mismatch, show a statistical significant, but positive coefficient. This result can be interpreted as evidence of a "systemic risk shield" provided by both variables. We interpret these results as empirical evidence that maturity mismatch may be a proxy for interconnectedness of the financial system intermediaries and that, therefore, the coefficient sign shows a higher degree of interconnectivity.

If we analyse the interactions between crisis dummies and corporate variables, we find that size is likely to be a "shield" with respect to the increase of systemic risk, although with different magnitudes in the three subperiods. On the contrary, maturity mismatch plays an important role in increasing the level of systemic risk of European banks between 2007 and 2010, period of the Great Financial Depression. This result implies that a decrease in banks' short term debt may be at a first sight a signal of low risk, being the banks less depending on external potentially unstable market funding. A decrease in short term debt means a substantial reduction of interconnected credit lines and a fear of running out of liquidity for some banks. For this reason, the decrease of the degree of the banking system interconnection represents a clear sign of an increasing of systemic risk, which took place mainly during the Great Financial Depression[8].

[8] Short term or unstable liabilities may be not a feasible device in the banking activity of transforming risks and maturities, being assets illiquid. The Economist April 12th 2014 in an article entitled "The slumps that shaped modern finance" writes: *"Future risks were to be neutralized by a new legislation, the Glass Steagall rules that separated stock market operations from more mundane lending and gave the Fed new powers to regulate banks whose customers use credit for investment."*

During the Great Financial Depression beta coefficient shows a positive impact on systemic risk. The same occurs for the market to book variable. This financial ratio is often implemented in the corporation evaluation process in order to determine corporation terminal value. If we consider the market to book value, the decrease of the market value may be partially slackened or emphasized by a faster or slower decrease in the book value. From an economic point of view, while a decrease in the market to book value of a corporation relies essentially on the dynamics of state macroeconomic variables, a decrease in the book value may eventually hide its roots in several reasons, ranging from accounting principles to the existence of possible regulation arbitrages. These institutional aspects strictly connected with regulation may be of some relevance in determining an increase for the systemic risk.

Specification (v) includes a set of country dummies interacted with the corporate variables employed in our analysis. The results confirm our earlier findings from specifications (ii)-(iv). The negative coefficient of Greece relates to an increase of systemic risk since the beginning of the crisis. Lastly, as a robustness check, we report specification (vi), that contains the same market variables used for the construction of the CoVar measures, replacing time dummies and crisis dummies. Though all market variables are highly statistically significant, the information content is much lower than what is in the two sets of dummies dropped..

5. Conclusions

In this paper we provided empirical evidence on the role of banks' corporate determinants to the overall systemic risk in the European financial system over a period of time comprising the recent financial crises. We implemented the CoVar methodology (Adrian and Brunnermeier, 2011, 2014) on a sample of141 European banks, continuously listed over the period 2006Q1- 2012Q4 and belonging to 24 Euro and non-Euro countries. We contribute

to extant literature by analysing the marginal effects of corporate variables during the three crisis sub-periods in Europe. Size did not contribute to spread systemic risk neither in the Subprime Crisis, neither in the Sovereign Debt Crisis, while a marginal contribution to systemic risk occurs during the Great Financial Depression. On the contrary, maturity mismatch contributed to systemic risk in the period between 2007 and 2010. Market to book value and beta coefficient did provide a marginal contribution to systemic risk during the Great Financial Depression.

As a whole, our results provide new evidence on the specific nature of the "too big to fail" idea. Out of crisis periods, small and medium size banks are more likely to increase systemic risk, while in period of crisis size may be seen as a useful device against the propagation of the crisis, because large banks are characterized by a negative contribution to the systemic risk. These results complements those of Pais and Stork (2013), with specific reference to the case of crisis periods in Europe. In accordance to Lopez Espinosa et al (2012), we confirmed, with reference to Europe, that maturity mismatch plays a relevant role for systemic risk. This ratio can be interpreted as a proxy of interconnectivity among banks, and acts as a device for diversifying risk in normal times, while it increases systemic risk overall the system during turbulent times. In addition, other corporate variables also have some valuable effects on systemic risk: in particular, the market to book variable increased systemic risk during the Great Financial Depression, raising some questions about the importance of accounting methods, as well as legal system and tax arbitrage techniques in spreading systemic risk.

As a prosecution to our research, it will be important to compare the empirical findings in this paper by extending the CoVar analysis to a wider range of European banks using a larger data set incorporating also banks listed with interruptions during the above described period. An unbalanced dataset might allow increasing the number of banks for

countries: a larger number of intermediaries may better capture country effects, allowing to better evaluate the specific impact of the systemic risk in the Euro and non-Euro area. We leave this to future research.

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TABLES

Table 1. Countries and banks included in the sample

The Table classifies all banks included in our sample according to their nationality. The sample covers all the 24 countries in the European Union with at least one bank listed over the full period 206Q1-2012Q4: 15 countries belong to the Euro zone, and 9 are out of the Euro zone. Source: Datastream.

Euro countries		Non-Euro countries	
Country	N. of banks	Country	N. of banks
Austria	7	Bulgaria	1
Belgium	3	Czech Republic	1
Cyprus	4	Denmark	25
Finland	2	Hungary	1
France	18	Lithuania	2
Germany	7	Poland	13
Greece	7	Romania	2
Ireland	2	Sweden	4
Italy	18	UK	6
Luxembourg	1		
Malta	4		
Netherlands	1		
Portugal	3		
Slovakia	2		
Spain	7		
Total Euro	86	Total Non-Euro	55

Table 2. Summary statistics for X(i), VaR, CoVaR, Δ*CoVaR*

The table reports the number of observations (Obs.), mean, median, min and max values, standard deviation (Std. Dev.), respectively, for the market equity losses X(i) and the 95%-risk measures, calculated for the 141 financial firms on weekly data from 2006Q1-2012Q4. The individual firm risk measures, VaR, are obtained by running 95%-quantile regressions of returns on the one-week lag of the market variables and by computing the predicted value of the regression. CoVaR is the predicted value from a 95%-quantile regression of the financial system equity losses on the institution equity losses and on the lagged market variables. ΔCoVaR is the difference between CoVaR calculated from a 95%-quantile regression and the CoVaR calculated from a 50%-quantile regression. Source: Datastream.

	Obs.	Mean	Median	Min	Max	Std. Dev
X(i)	3,948	0.002	0.000	-0.398	0.655	0.054
VaR	3,948	-0.090	-0.076	-0.586	0.000	0.056
CoVaR	3,948	-0.052	-0.045	-0.202	-0.011	0.024
Δ*CoVaR*	3,948	-0.036	-0.033	-0.147	-0.006	0.016

Table 3. Summary statistics for $\Delta CoVaR$ by country

The table reports the number of observations (Obs.), mean, median, min and max values, standard deviation (Std. Dev.), respectively, for the $\Delta CoVaR$ variable, for each country in the sample. Source: Datastream.

Country	Obs.	Mean	Median	Min	Max	Std. Dev
Austria	196	-0.036	-0.033	-0.102	-0.013	0.016
Belgium	84	-0.035	-0.029	-0.137	-0.013	0.022
Bulgaria	28	-0.040	-0.036	-0.079	-0.019	0.015
Cyprus	112	-0.032	-0.030	-0.076	-0.008	0.015
Czech Republic	28	-0.030	-0.026	-0.059	-0.017	0.010
Denmark	700	-0.040	-0.037	-0.147	-0.009	0.018
Finland	56	-0.039	-0.036	-0.101	-0.014	0.019
France	504	-0.035	-0.033	-0.092	-0.006	0.015
Germany	196	-0.037	-0.033	-0.093	-0.010	0.017
Greece	196	-0.044	-0.040	-0.114	-0.009	0.019
Hungary	28	-0.035	-0.032	-0.076	-0.015	0.013
Ireland	56	-0.029	-0.026	-0.058	-0.013	0.010
Italy	504	-0.036	-0.033	-0.102	-0.010	0.014
Lithuania	56	-0.041	-0.037	-0.084	-0.020	0.013
Luxembourg	28	-0.041	-0.037	-0.087	-0.016	0.017
Malta	112	-0.037	-0.034	-0.077	-0.013	0.015
Netherlands	28	-0.034	-0.031	-0.066	-0.012	0.014
Poland	364	-0.035	-0.033	-0.083	-0.009	0.013
Portugal	84	-0.040	-0.036	-0.091	-0.020	0.014
Romania	56	-0.032	-0.029	-0.074	-0.010	0.014
Slovakia	56	-0.043	-0.039	-0.090	-0.020	0.014
Spain	196	-0.031	-0.028	-0.127	-0.008	0.018
Sweden	112	-0.027	-0.026	-0.063	-0.011	0.011
UK	168	-0.033	-0.030	-0.096	-0.015	0.013

Table 4. Summary statistics for market variables

The table reports the number of observations (Obs.), mean, median, min and max values, standard deviation (Std. Dev.), respectively, for all market variables: the volatility index $(FTSEVol_t)$ is the FTSE Eurotop 100; the liquidity spread $(LiqSpread_t)$ is the difference between the UK 3-month repo rate and the UK 3-month T-bill yield; the change in the T-Bill rate $(\Delta Tbill_t)$ is the first difference in the 3-month interest rates on French government bonds; the yield slope $(\Delta Slope_t)$ is the change in the yield slope between the French 5 year and 3 month interest rates on government securities; the change in credit spread $(\Delta CredSpread_t)$ is the difference between the Moody's seasoned BAA corporate bond yield and the 10 year German government bond; market return $(FTSE\,\mathrm{Re}turns_t)$ is the weekly equity returns from the FSTE European Stock Market Index. Source: Datastream.

Country	Obs.	Mean	Median	Min	Max	Std. Dev
FTSEVol	51,324	0.012	0.011	0.005	0.037	0.006
LiqSpread	51,324	0.079	0.061	-0.005	0.303	0.072
$\Delta TBill$	51,324	0.013	0.000	-0.210	0.355	0.122
$\Delta Slope$	51,324	-0.013	-0.075	-0.655	1.000	0.407
$\Delta CredSpread$	51,324	0.015	-0.059	-1.540	1.753	0.640
FTSEReturns	51,324	0.001	0.022	-0.242	0.149	0.088

Table 5. Summary statistics for corporate variables

The table reports the number of observations (Obs.), mean, median, min and max values, standard deviation (Std. Dev.), respectively, of the corporate variables of the European banks in our sample, calculated over the full period 2006Q1-2012Q4. *Leverage* is defined as the ratio between the total assets and the book value of total equity (average value); *maturity mismatch* is calculated as the total short term debt minus cash to total liabilities ratio; *equity return volatility* is calculated as the standard deviation of the daily equity returns of each banks in the sample; *beta* is the equity market beta and is calculated as the ratio between the covariance of the equity security on the market and the variance in the market; *market to book value* is calculated as the ratio between market and book value of each bank; *size* represents the total assets of the banks, in millions of Euro (average value calculated over the full sample 2006-2012). Source: Datastream.

Variable	Obs.	Mean	Median	Min	Max	Std. Dev
Leverage	3,226	16.860	13.848	1.180	87.534	35.730
Maturity Mismatch (%)	2,945	13.730	11.996	-118.033	78.617	15.031
Equity return volatility	3,948	0.020	0.019	0.000	0.198	0.020
Beta	3,948	0.760	0.723	-0.968	3.948	0.690
Market to book value	3,268	1.170	0.949	-6.454	5.289	1.240
Size (mn €)	2,975	53,189	7,014	-2,947	940,351	177,298

Table 6. Regression results. Corporate variables and marginal effect during the sub-periods

The table reports regressions using alternative model specifications. Model (i) is the benchmark specification using corporate variables and time dummies. Model (ii) replicates the first model adding a set of three crisis dummies. Model (iii) includes corporate variables, crisis dummies, but excludes time dummies. Model (iv) includes corporate variables, time dummies and the interaction of corporate variables with the three crisis dummies. Model (v) includes the interactions of crisis dummies with country dummies. Model (vi) replaces time dummies with the market variables used for the estimation of CoVar variables. *, **, *** denote the 1%, 5% and 10% significance level, respectively. AIC is the Akaike Information Criterion, BIC is the Bayesian Information Criterion. Sample period: 2006Q1-2012Q4.

	(i)	(ii)	(iii)	(iv)	(v)	(vi)
ΔCovar(-1)	0.490***	0.490***	0.228***	0.379***	0.375***	-0.267***
	(0.020)	(0.020)	(0.020)	(0.056)	(0.056)	(0.054)
VaR(-1)	0.007*	0.007*	0.011	0.024**	0.028**	0.004
	(0.004)	(0.004)	(0.008)	(0.011)	(0.012)	(0.020)
Leverage(-1)	0.000	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
MM(-1)	0.001	0.001	-0.027	0.019*	0.018	0.030*
	(0.012)	(0.012)	(0.023)	(0.011)	(0.012)	(0.018)
ERV(-1)	-0.290**	-0.290**	-0.041	-0.102	-0.127	0.495
	(0.115)	(0.115)	(0.148)	(0.248)	(0.263)	(0.373)
Beta(-1)	0.004	0.004	0.003	0.010**	0.011**	0.024***
	(0.003)	(0.003)	(0.005)	(0.004)	(0.005)	(0.007)
MBV(-1)	0.000	0.000	-0.003	0.001	0.000	-0.006
	(0.000)	(0.000)	(0.003)	(0.002)	(0.002)	(0.005)
Size(-1)	-0.003	-0.003	-0.003	-0.007***	-0.007***	-0.005
	(0.002)	(0.002)	(0.004)	(0.002)	(0.002)	(0.005)
Crisis 1		0.004**	-0.093***			
		(0.002)	(0.003)			
Crisis 2		0.155***	-0.121***			
		(0.015)	(0.005)			
Crisis 3		0.019***	-0.077***			
		(0.003)	(0.004)			
Time Dummies (28 quarters)	Yes	Yes	No	Yes	Yes	No
C1*ΔCoVaR				0.052	0.040	0.318***
				(0.042)	(0.044)	(0.044)
C1*VaR				-0.007	-0.018	0.006
				(0.009)	(0.012)	(0.013)
C1*Leverage				-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.000)
C1*MM				-0.027**	-0.024**	0.012
				(0.011)	(0.012)	(0.026)
C1*ERV				-0.227	-0.344	-1.053**
				(0.274)	(0.294)	(0.515)
C1*Beta				-0.007	-0.007	-0.026**
				(0.006)	(0.006)	(0.010)
C1*MBV				-0.003	-0.002	0.015***
				(0.002)	(0.002)	(0.004)
C1*Size				0.007***	0.006***	0.007***
				(0.002)	(0.002)	(0.001)
C2*ΔCoVaR				0.072	0.065	0.411***
				(0.044)	(0.046)	(0.053)
C2*VaR				-0.015	-0.019*	0.018
				(0.010)	(0.011)	(0.018)
C2*Leverage				-0.000	-0.000	-0.000
				(0.000)	(0.000)	(0.001)
C2*MM				-0.052**	-0.049*	-0.151***
				(0.023)	(0.025)	(0.041)
C2*ERV				-0.018	0.052	0.213
				(0.278)	(0.317)	(0.514)

C2*Beta	-0.017**	-0.017**	-0.039***
	(0.007)	(0.007)	(0.015)
C2*MBV	-0.006*	-0.006	-0.055***
	(0.004)	(0.004)	(0.011)
C2*Size	0.008***	0.007***	0.007***
	(0.002)	(0.002)	(0.002)
C3*ΔCoVaR	0.131***	0.130***	0.310***
	(0.043)	(0.044)	(0.048)
C3*VaR	-0.005	-0.004	-0.001
	(0.010)	(0.011)	(0.016)
C3*Leverage	-0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)
C3*MM	-0.019	-0.021	-0.047*
	(0.013)	(0.014)	(0.027)
C3*ERV	-0.196	-0.156	-1.436***
	(0.273)	(0.282)	(0.444)
C3*Beta	-0.005	-0.008	-0.021**
	(0.005)	(0.005)	(0.008)
C3*MBV	-0.001	-0.000	0.005
	(0.003)	(0.002)	(0.005)
C3*Size	0.003**	0.003**	0.006***
	(0.001)	(0.001)	(0.001)
C1*UK		-0.001	
		(0.015)	
C1*Portugal		-0.004	
		(0.020)	
C1*Ireland		0.016	
		(0.011)	
C1*Italy		0.002	
		(0.007)	
C1*Greece		-0.040***	
		(0.014)	
C1*Spain		0.000	
		(0.016)	
C2*UK		-0.006	
		(0.016)	
C2*Portugal		0.002	
		(0.019)	
C2*Ireland		0.027**	
		(0.012)	
C2*Italy		0.006	
		(0.006)	
C2*Greece		-0.025*	
		(0.013)	
C2*Spain		0.011	
		(0.013)	
C3*UK		0.015	
		(0.016)	
C3*Portugal		-0.000	
		(0.023)	
C3*Ireland		0.053***	
		(0.012)	
C3*Italy		0.003	
		(0.008)	
C3*Greece		-0.005	
		(0.014)	
C3*Spain		-0.006	
		(0.012)	
FTSE Volatility			-2.355***
			(0.204)

Liquidity Spread						0.905***
						(0.031)
TBill change						-0.170***
						(0.008)
Credit Spread						0.011***
						(0.002)
Change in slope						0.055***
						(0.002)
FTSE Return						0.080***
						(0.018)
Constant	-0.219***	-0.219***	-0.213***	-0.190***	-0.184***	-0.463***
	(0.032)	(0.032)	(0.068)	(0.043)	(0.042)	(0.073)
N	141	141	141	141	141	141
T	28	28	28	28	28	28
R-squared	0.870	0.870	0.252	0.874	0.875	0.427
AIC	-12494	-12494	-6138	-12545	-12547	-7045
BIC	-12283	-12283	-6069	-12185	-12094	-6810

Supplementary Material

Table S.1. List of banks included in the sample

This table reports the name of all banks included in the sample, and continuously listed on any of the stock markets in the European Union. Sample period: 2006Q1-2012Q4.

Country	Bank
Austria	Bk.Fur Tirol Und Vbg.
	Bks Bank
	Erste Group Bank
	Oberbank
	Oest.Volksbanken Pc.
	Raiffeisen Bank Intl.
	Volksbank Vbg.Pc.
Belgium	Dexia
	Kbc Ancora
	Kbc Group
Bulgaria	Cb Central Coop.Bank
Cyprus	Bank Of Cyprus
	Cyprus Popular Bank
	Hellenic Bank
	Usb Bank
Czech Republic	Komercni Banka
Denmark	Danske Bank
	Diba Bank
	Djurslands Bank
	Gronlandsbanken
	Hvidbjerg Bank
	Jyske Bank
	Kreditbanken
	Lan & Spar Bank
	Lollands Bank
	Mons Bank
	Nordfyns Bank
	Nordjyske Bank
	Norresundby Bank
	Ostjydsk Bank
	Ringkjobing Landbobank
	Salling Bank
	Skjern Bank
	Spar Nord Bank
	Sparekassen Faaborg
	Svendborg Sparekasse
	Sydbank
	Totalbanken

	Vestfyns Bank
	Vestjysk Bank
	Vordingborg Bank
Finland	Alandsbanken 'A'
	Pohjola Pankki A
France	Banque Reunion
	Bnp Paribas
	Cic 'A'
	Cr.Agr.Alpes Provences
	Cr.Agr.Sud Rhone Alpes
	Cr.Agricole Morbihan
	Crcam Atlantique Vendee
	Crcam Ille-Vil.Cci
	Crcam Nord De France Cci
	Crcam Normandie Seine
	Credit Agr.Ile De France
	Credit Agr.Loire-H-Loire
	Credit Agr.Toulouse
	Credit Agr.Touraine
	Credit Agricole
	Credit Foncier De Moco
	Tixis
	Societe Generale
Germany	Commerzbank
	Deutsche Bank
	Deutsche Postbank
	Ikb Deutsche Indstrbk.
	Landesbank Bl.Hldg.
	Merkur Bank
	Oldenburgische Lb.
Greece	Agri.Bank Of Greece
	Alpha Bank
	Attica Bank
	Bank Of Piraeus
	Eurobank Ergasias S A
	General Bank Of Greece
	Tiol Bk.Of Greece
Hungary	Otp Bank
Ireland	Allied Irish Banks
	Bank Of Ireland
Italy	Banca Carige
	Banca Fint Euramerica
	Banca Monte Dei Paschi
	Banca Popolare Di Milano
	Banca Ppo.Di Sondrio

	Banca Ppo.Di Spoleto
	Banca Ppo.Emilia Romag
	Banca Ppo.Etruria Lazio
	Banco Di Sardeg Rsp
	Banco Popolare
	Bca.Piccolo Cdt.Valtell
	Bnc.Di Desio E Delb.
	Credito Bergamasco
	Credito Emiliano
	Intesa Sanpaolo
	Mediobanca Bc.Fin
	Unicredit
	Unione Di Banche Italiane
Lithuania	Siauliu Bankas
	Ukio Bankas
Luxembourg	Espirito Santo Finl.Gp.
Malta	Bank Of Valletta
	Fimbank
	Hsbc Bank Malta
	Lombard Bank
Netherlands	Van Lanschot
Poland	Bank Bph
	Bank Millennium
	Bank Polska Kasa Opieki
	Bank Zachodni Wbk
	Bnp Paribas Bank Polska
	Bos
	Bre Bank
	Getin Holding
	Handlowy
	Ing Bank Slaski Bsk
	Kredyt Bank
	Nordea Bank Polska
	Pko Bank
Portugal	Banco Bpi
	Banco Comr.Portugues 'R'
	Banco Espirito Santo
Romania	Banca Comerciala Carpatica
	Banca Transilvania Cluj
Slovakia	Otp Banka Slovensko
	Vseobec Uverova Banka
Spain	Banco De Sabadell
	Banco De Valencia
	Banco Espanol De Credito
	Banco Popular Espanol

	Banco Santander
	Bankinter 'R'
	Bbv.Argentaria
Sweden	Nordea Bank
	Seb 'A'
	Svenska Handbkn.'A'
	Swedbank 'A'
UK	Barclays
	Bcb Holdings
	Hsbc Hdg.
	Lloyds Banking Group
	Royal Bank Of Sctl.Gp.
	Standard Chartered

Table S.2 Summary statistics for market variables by year

The table reports the mean, standard deviation (Std. Dev.), median, min and max values of the market variables, calculated year by year. The definitions of the variables are reported in Table 2. Source: Datastream.

2006	*FTSEVol*	*LiqSpread*	Δ*TBill*	Δ*Slope*	Δ*CredSpread*	*FTSEReturns*
Mean	0.0076	0.0021	0.0125	-0.06	-0.2602	0.0310
Std. Dev.	0.0070	0.0033	0.0050	0.0300	-0.2746	0.0514
Median	0.0053	-0.0050	-0.0300	-0.6400	-0.4464	-0.0354
Min	0.0110	0.0065	0.0700	0.3400	-0.0452	0.0566
Max	0.0025	0.0055	0.0465	0.4137	0.1647	0.0444

2007	*FTSEVol*	*LiqSpread*	Δ*TBill*	Δ*Slope*	Δ*CredSpread*	*FTSEReturns*
Mean	0.0094	0.0301	0.0225	-0.0275	-0.1434	0.0085
Std. Dev.	0.0091	0.0202	0.0250	-0.0900	-0.0919	-0.0037
Median	0.0063	0.0088	-0.0200	-0.2000	-0.3457	-0.0233
Min	0.0131	0.0711	0.0600	0.2700	-0.0442	0.0648
Max	0.0028	0.0286	0.0386	0.2108	0.1375	0.0413

2008	*FTSEVol*	*LiqSpread*	Δ*TBill*	Δ*Slope*	Δ*CredSpread*	*FTSEReturns*
Mean	0.0212	0.1588	-0.0075	0.1775	0.6393	-0.1318
Std. Dev.	0.0187	0.1462	-0.0600	0.1450	0.6274	-0.1161
Median	0.0107	0.0399	-0.2100	-0.3500	-0.4505	-0.2422
Min	0.0369	0.3029	0.3000	0.7700	1.7531	-0.0527
Max	0.0111	0.1084	0.2243	0.5220	0.9649	0.0933

2009	*FTSEVol*	*LiqSpread*	Δ*TBill*	Δ*Slope*	Δ*CredSpread*	*FTSEReturns*
Mean	0.0148	0.0669	-0.0150	0.2500	-0.4064	0.0698
Std. Dev.	0.0134	0.0556	0.0000	0.0800	-0.2999	0.0987
Median	0.0113	0.0277	-0.1900	-0.1600	-1.5402	-0.0672
Min	0.0211	0.1288	0.1300	1.0000	0.5143	0.1489
Max	0.0045	0.0433	0.1380	0.5191	0.9355	0.0990

2010	*FTSEVol*	*LiqSpread*	Δ*TBill*	Δ*Slope*	Δ*CredSpread*	*FTSEReturns*
Mean	0.0112	0.0497	-0.0250	-0.0625	0.1105	0.0160
Std. Dev.	0.0099	0.0473	-0.0400	-0.1200	0.0480	0.0310
Median	0.0082	0.0285	-0.0800	-0.4300	-0.6231	-0.0638
Min	0.0170	0.0757	0.0600	0.4200	0.9691	0.0657
Max	0.0040	0.0205	0.0597	0.3713	0.6965	0.0557

2011	*FTSEVol*	*LiqSpread*	Δ*TBill*	Δ*Slope*	Δ*CredSpread*	*FTSEReturns*
Mean	0.0128	0.0948	0.0150	0.0250	0.1479	-0.0190
Std. Dev.	0.0119	0.0880	0.0300	0.0650	0.2069	-0.0203
Median	0.0082	0.0640	-0.1300	-0.5500	-0.6685	-0.1303
Min	0.0193	0.1392	0.1300	0.5200	0.8465	0.0950
Max	0.0055	0.0317	0.1182	0.4645	0.6250	0.0945

2012	*FTSEVol*	*LiqSpread*	Δ*TBill*	Δ*Slope*	Δ*CredSpread*	*FTSEReturns*
Mean	0.0089	0.1545	0.0888	-0.3963	0.0204	0.0265
Std. Dev.	0.0089	0.1507	0.0150	-0.3500	-0.0580	0.0431
Median	0.0068	0.1097	-0.0300	-0.6550	-0.0951	-0.0402
Min	0.0112	0.2067	0.3550	-0.2300	0.2926	0.0601
Max	0.0018	0.0516	0.1792	0.1958	0.1835	0.0457

Corporate variables

In the light that we have a cross-country database, matching time and countries specific features, it is useful to highlight the main features of the corporate variables and ratios focusing on the single countries. Table S.3 reports the average values of variable *leverage* by countries. We notice a relevant difference between the average implicit Core Tier 1 ratio of Euro countries area, i.e. 5.02% and the percentage which features non Euro countries of 7.95%. Moreover, for the majority of the countries of the sample this measure remains quite stable overall the whole period. For instance, the implicit core tier one ratio ranges between 6.97% and 8.07% for Italy and between 5.54% and 6.96% for France. When we consider the other countries, like Denmark or Poland, with a relevant number of banks in the sample, there is evidence of a substantial stability of the leverage ratio: the implicit core tier 1 value for Denmark ranges between 8.85% and 9.20%, while for Poland between 7.93% and 10.44%. Other countries register relevant unbalances in the data, like for example United Kingdom ranging from a very low implicit tier one level in 2008 (2,67%) to a definitely higher in 2011 (6,69%), though the values may be affected by that these countries have a small number of intermediaries. Finally, it is worth noticing the very high level of leverage of the German banks, in this case too this can be explained by that the limited number of German banks in our sample.

Maturity mismatch measures the percentage of short term debt over banks' total liabilities, assumed as a proxy of the dependence of a single intermediary on the well working of the whole system. Moreover, maturity mismatch can also be interpreted as a proxy of the level of interconnectedness between financial intermediaries. We notice a difference between Euro and non Euro countries, the former showing a higher level of maturity mismatch than the latter (Table S.4). This result is consistent with the hypothesis that Euro countries are more interconnected than non Euro one. Wherever cash exceeds the level of short term debt,

the ratio is negative. This result is consistent for Cyprus and Malta, countries with a financial system strictly connected with the fiduciary holdings of many wealthy Russian and Eastern families. The results of the other nations, such as for instance Bulgaria or Romania, has to be interpreted with conscious given the very low level observations available.

The level of maturity mismatch in the other countries is quite variable. Among the main European countries, we notice that the average value for Italy (12.27%) is lower than the one in Germany (18.27%). Moreover, France definitely exceeds Germany and Italy, representing the highest average level (32.05%) amongst all nations. Other countries show a low but positive level of maturity mismatch, which looks reasonable given both the low interconnectedness of the financial systems of these countries (as for the case Czech Republic (1.76%), Lithuania (3,76%), Slovakia (3.93%)) and the low numbers of banks in our sample.

The evidence above is confirmed when we consider the average *percentage of deposit on total assets of the banks* (Table S.5). This measure can be considered a reasonable proxy of the degree of stability of liabilities issued by intermediaries. The figures confirm the lower percentage of deposit on total assets of Euro countries in comparison with non Euro ones. Moreover, it clearly emerges the lower percentage level of deposit in some of the more financially developed and interconnected European countries, such Finland, Sweden or France, in comparison with a lower percentage of at least ten points in Germany, Italy and Spain.

The *beta* coefficient average values (Table S.6) of the Euro countries is higher than the non-Euro ones, being this result coherent with the pattern of both leverage and maturity mismatch variables. On average, the beta coefficient increases of 34% over the whole period. However, the rate of increase of the beta coefficient varies significantly across countries. In particular, there is evidence of a high beta coefficient level of Irish and Greek banks, though with significant differences. The main European countries show average beta coefficient

between 0.45 of France, 0.62 of Germany and of 0.86 of Italy. However, while the beta coefficient of the Italian and French banks show a substantial increase of 42.67% and 69.08% respectively, the German one decreases of 26.73%.

Similar evidence occurs in the analysis of *equity return volatility* index (Table S.6). While the average index of volatility is quite similar within the two areas, the increase of volatility over time is very impressive in some countries, like Ireland, Austria, Greece, Belgium and Spain, belonging to the Euro area.

Moreover, Euro countries show a 1.03 average value of *market to book ratio* as compared to the 1.36 of non-Euro countries (Table S.7). This evidence confirms our previous analysis about the different level of potential riskiness of the two areas, underlining again how Euro area would have been featured by a higher dimension of risk in that period. The average ratio of market to book value of different countries is less than one, like France (0.47) and with a minor degree Italy (0.89) and Ireland (0.93), and this average value is still largely positive for the remaining countries. In the light that banks with a market to book ratio between 0 and 1 are defined as distressed, apart from the above mentioned countries, only very few of the others countries (Austria, Finland, Lithuania, Netherlands and Slovakia, which however represented by low number of banks in our sample) may be technically considered distressed.

Some interesting stories can be derived if we consider the evidences for countries and years: we notice a widespread fall in the level of the average market to book value between 2007-2008 and 2009, i.e. during the period of Great Financial Depression. For instance, the market to book value of Irish banks changes dramatically, dropping from 1.85 in 2007 to 0.62 in 2008 and then to 0.12 in 2009, wiping out the whole Irish banking system. With less intensity, both German and Italian banks show similar pattern. Finally, south European

nations, like Greece, Spain and Portugal show a relevant decrease in the market to book value since 2010, i.e. period of the Sovereign Debt Crisis.

Summary statistics of bank *size* (Table S.8), expressed by the market value of total assets, that the average size of the Euro countries is significantly higher than for the non-Euro banks. There exists a relevant variance about size, being the average size of the banks belonging to some countries almost irrelevant. Size's data confirm the previously outlined outcome about the substantial dimensional drop between 2008 and 2009. Despite the obtained results in the market to book value analysis, the data about size do not reveal a relevant dimensional fall in any countries since 2010.

The descriptive analysis of the variables of interest suggests some important features of the data. The first is the different institutional environments between Euro and non-Euro area, with Euro nations more likely to be affected by risk than the other ones. On the one hand, this may indicated a substantial failure in the Euro area regulation in reducing the overall level of risk, on the other hand this result may also be interpreted as proxy for a more financially advanced and interconnected area. This is consisting with the financial literature about systemic risk given that during financial turmoil interconnectedness may be a device for propagating rather than diversifying risks. A second important feature is related to the different level of financial fragility among banks belonging to Euro area. In this case, our results can be accurately interpreted. It is evident the weakness of Irish and Greek systems and the severe difficulties affecting Italy and Spain, the French financial system shows fragile fundamentals. Other countries, such as Sweden and Finland show a quite homogeneous relation in terms of riskiness among leverage, maturity mismatch and beta coefficients.

Table S.3 Leverage: average values by country and by year

Columns 2006-2012 report the variable *leverage* calculated as the ratio between the total assets and the book value of total equity (average between banks of the single country). Mean indicates the average value over 2006-2012. For Romania, the variable *leverage*, is unavailable for 2009 and 2010, for Slovakia for 2006, 2007 and 2008. Source: Datastream.

Country	Mean	2006	2007	2008	2009	2010	2011	2012
Austria	23.70	17.68	19.27	19.62	19.21	18.84	40.79	29.23
Belgium	24.49	22.23	23.04	47.88	33.01	34.24	-0.27	6.00
Bulgaria	8.79	10.81	8.88	7.44	7.60	7.81	9.37	10.00
Cyprus	16.93	17.18	13.94	14.13	15.74	15.66	19.39	23.87
Czech Republic	10.85	11.26	13.34	12.63	11.02	9.50	9.55	8.66
Denmark	11.28	10.86	11.10	11.47	11.41	11.69	11.16	11.12
Finland	18.38	16.54	16.91	19.30	18.93	19.13	19.17	18.66
France	16.49	14.35	15.02	18.04	16.94	16.58	17.02	17.36
Germany	41.61	41.01	38.99	62.85	40.04	36.81	34.76	35.42
Greece	11.05	18.73	18.66	18.03	19.33	67.12	-2.18	-72.23
Hungary	8.29	9.56	9.25	9.17	8.47	7.61	7.26	6.94
Ireland	21.11	24.95	24.12	22.83	16.22	27.37	16.52	13.72
Italy	13.06	13.69	12.83	12.58	12.39	12.59	13.21	14.33
Lithuania	2.65	2.91	2.75	2.25	2.36	2.88	2.86	2.71
Luxembourg	90.74	100.66	85.23	110.62	94.59	91.13	86.12	42.85
Malta	11.72	12.11	12.00	12.15	11.60	11.52	11.36	11.27
Netherlands	15.50	18.61	16.17	16.68	17.45	14.14	12.67	12.78
Poland	10.96	10.45	10.55	11.62	12.60	10.89	10.98	9.57
Portugal	22.37	20.36	20.20	21.49	19.69	20.51	28.24	26.13
Romania	9.99	8.48	9.89	9.80	-	-	11.34	11.66
Slovakia	12.11	-	-	-	10.59	13.34	12.41	11.58
Spain	20.51	20.87	20.12	20.18	18.79	18.06	21.14	24.32
Sweden	24.69	26.38	26.47	26.54	24.16	23.39	23.07	22.83
United Kingdom	22.34	28.11	29.96	37.39	24.60	18.67	14.36	15.34
Whole sample	16.86	17.09	17.04	19.43	17.15	19.46	15.95	11.91
Euro countries	19.89	19.93	19.47	23.60	20.13	24.44	19.02	12.15
Non-Euro countries	12.57	12.91	13.33	13.63	12.80	12.18	11.84	11.59

Table S.4 Maturity mismatch: average values by country and by year (%)

Columns 2006-2012 report the variable *maturity mismatch* calculated as the ratio between the total short term debt minus cash, to total liabilities (average between banks of the single country). Mean indicates the average value over 2006-2012. For Romania, the variable *maturity mismatch* is unavailable for 2009 and 2010, for Slovakia for 2006, 2007, and 2008. Source: Datastream.

Country	Mean	2006	2007	2008	2009	2010	2011	2012
Austria	21.53	18.27	22.08	23.53	21.41	23.25	19.95	21.10
Belgium	15.36	19.79	23.13	20.40	13.28	10.52	10.30	10.08
Bulgaria	-6.93	-14.13	-27.41	-6.54	-7.40	-2.34	-5.83	(4.89)
Cyprus	-8.18	2.24	3.05	-2.19	-17.73	-17.36	-1.98	-5.40
Czech Republic	1.76	2.46	0.75	0.46	0.45	1.41	3.73	3.04
Denmark	8.77	11.99	13.66	11.27	9.38	6.84	7.19	3.35
Finland	13.56	8.97	20.14	18.29	11.68	12.41	13.98	9.48
France	32.05	36.33	34.52	34.07	33.01	30.16	28.83	28.34
Germany	18.27	20.85	24.46	20.57	18.60	11.84	14.81	16.39
Greece	20.53	14.39	14.20	17.15	20.07	25.43	24.44	25.77
Hungary	3.11	-1.42	5.93	5.61	7.46	2.44	1.78	0.67
Ireland	23.11	25.41	22.23	18.87	28.43	23.29	26.45	18.69
Italy	12.27	7.42	14.40	13.73	10.72	12.84	11.80	13.44
Lithuania	3.76	-2.21	16.20	11.78	2.81	3.12	2.08	0.29
Luxembourg	17.57	16.61	16.69	16.23	19.21	16.57	20.28	17.26
Malta	-7.53	-6.32	-6.59	-5.07	-7.67	-8.37	-9.06	-9.66
Netherlands	4.77	6.36	3.73	1.69	10.79	5.70	0.77	4.33
Poland	10.80	9.51	9.79	11.36	14.01	10.10	11.90	9.32
Portugal	12.28	13.35	11.13	10.16	10.07	11.77	14.93	14.56
Romania	-2.15	-2.47	5.62	1.86	-	-	-12.69	-1.80
Slovakia	3.93	-	-	-	2.27	7.91	2.87	2.11
Spain	17.32	19.05	15.76	16.25	16.86	16.77	16.22	20.36
Sweden	15.69	20.35	20.71	20.04	17.52	13.87	14.12	10.80
United Kingdom	7.17	13.79	13.78	11.59	10.40	6.75	3.24	0.67
Whole sample	13.73	14.35	16.04	15.23	13.81	12.96	12.56	11.82
Euro countries	17.18	17.31	18.76	17.96	16.06	16.56	16.46	17.45
Non-Euro countries	8.82	10.47	11.84	10.90	10.11	7.71	7.55	4.89

Table S.5 Deposit on total assets: average values by country and by year (%)

Columns 2006-2012 report the Percentage of deposits on total assets, calculated as the ratio between the total deposit and total assets (average between banks of the single country). Mean indicates the average value over 2006-2012. For Romania, the variable *percentage of deposits on total assets*, is unavailable for 2009 and 2010, for Slovakia for 2006, 2007 and 2008. Source: Datastream.

Country	Mean	2006	2007	2008	2009	2010	2011	2012
Austria	48.25	51.12	49.32	48.56	49.57	46.86	45.94	47.31
Belgium	36.99	37.58	36.28	33.27	37.96	38.90	37.61	37.69
Bulgaria	84.78	83.04	87.25	85.14	83.43	83.20	86.17	87.08
Cyprus	85.14	84.26	82.88	84.08	84.71	84.84	86.80	89.30
Czech Republic	77.70	78.04	79.95	79.38	80.12	77.26	74.89	74.29
Denmark	61.23	59.26	58.26	58.82	61.81	60.82	62.33	66.00
Finland	30.45	30.51	33.08	35.64	36.29	35.61	38.95	41.18
France	30.44	30.39	28.62	26.91	29.85	31.76	32.23	32.69
Germany	41.59	44.11	32.43	35.92	42.53	43.69	47.07	45.87
Greece	59.53	58.84	56.41	63.15	61.56	57.63	54.90	63.58
Hungary	59.84	62.41	57.97	57.30	56.48	59.56	61.49	63.19
Ireland	43.96	41.57	40.85	43.22	47.24	39.66	46.32	50.31
Italy	46.04	48.24	43.97	45.00	48.72	47.76	44.13	44.47
Lithuania	75.07	82.73	78.32	67.32	73.68	75.82	76.62	77.09
Luxemburg	33.56	33.40	30.01	31.17	30.28	34.39	39.33	39.19
Malta	82.95	86.09	84.07	83.09	81.48	82.10	82.20	81.66
Netherlands	66.40	60.11	65.06	73.65	66.72	65.21	69.93	64.10
Poland	64.73	67.02	65.75	64.73	63.06	64.57	62.77	65.31
Portugal	44.65	41.76	40.92	41.58	45.6	43.96	48.50	50.23
Romania	67.16	64.61	58.33	59.97	-	-	79.97	83.01
Slovakia	72.41	-	-	-	70.40	70.00	73.10	75.47
Spain	43.53	40.89	42.07	40.58	42.44	44.87	47.95	45.48
Sweden	30.57	31.96	31.33	30.61	29.82	29.05	30.68	30.55
United Kingdom	41.66	42.20	40.50	37.03	40.24	39.96	41.95	45.71
Whole sample	52.46	52.53	49.91	51.02	52.95	52.72	53.22	54.48
Euro countries	47.50	47.68	44.64	45.98	48.45	48.20	48.41	48.89
Non-Euro countries	59.46	59.64	57.85	58.09	59.51	59.24	59.58	61.91

Table S.6 Beta and equity return volatility: mean and Δ% over 2006-2012

Columns 2006-2012 report Beta and Equity Return Volatility. Beta is calculated as the ratio between the covariance of the equity security on the market and the variance in the market. Equity Return Volatility represents the equity return volatility during the period of analysis, calculated as the standard deviation of the daily equity returns of each banks in the sample. Mean reports the average value over 2006-2012. Δ% represents the rate of change calculated over the value 2006-2012. Source: Datastream.

Country	Beta		Equity Return Volatility	
	Mean	Δ%	Mean	Δ%
Austria	0.43	34.47	1.58	189.36
Belgium	1.80	95.51	3.59	261.44
Bulgaria	1.04	-51.82	2.38	41.67
Cyprus	0.56	-31.47	3.07	69.34
Czech Republic	1.10	13.29	2.14	8.16
Denmark	0.26	15.17	2.31	85.07
Finland	0.52	-9.66	2.50	40.25
France	0.45	69.08	1.91	53.33
Germany	0.62	-26.73	2.54	51.78
Greece	1.40	51.80	3.87	238.75
Hungary	1.36	8.38	2.68	-5.80
Ireland	1.75	16.06	4.89	191.07
Italy	0.86	42.67	2.14	126.01
Lithuania	0.98	102.45	2.40	19.51
Luxembourg	0.08	96.08	1.26	-25.98
Malta	0.83	42.51	1.43	8.19
Netherlands	0.32	-35.45	1.53	2.14
Poland	0.83	18.79	2.41	-11.51
Portugal	1.22	142.98	2.25	214.49
Romania	0.84	47.84	2.43	15.32
Slovakia	1.31	11.26	2.44	23.89
Spain	1.08	16.61	2.26	195.12
Sweden	1.18	8.51	2.29	0.79
United Kingdom	1.26	73.30	2.74	84.84
Whole sample	0.76	34.11	2.37	83.21
Euro countries	0.82	36.80	2.36	115.16
Non-Euro countries	0.66	28.49	2.39	41.11

Table S.7 Market to book ratio: average values by country and by year

Columns 2006-2012 report the Market to book value, calculated as the ratio between market and book value of banks (average between banks of the single country). Mean is the average value over 2006-2012. Notes: for Romania, the variable *market to book value*, is unavailable for 2009 and 2010, for Slovakia for 2006, 2007 and 2008. Source: Datastream.

Country	Mean	2006	2007	2008	2009	2010	2011	2012
Austria	0.94	1.63	1.63	1.06	0.67	0.67	0.69	0.56
Belgium	1.02	1.82	1.82	1.28	0.75	0.63	0.35	0.32
Bulgaria	1.43	4.33	4.33	1.42	0.42	0.36	0.35	0.18
Cyprus	1.24	2.72	2.72	1.27	0.84	0.74	0.51	0.30
Czech Republic	2.24	3.26	3.26	2.49	1.83	2.02	1.89	1.61
Denmark	1.04	1.98	1.98	1.07	0.75	0.74	0.59	0.56
Finland	0.97	1.24	1.24	1.07	0.88	0.95	0.82	0.68
France	0.47	0.74	0.74	0.37	0.35	0.39	0.35	0.20
Germany	1.20	1.70	1.70	1.45	0.87	0.92	0.85	0.83
Greece	1.32	3.19	3.19	1.66	1.07	1.83	-0.53	-1.30
Hungary	1.64	3.21	3.21	1.56	0.98	1.19	0.94	0.75
Ireland	0.93	1.85	1.85	0.62	0.12	0.24	0.21	0.31
Italy	0.89	1.46	1.46	0.88	0.71	0.62	0.49	0.39
Lithuania	0.22	0.45	0.45	0.23	0.16	0.21	0.20	0.16
Luxembourg	0.92	1.02	1.02	0.66	0.64	0.67	0.58	0.49
Malta	2.21	3.12	3.12	2.41	1.89	1.79	1.52	1.32
Netherlands	0.74	0.97	0.97	0.88	0.63	0.64	0.56	0.43
Poland	2.05	3.58	3.58	1.90	1.45	1.79	1.58	1.29
Portugal	1.27	2.52	2.52	1.26	0.87	0.71	0.57	0.46
Romania	2.57	3.88	3.88	1.83	-	-	0.95	0.46
Slovakia	0.30	-	-	-	0.34	0.45	0.32	0.10
Spain	1.49	2.49	2.49	1.61	1.33	1.00	0.78	0.61
Sweden	1.32	1.86	1.86	1.03	0.92	1.18	1.08	1.15
United Kingdom	1.01	1.80	1.80	1.02	0.96	0.88	0.59	0.56
Whole sample	1.17	2.12	2.09	1.20	0.87	0.91	0.66	0.52
Euro countries	1.03	1.97	1.81	1.13	0.81	0.81	0.48	0.31
Non-Euro countries	1.36	2.34	2.52	1.31	0.96	1.06	0.89	0.79

Table S.8 Size: average values by country and by year (millions of euro)

Columns 2006-2012 report the Size, represented by total assets of banks. Mean is the average value over 2006-2012. For Lithuania, the variable *size*, is unavailable for 2007, for Romania for 2009 and 2010, and for Slovakia for 2006, 2007 and 2008. Source: Datastream.

Country	Mean	2006	2007	2008	2009	2010	2011	2012
Austria	24,360	25,399	27,359	27,933	21,380	22,815	26,635	21,591
Belgium	159,625	163,129	221,342	236,003	151,739	157,283	106,402	73,759
Bulgaria	40	211	244	42	14	53	-1	-14
Cyprus	506	1,306	5,252	776	27	-477	-366	-1,229
Czech Republic	6,822	5,498	7,108	6,870	5,524	7,238	7,821	7,364
Denmark	11,237	13,179	14,260	12,042	8,425	9,628	9,841	12,419
Finland	10,929	9,369	9,808	10,696	11,582	12,374	12,075	10,601
France	84,075	62,771	81,784	82,960	82,353	91,037	93,684	86,616
Germany	164,676	175,062	225,228	168,367	140,641	164,414	132,841	160,447
Greece	18,101	17,902	22,649	15,391	16,339	18,009	18,853	18,968
Hungary	11,440	10,351	17,357	14,476	11,972	10,988	9,026	7,395
Ireland	73,782	85,534	97,242	97,999	70,122	67,411	65,564	54,749
Italy	48,235	33,486	54,826	52,828	44,102	47,101	52,141	48,134
Lithuania	120	204	-	195	91	129	94	78
Luxembourg	44,412	33,269	41,442	45,045	51,417	49,745	44,366	41,231
Malta	364	576	536	360	287	218	238	271
Netherlands	5,172	7,665	7,485	4,889	5,389	4,791	3,560	3,675
Poland	4,650	3,548	6,021	4,545	3,608	4,946	4,996	4,689
Portugal	31,563	28,143	35,715	32,610	32,020	35,200	30,560	27,541
Romania	141	174	275	120	-	-	20	23
Slovakia	1,446	-	-	-	2,514	1,203	1,199	1,182
Spain	126,950	140,786	152,214	150,678	120,636	115,938	106,558	112,727
Sweden	123,234	117,340	99,756	71,207	112,987	135,989	142,725	149,551
United Kingdom	336,304	391,153	529,837	434,218	364,362	327,093	304,875	225,216
Whole sample	53,189	52,160	63,718	54,792	48,716	51,614	52,396	50,834
Euro countries	63,627	60,260	78,603	71,112	59,316	61,777	58,974	57,521
Non-Euro countries	38,318	40,500	41,442	31,371	32,989	36,744	43,450	41,964