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Systemic risk and individual risk: A trade-off?[1]

Preliminary draft

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Abstract

The global financial crisis raised concerns about the European financial system structure. The systemic nature of financial institutions, especially banking institutions, was highlighted, questioning the bottom-up approach used so far to ensure the financial stability as a whole. In this study, we legitimize the calibration of micro-prudential instruments for macro-prudential purposes in order to measure and manage systemic risk. The debate on the best way to eliminate the negative externalities of systemic risk is politically controversial and economically complicated. Using bank balance sheet and daily stock market data from listed banks classified as Monetary Financial Institutions (MFIs) across EU-17 over the period 1999-2013, we investigate whether more individual bank soundness is conducive for financial stability.

Through a 2SLS model to correct the observed endogeneity between the individual risk, measured by Z-score (Roy, 1952) and the systemic risk, measured by SRISK (Acharya, Engle and Richardson, 2012), our strong empirical results suggest that riskier banks contribute more to systemic risk. Thus, individual bank soundness increases the banking system resilience to potential shocks. On the one hand, this finding seems to challenge the traditional bottom-up approach. Indeed, our outcome emphasizes the fallacy of composition prior the crisis. Nevertheless, it shows that even if the sum of the risks borne by financial institutions does not reflect the global risks borne by the entire system, it is an important addition. On the other hand, this result justifies the calibration of micro-prudential tools for macro-prudential purposes; taking into account individual factors that are sources of systemic fragilities and a part of individual risk-taking. This study has important policy implications for designing and implementing new regulations to improve the financial system stability, in particular for MFIs because systemic risk remains misunderstood and its measuring tools are still ongoing (Hansen, 2012).

JEL classifications: G21, G28

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1. Introduction

The recent financial turmoil highlighted the need to protect the financial system and to refine the definition of "financial stability". Until the 2007-2008 global financial crisis, there was a consensus in prudential regulation focused on individual risks and based on a micro-prudential logic. Thus, ensuring the soundness of individual banks would strengthen the stability of the entire system. This bottom-up approach was successively implemented and reinforced by the Basel Committee on Banking Supervision (BCBS) through Basel I (1988) and Basel II (2005) in order to improve risk management and also strengthen banks' resilience to potential adverse shocks. Prior the financial disruptions, many studies focused on bank risk-taking and financial stability. The theoretical and empirical literature on these issues was flourishing and one main measure of individual soundness was commonly used to analyse the impact of financial mutations and market structure on financial stability: the Z-score. In their meta-analysis on the bank competition and financial stability, Havranek and Zigraiova (2015) collected 598 estimates from 31 studies published between 2003 and 2014 and shown that 45% of reported estimates in the literature were calculated using the Z-score as a proxy for bank stability. Among these studies, 7.5% used ROA or ROE volatility, 6.9% used the Distance-to-default and 5% used the Non-Performing Loans. Authors used Bayesian model averaging (BMA) to address model uncertainty and emphasized that the definition of financial stability used by researchers influences their results in a systematic way. The choice of data, estimation methodology, and control variables also affects the reported coefficient. Among studies that used the Z-score as measure of financial stability through the bank risk-taking or individual bank distress, we can list Boyd and Runkle, 1993; Boyd and al., 2006; Lepetit et al., 2008; Berger and al., 2009; Demirgüç-Kunt and Detragiache 2011; Laeven and Levine, 2009; Cihak and Hesse, 2010; Lepetit and Strobel, 2013; Beck and al., 2013.

However, the recent financial crisis questioned the exogeneity assumption of banking risks. Thus, the sum of the risks borne by financial institutions does not reflect the risks borne by the entire system. This one would be due to common exposures to a single risk factor, the pro-cyclicality of the financial imbalances and the interconnections between financial institutions characterized by their complexity. The latter does not exclusively relate to the importance of their size but also to the sophistication of their instruments, threatening the substitutability of their products. Although the banking risks are considered exogenous in Internal Risk models (IRM), financial crisis has highlighted its endogenous nature. According to Haldane (2009), excessive diversification has led to a homogenization of bank portfolios making them most vulnerable to systematic risk. The importance and hysteresis effect of social costs have led to consider financial stability as a public good, not only for supervisory authorities but more generally for public policymakers.

Prior to the global financial downturns, the regulatory framework in place was only based on a micro-prudential foundation. The crisis highlighted its shortcomings through the pro-cyclicality and the handling of solvency ratios, as well as the lack of a Macro-prudential dimension. The implementation of a macro-prudential risk assessment based on a general equilibrium and designed to safeguard the financial system as a whole appeared unavoidable to complete the micro-prudential risk assessment based on a partial equilibrium in its conception, and aiming at preventing costly failures of individual financial institutions

(Crockett, 2000; Borio, 2003; Brunnermeier and al., 2009; Aglietta and Scialom, 2010; Hanson, Kashyap and Stein, 2010; Kashyap, Berner and Goodhart, 2011).

Although the concept of systemic risk dates back to the bankruptcy of the Herstatt German bank in 1974, and despite the fact that the inclusion of a macro-prudential framework was documented before the crisis, the debate was still abstract. Indeed the measuring instruments of systemic risk are recent and the literature on the issue is thriving. In the aftermath of the crisis and its declensions, there seemed to be a broad consensus among academics, supervisors and policymakers that financial regulation needs to move in a macro-prudential direction in order to minimize the costs associated with crises and their probability of occurrence. Subsequently, two main responses to the 2008 global financial crisis were prudential and structural policies. Respectively through Basel III that allowed the calibration of micro-prudential tools for macro-prudential purposes and banking' structural reforms adopted in several advanced economies.

While it was long recognized that financial institutions play an important and a special role in economic developments (Schumpeter, 1911; McKinnon, 1973), these proposals marked a paradigm shift. Since the mid-70s, in parallel with the deregulation of financial markets, restrictions on banks' business lines have been relaxed. There was a widespread belief that banks which offer a full range of financial services are an important vector of economic efficiency because they contribute more to the economic growth and to the economic welfare (Levine and King, 1993; Berger, Hancock, and Humphrey, 1993 ; Tirole, 1998). Nevertheless, in evaluating the European banking sector, the High-level Expert Group on structural bank reforms mandated by European commission highlighted that if no particular business model fared particularly well in the financial crisis, Universal bank model has unusually underperformed (Liikanen, 2012).

The financial crisis that peaked in 2008 has led to a renewed interest in the macro-prudential policy; it has also triggered a reassessment of the economic costs and advantages of universal banks' involvement in trading activities especially for European countries. Indeed, unlike to the United States where the banking system is historically fragmented, the European banking system is highly concentrated and the largest European banking groups are typically financial conglomerate, so-called 'Universal banks'.

Thus, effective and efficient regulation requires an understanding of active institutions in the financial markets particularly institutions that pose systemic challenges so-called Systemically Important Financial Institutions (SIFIs) in order to adapt supervisory tools and to strengthen the stability of the entire system. The Financial Stability Board (2010) defines SIFIs as "financial institutions whose distress or disorderly failure, because of their size, complexity and systemic interconnectedness, would cause significant disruption to the wider financial system and economic activity". In an environment characterized by more deep markets and encouraged by cheap funding, many large universal banks shifted too many resources to trading books. Their complexity weakened market discipline through regulatory capture, while their interconnectedness increased systemic risk through strong linkages between banks and non-banks. It has therefore become very difficult to resolve banks in an orderly manner without triggering further financial instability.

According to the structural approach, financial system consists of three main components, namely financial markets, financial intermediaries and financial regulators. The endogenous nature of risk introduced the need for a macro-prudential approach to bank regulation, giving a key role to banking regulators in the computing and management of global risk, so-called systemic risk. To measure and manage the systemic risk, it is crucial to understand and define the financial stability concept. Financial stability is a difficult concept to explain, because there is no widely accepted definition (Oosterloo and De Hann, 2003). Positive outlook highlights what financial stability is (Schinasi and al., 2004); whereas negative outlook emphasizes what financial stability is not (Crocket, 1997; Chant, 2003).

According to the European Central Bank (2010), systemic risk can be defined as a risk of financial instability insofar it adversely affects the effective functioning of the financial system, and it significantly impairs the sustainable growth of the economy and social welfare. This wording is large and highlights the first challenge of systemic risk based on the shortcomings in its definition; multifaceted in nature. Some studies pointed out the specific mechanisms that are transmission canals of systemic risk. Among these mechanisms we can quote the impact on the real economy, disruptions in information flows and paralysis of markets, imbalances, feedback behaviours, negative externalities, asset bubbles, contagion, respectively underlined by Group of ten, 2001; Mishkin, 2007; Kapadia and al., 2012; FSB, 2009; Rosengren, 2010; and Moussa, 2011. In a survey on new measures of risks assessment and management borne by the financial system, Bisias and al., (2013) show that there is no measure able to take into account all factors of financial instability because the systemic risk poses multiple challenges, including its definition and its multifaceted nature. The choice of method relies on the factors of instability we want to capture. Macro-prudential indicators were implemented and some, widely criticized cover a micro-prudential dimension to take into account some instability factors. In the one hand, macro-level metrics tend to concentrate on aggregate imbalances with a high tendency to use macroeconomic time series. Thus, Alfaro and Drehmann (2009) analyze the time series of GDP as signs of weakening in advance of a crisis; Alessi and Detken (2009) investigate anomalous levels in macroeconomic time series as possible indicators of boom/bust cycles; while Kritzman and al., (2010) compute an absorption ratio to measure the tendency of markets to move in unison, suggesting tight coupling. In the other hand, micro-level metrics that taking into account individual bank characteristics to capture some factors of systemic instability were calibrated to macro-prudential purposes.

If the banking sector was not the only source of vulnerabilities, it was at the heart of recent financial disturbances that peaked in 2008 and escalated into a full-blown economic crisis. Some banks individual characteristics were found to be factors of systemic instability. Many empirical investigations to compute the systemic risk introduced these factors of systemic instability in a macro-prudential framework and encompassed the “Too Interconnected to Fail” and the “Too Big to Fail” concepts. Among these studies the most popular rely on public market data, making the regulators able to reveal to the markets the reasons behind their decisions. The SRISK developed by Acharya, Engle and Richardson (2012) is widely used in the literature to measure the systemic risk. Furthermore, using an unbalanced panel of top US financial institutions spanning the 2000-2012 period, Brownlees and Engle (2016) show that aggregate SRISK provides early warning signals of distress in indicators of real activity such as a decline in industrial production and an increase in the unemployment rate.

Post-crisis studies used systemic risk particularly the so-called SRISK to examine the impact of financial mutations and market structure on financial stability. Among them we can quote Laeven, Ratnovski and Tong (2016) which analyse the impact of concentration and consolidation movements on the financial stability through the Too Big to fail concept. Authors used a panel of 56 countries from 2007 to 2008 and show that large banks contribute more to systemic risk. Leroy and Lucotte (2017) empirically investigate if there is a trade-off in the relationship between competition and bank risk (SRISK and Z-score) across a sample of 97 European listed banks from 2004 to 2013. They find that competition increases individual bank vulnerabilities but enhances financial stability by decreasing systemic risk.

While most of the empirical literatures are focused on the relationship between market structure, banking structure and financial stability using the prior and novel metrics to take into account the macro-prudential framework, our investigation relies on the Fallacy of Composition. Most fundamentally, the global financial downturn revealed the fallacy of composition that strong individual financial institutions collectively ensure the safety and the soundness of the entire system. The assessment and improvement of the resiliency of financial system as a whole go through the introduction of a Macro-prudential framework for assessing the banking risks. If there is no consensus about the systemic risk measures, we can observe that some indicators of systemic risks are especially macro-prudential measures while others are micro-prudential instruments calibrated to macro-prudential level. This latter is the subject of our attention. This study empirically addresses the traditional and current debate about the relationship between individual bank soundness and financial stability. Indeed, if the crisis highlighted the fallacy of composition, we question whether bank-individual soundness does not contribute to a better resilience of the global financial system.

The underlying aim is to no longer exclusively focus on the individual bank risk-taking and the systemic risk contribution. We also intend to justify the calibration of micro-prudential instruments for macro-prudential purposes, by taking into account individual factors that cause systemic instability. In other words, the regulation purpose is to calculate the systemic risk externalities to eliminate the systemic risk incentives. An outstanding example is the implementation of an additional capital charge for institutions deemed SIFIs. To the best of our knowledge, we are the first study to address both the bottom-up and top-down approaches in the financial stability analysis. The assumption being that the sum of the risks borne by financial institutions does not reflect the global risks borne by the entire system, but it is an important addition. Even if the individual risk contributes to the financial system vulnerabilities, it remains suboptimal because of the endogenous nature of risks. Thus, the financial soundness indicators should be considered in a macro-prudential logic for better efficiency of regulation. The latter should be an optimal mix of micro- and macro-prudential policy.

In light of this backdrop, the present study investigates whether or not individual bank risk-taking is more conducive to financial instability. Our sample consists of 83 banks from 17 European Union countries' members, with annual frequency data over the 1999-2013 periods. From an empirical perspective, our dual dimensions of risk require different instruments. First, we proxy bank individual risk with an accounting popular measure: The so-called Z-score (firstly developed by Roy, 1952). This indicator is an inverse proxy of risk: A larger value indicates a higher individual bank soundness and a lesser bank risk-taking. Second, we proxy for Systemic Risk by following Acharya and al.,(2012) which use a dynamic conditional correlation model with fat idiosyncratic tails to estimate the systemic risk: The so-called SRISK. Basically, the SRISK can be described as a bank contribution to the deterioration of the capitalization of the financial system as a whole during a financial turmoil. Owing to the existence of several metrics, the following elements have led us to choose the SRISK: 1) large acceptation, 2) large diffusion, 3) easy to implement because of public data, 4) easy interpretation, 5) global measure of systemic risk, and 6) bank-specific risk measure.

We extract annual information on consolidated financial statements from Bankscope and daily stock market data from Datastream (quarterly data on liabilities and market capitalisation are provided by Datastream to compute our systemic risk measure). We only use banks that collect deposits in order to impose a financial intermediation approach and to capture a particular business model: the universal bank model.
Our analysis has to overcome some important challenges. Firstly, we only use listed banks in our sample excluding many banks, sometimes significant. Secondly, the exclusively use of Monetary Financial Institutions (MFIs) also excludes an important source of systemic vulnerabilities: the shadow banking. Thirdly, we take into account a large number of delisted banks in our sample, because these events are associated with changes in ownerships, business strategies and risks. Fourthly, the use of consolidated data implies that parent company remains responsible of its subsidiaries. Finally, there is a caveat about the measurement of systemic risk because it is still in its infancy (Hansen, 2012).

Through a 2SLS model to correct the observed endogeneity between the individual risk, measured by the Z-score (Beck and al., 2013) and the SRISK (Acharya and al., 2012); our strong empirical results suggest that riskier banks contribute more to Systemic Risk. Thus, individual bank soundness increases the banking system resilience to potential shocks. On the one hand, this finding seems to challenge the traditional bottom-up approach. Indeed, our outcome emphasizes the fallacy of composition prior the crisis. Nevertheless, it shows that even if the sum of the risks borne by financial institutions does not reflect the global risks borne by the entire system, it is an important addition. On the other hand, this result justifies the calibration of micro-prudential tools for macro-prudential purposes; taking into account individual factors that are sources of systemic instabilities and a part of individual risk-taking.

The use of both individual and systemic risk measures must not be viewed as a discrepancy because the two indicators do not share the same dimension. Whereas the Z-score refers to a partial equilibrium approach, describes the risks internalized by the bank, and relies on bottom-up approach, the SRISK refers to a general equilibrium approach, describes the risks externalized by the bank and relies on top down approach. Our outcome can be explained by economic theory. Since the mid-70s, an extensive reform under the 3D policy so-called “Financial globalisation” led to deep changes in the financial system, including a spectacular restructuring of the banking industry. The increased competition led to a loss of the franchise value. Banks were incited to increase individual risk-taking in order to rebuild their margins, leading to higher individual and global fragilities. This is consistent with the traditional “competition-fragility” viewpoint, widely documented in the literature through the following studies: Marcus, 1984; Keeley, 1990; Demsetz and al., 1996. Among recent studies, we can quote Berger and al., 2009; Ariss, 2010; Fungáčová and Weill, 2013, Anginer and al., 2013. Moreover, financial engineering encouraged the increased interconnections between bank and non-bank financial intermediaries, spreading the risk across the system. Thus, excessive diversification of bank portfolios has led to a higher correlation between asset and market returns, with institutions becoming more similar to each other. Consequently, the global risk could not be treated at the individual level, but this latter is an important addition. According to Acharya and Yorulmazer (2006), Acharya (2009), banks invest in correlated assets because they do not internalize the costs of a joint failure. All this items emphasized the fallacy of composition.

These findings are important to the current policy debate on financial structure and regulation, in particular for Monetary Financial institutions (MFIs). More specifically, our results are consistent with the Basel III regulatory framework, which introduces the macro-prudential concept in risk management to ensure the stability of the entire system. We have shown that riskier banks contribute more to systemic risk. Thus, a relevant measure of systemic risk should take into account microeconomic factors of instability. These outcomes support the path that micro-prudential and macro-prudential regulations must be complementary and not substitutable. A policy mix is therefore desirable. According to Wagner's theoretical model (2010), the willingness to reduce portfolio risks has led banks to take excessive diversification strategies. Nevertheless, diversification reduces each institution's individual probability of failure, but exacerbates systemic risk, with an increased likelihood of systemic disruptions. Thus, prudential regulation must arbitrate between two types of fragilities and not neglect an aspect. The exclusive consideration of microeconomic factors implies a rejection of the endogenous nature of the risks. While the exclusive consideration of macroeconomic factors leads to an omission of microeconomics factors that are potential sources of systemic instability. It must be emphasized that systemic risk remains misunderstood and its measuring tools are still ongoing.

The remainder of our paper is structured as follows. Section 2 describes the data and provides an overview of the variables employed in our analysis. In section 3, we present the econometrical approach. Section 4 summarizes the results from estimations and checks the robustness. Concluding remarks are contained in the final section.

2. The data

This section describes data on banks' systemic and individual risk. As well as other bank-specific factors used in this study. We also provide some details concerning the composition of our sample. As outlined in the previous section, we use the SRISK as our key measure of systemic risk, and we employ the Z-score as our main indicator of individual risk.

We use consolidated bank statements. This choice is in line with a relevant economic concept: An internationally active bank takes decisions on its worldwide consolidated assets and liabilities. This approach is also motivated by the fact that systemic institutions are typically measured at the group level. Nevertheless subsidiary banks are included in the sample if parent banks are not publicly traded. Our sample is restricted to publicly-listed banks to ensure relatively high data quality and to enhance comparability across countries. Moreover, the systemic risk indicator used in our investigation relies on market data. During the recent financial turmoil, large Universal banks have particularly underperformed (LiiKanen, 2012) and most enjoyed implicit subsidy by massive taxpayer bail-outs and cheap funding costs. Largest banks tend to be listed and international. They have important share of assets and liabilities in foreign subsidiaries and branches.

"*In these instances, the home-country fiscal authorities remain responsible wholly or in part for insuring the bank's liabilities and for paying for any bail-out. In the European Economic Area (including the European Union, Iceland, Liechtenstein, and Norway), bank deposits located at foreign branches are formally covered by the deposit insurance scheme of the home country, according to the EU directive on deposit insurance adopted in 1994. Furthermore, the EU directive on the reorganization and winding-up of credit institutions adopted in 2001 requires that domestic and foreign bank creditors are treated equally in bankruptcy proceedings, preventing selective bail-outs of only 8 domestic bank liability holders. The distinction between foreign branches and subsidiaries in practice is often blurred, as international banks "(Demirgüç-Kunt and Huizinga, 2010).*

We apply a number of selection criteria to arrive at our sample. Firstly, we select the listed and delisted banks for our investigation. Secondly, we use consolidated bank statements and we delete the unconsolidated entries of the group from the sample to avoid double counting. Thirdly, we restrict our analysis to deposit-taking institutions in order to capture a particular business model: universal banks model. It is also a simplest way to impose an approach by banking financial intermediation. Our sample consists of Commercial Banks, Saving Banks, Bank Holding Companies, Mutual and Cooperative Banks. Fourthly, we delete banks that report information for fewer than three consecutive years, because our individual risk is computed over rolling windows of three years. Fifthly, we drop all banks for which most observations on control variables are not available.

Balance sheets and income statements data are taken in Euro currency. Outliers are identified and removed by filtering-out observations below the 1 percentile and above the 99 percentile, in particular for the solvency ratio (Tier 1 ratio).

We end up with a sample of 83 banks from 17 countries. Our sample effectively covers the whole universe of European Union publicly traded banks for which data are available from Bankscope. Among these banks, most were identified as Systemically Important financial institutions (SIFIs) by the Basel Committee. Table A provides more information about the banks included in our sample as well as their country of origin and the number of large banks by country. The total assets of the 83 banks at the end of 2013 were € 24 trillion, which represents approximately 74% of all domestic credit institutions in European Union. The data have annual frequency and the sample includes major European international banks. It covers a period of 15 years from 1999 to 2013. This time range spanning different economic cycles, a wave of consolidation and the global financial crisis.

The bank-level financial statements are derived from the Bankscope Database. There are two major benefits to use this data source. Firstly, the coverage of banking data accounts a significant share of banks' total assets in each country. Secondly, the information at the bank level is highlighted in standardized formats, after adjusting for differences in accounting and reporting standards across countries.

Nevertheless, there are some limitations to the use of publicly available data. On the one hand, the lack of granularity in balance sheet: the detailed breakdown of loan portfolio' exposures by category, grade, maturity or currency is not available. Moreover, securities portfolios are not segregated by assets class, or by maturity. Unfortunately, Bankscope does not provide information on the size and the composition of bank's off-balance sheet activities that are re-intermediated if financial disruptions occur. In the case of derivatives, banks are not engaged on the business volume but on the notional. For example, when real estate damages occur, the value of property is taken into account, not the contribution of the protection buyer. Therefore, this latter should be added to banks' absolute and systemic size. On the other hand, the relatively richer information are available on bank liabilities: Deposits are classified by type and non-deposits funding are classified according to their maturities (short-term versus long-term).

Daily market data and market capitalization, crucial to compute our Systemic Risk measure are extracted from Datastream. Unlike to "Yahoo Finance", this database provides information on a larger sample of banks. Quarterly data on bank liabilities, essential to compute our systemic risk measure, are also retrieved from this latter. If currency conversions are required, we use "Bank of France" database which provides the daily and monthly exchange rates between currencies. A full list of variable definitions, data sources and expected signs is given in the Appendix.

Before the mid-2000s, many countries used the local General Accepted Accounting Practices (GAAP) as accounting standards. In order to harmonize the presentation, clarity and comparability of financial statements, the International Accounting Standards Board has implemented the International Financial Reporting Standards (IFRS), mainly for publicly-traded banks. However, this change in accounting standards had a noticeable impact on banks' balance sheets and income statements. For example, under IFRS accounting standards, derivative assets and liabilities are not netted, increasing banks size. Our analysis may face to bias due to the change in accounting treatment. We follow some studies that introduced a year dummy variable to avoid biases due to the change in accounting treatment.

2.1 Estimating Systemic Risk

The global financial crisis and its avatars highlighted the endogenous nature of risks widely viewed in the economic literature as exogenous. Consequently, there was a raise of macro-prudential policies to contain the systemic risk.

What about systemic risk? The systemic risk concept appeared for the first time with the bankruptcy of Herstatt Bank in 1974. Mainly located in the foreign exchange market, it highlighted the dramatic consequences of the bankruptcy of a small Germany bank: leading to a paralysis of the New York's interbank payment system and a serious crisis on the foreign exchange market.

According to the European Central Bank (2010), Systemic Risk can be defined as a risk of financial instability insofar it adversely affects the effective functioning of the financial system and it significantly impairs the sustainable growth of economy and social welfare. This wording is large and highlights the first challenge of the systemic risk based on the shortcomings of its definition, and its multifaceted nature. Some studies pointed out specific mechanisms that are transmission canals of the systemic risk. Among these mechanisms we can quote: the impact on the real economy, disruptions in information flows and paralysis of markets, imbalances, feedback behaviours, negative externalities, asset bubbles, contagion, respectively underlined by the group of ten, 2001; Mishkin, 2007; Kapadia and al., 2012; FSB, 2009; Rosengren, 2010; and Moussa, 2011. Far from being exhaustive, this partial list of special drivers of systemic risk suggests that this latter is difficult to understand, define, measure and ultimately manage. Moreover, given the endemic nature of financial innovation, the complex and evolving nature of the financial system, we notice that systemic risk remains misunderstood. Can you manage what you cannot measure?

From Bisias and al., (2012), *"Moreover a single consensus measure of systemic risk can be Neither May nor desirable, as Maginot Such a strategy has blindsided surprise guests from gold Some Unforeseen newly emerging crisis mechanism. Instead, a robust framework for managing and monitoring financial stability must Incorporate Both a diversity of perspectives and a continuous process for re-Evolving Evaluating the structure of the financial system and systemic risk Adapting Measures to thesis changes ".*

In their survey, authors identify 31 quantitative measures of systemic risk. They emphasize the diversity of models and measures, sometimes competing and also highlight different aspects of systemic risk. Thus, there are several taxonomies based on data requirements, scope of supervision, decision horizon and research methodology. Although each approach is interesting, this study requires the use of a measurement based on the model sensitivity to capture a particular aspect of financial stability and granularity of data. The lack of publicly available data has popularized some measures of systemic risk based on market data. These are the measures of bank's contribution to aggregate risk borne by the entire system. Despite the fact that a systemic event remains a macro-prudential concern, these metrics have common features: 1) They are micro-prudential measures calibrated to macro-prudential level. 2) They have general purposes because they are not limited to specific sectors such as banking and housing, insurance and pension funds, or securities. 3) They depend on tail probability distributions. 4) They are cross-sectional.

The failure of one-factor linear models to explain all variations in the different estimates of systemic risk indicates that risk measures fail to capture the multifaceted nature of systemic risk. The choice of methodology to measure the systemic risk is related to the vector of instability that you want to capture. In this case, we want to take into account structural parameters. We follow the Financial Stability Board (2010) which highlights that a consistent and efficient measure of systemic risk should take into account the characteristics of financial institutions that amplify financial vulnerabilities such as size, leverage, liquidity, interconnection, complexity and substitutability of services. The SRISK developed by Acharya, Engle and Richardson (2012); and the CES developed by Banulescu and Dumitrescu (2015) turn out to be the best indicators for two reasons: 1) they are hybrid measure, which combines the Too Interconnected to Fail and the Too Big to Fail logics. 2) They encompass the popular Marginal expected shortfall. Nevertheless, we use the SRISK in our investigation to compute the systemic risk because it is the most appropriate indicator. This measure presents several advantages. First, in contrast to the aforementioned CES approach, it takes into account the size and the leverage of financial institutions. Second, it is expressed in monetary terms and appears to have good economic interpretations. Thus, international comparisons are possible. Third, it computed at a daily frequency with no cost. Fourth, Brownlees and Engle (2016), show that the SRISK provides useful rankings of systemic institutions at various stages of the crisis. Additionally, the aggregate SRISK is an early warning signal of distress in indicators of real activity.

During the crisis, we observed an increase in the banking resolution costs due to the inaccuracy in the identifying of risk factors, indecisiveness about the method to be adopted, and also due to the boundaries of instruments available to regulators, extending the reaction time of competent authorities. The assertion which supports the thought, "forewarned is forearmed" is relevant from a regulatory viewpoint because the anticipation of impending threats due to the onset of growing imbalances enables a consistent response once a crisis occurs.

A key issue for regulators is the identification of the so-called Systemically Important Financial Institutions (SIFIs) in order to implement strategies to ensure the financial stability. The SRISK appears to be an ex-ante indicator; it could be substituted to the stress tests performed by regulators (Dodd Frank Act, 2010) to assess the capital adequacy of financial institutions. The SRISK measure allows an analysis of the system behaviour under specific counterfactual conditions that are probability distributions associated with systemic events. Indeed, a key concern for regulators is the identification of the so-called Systemically Important Financial Institutions (SIFIs) to implement strategies to ensure the financial stability. Table D shows the top 20 banks according to their systemic risk contribution over four periods. Among this 20 banks identified as Global Systemically Important Banks (G-SIBs), 12 were included in the G-SIBs list published by the FSB and the Basel Committee on Banking Supervision (BCBS)[2] in 2014. All others are Non-European banks, apart from Standard Chartered Bank.

The SRISK can also be viewed as an ex-post risk measure. There is a need to regulate ex-post financial institutions, but more important is ex-ante regulation to prevent the occurrence of systemic crisis.

[2] http://www.fsb.org/wp-content/uploads/r_141106b.pdf

The main drawback of the SRISK measure is that it assumes that the liabilities of financial institutions are constant over a quarterly period of time. This assumption is the fact that the SRISK measure combines high frequency market data (daily stock prices and market capitalization) and low frequency balance sheet data (quarterly leverage).
The so-called SRISK, originally proposed by Acharya and al. (2012) corresponds to the expected capital shortfall of a given financial institution, conditional on a crisis affecting the entire system. The failure of a firm to honour its commitments due to its undercapitalization is insignificant when other institutions can provide this function. The question arises when the bank failure occurs when the capital as a whole is low. This causes the paralysis of markets and intermediation activities, and also leads to strong negative externalities for the economy (Acharya and al., 2010). Therefore, the contribution of each financial institution to the systemic risk is gauged through its expected capital shortfall. The financial institutions with the largest capital shortfall are assumed to be the greatest contributors to the risk borne by the entire system. Higher values of our SRISK measure imply a higher individual contribution and more systemically risky institutions. The SRISK is defined as:

$$SRISK_{i,t} = \text{Max}\left[0; [kL_{i,t} - 1 + (1-k)LRMES_{i,t}]W_{i,t}\right]$$

Where k is the minimum fraction of capital each firm needs to hold (i.e., prudential capital ratio of 8 percent), $L_{i,t}$ is the book value of total liabilities, and $W_{i,t}$ is the market capitalization or market value of equity. $LRMES$ is the long-run marginal expected shortfall. It corresponds to the capital shortfall of a firm i conditionally on a market drop of 40% over the following six months. It aims to capture the interconnection of a firm with the rest of the system.

$$LRMES \simeq 1 - \exp(18 \times MES_{i,t})$$

The SRISK is an extension of the marginal expected shortfall (MES) proposed by Acharya and al. (2017). This key component of our SRISK measure can be defined as the tail expectation of the firm's equity return conditional on a market decline beyond a threshold C.

$$MES_{it} = E_{t-1}(r_{it} | r_{mt} < C)$$

Where r_{it} and r_{mt} respectively denote the return of firm i at time t and the market return at time t. C is the threshold of the decline in market index or the Value-at-Risk at α%.

The MES is the one-day loss expected if market returns are less than 2 percent. It can be defined as short-run expected equity loss of a financial firm conditional on the market taking a loss greater than the threshold.

The market return is the value-weighted average of all firm returns.

$$r_{mt} = \sum_{i=1}^{N} w_{it} r_{it}$$

Where N is the number of firms and w_{it} is the relative market capitalization of the firm i at the period t.

According to Gilbert and al., (2013), in period of financial turmoil, the consideration of interconnections as a disruptions vector is intensified in line with the “Too-interconnected-to-fail” paradigm (through the MES). Since the 2008 financial crisis, we observed strong similarities reaching 100% in the classification of systemic institutions based on the SRISK and liabilities. This observation is in line with the “Too big to fail” paradigm. Therefore, the SRISK can be viewed as a compromise between both paradigms.
The MES estimation requires the introduction of appropriate time series techniques. We use a multivariate GARCH-DCC model to compute the MES. We don’t have time-varying linear dependencies because our sample only includes European banking sector. According to Laeven and al., (2016); the negative values of SRISK provide information on the relative contribution of an institution to systemic risk, but we follow Acharya, Engle, and Richardson (2012) and restrict SRISK to zero. We obtain a daily measure of our systemic risk (SRISK) that we annualize.

2.2 Estimating Individual Risk

Until the recent financial crisis that peaked in 2008, there was a consensus regarding prudential regulation, focused on individual risks. Thus, the sum of the risks borne by financial institutions reflected the global risks borne by the entire system. This fallacy of composition was based on a micro-prudential approach and was part of bottom-up logic.

Academic literature on this issue flourished and two popular indicators of bank risk-taking were commonly used as financial stability indicator; namely the Z-score and Distance-to-Default. Although most studies use the Z-score to measure bank risk-taking, both indicators turn out to be conceptually very close and largely differ in their construction. Havranek and Zigraiova (2015) collect 598 estimates from 31 studies published between 2003 and 2014, and show that 45% of reported estimates in the literature are calculated using the Z-score as a proxy for bank stability.

According to Gropp, Vesala and Vulpes (2004), the useful indicators for supervisors and policymakers must be early signals of increased vulnerabilities, and warnings of increased probability of default. Thus, the Z-score and the Distance-to-Default appear to be robust because in the following cases: 1) A decrease in assets value, 2) A higher volatility of assets, and 3) A higher leverage; they indicate an increased fragilities. However, through a matrix 4*2 emphasizing system features, Čihák and al. (2012) introduce the Z-score as the best proxy to capture global stability to financial institutions level.

We use the Z-score previously developed by Roy (1952). It is an accounting-based risk measure generally viewed in the banking literature as a measure of bank soundness (see, e.g., Boyd and Runkle, 1993; Craig and Santos, 1997; Boyd and De Nicolo, 2005; Cihak and Hesse, 2007; Demirgüç-Kunt and Detragiache, 2011; Laeven and Levine, 2009; Lepetit and Strobel, 2013; Fu et al., 2014). The Z-score indicator is inversely related to the probability of a bank's insolvency. A higher Z-score implies a lower probability of insolvency and lower risks. It is summarized as follows:

$$Z\text{-}score_{it} = \frac{\mu ROA_{it} + CAR_{it}}{\sigma ROA_{it}}$$

Where ROA_{it} is the return on assets, CAR_{it} is the ratio of Equity to total assets, and σROA_{it} is the standard deviation of return on assets.

This wording shows that the Z-score combines in one single indicator the bank profitability, bank capital and return volatility. From a statistical point of view, the Z-score indicates the critical threshold of standard deviations below which the collapse of bank returns wipes out all equity and led to bank insolvency (Boyd and Runkle, 1993). From an economic viewpoint, the Z-score measures the probability that a bank becomes insolvent due to a decline in its assets value below its debts value.
We follow Beck and al., (2013) that use a three-year rolling time window to compute the standard deviation of return assets rather than the full sample period. However, the return on assets and the equity to total assets ratio are contemporaneous. This approach has two main advantages. Firstly, it avoids that the variation in Z-scores within banks over time is exclusively driven by variation in the levels of capital and profitability (Schaeck and Cihak, 2010). Secondly, given the unbalanced nature of our panel dataset, it avoids that denominator is computed over different window lengths for different banks. In the regressions, we use ln(1+ Z-score) as a measure of bankruptcy predictions because the Z-score is highly skewed and we want to smooth out higher values and also avoid truncating it to 0.
The summary statistics of regression variables are reported in Table 1. We observe that the Z-score shows a low variation (-3.255 to 6.336) for large set of banks in different European countries and over time. The average value of Z-score is slightly below 3.5, with a standard deviation of 1.023.

2.3 Bank-specific data

Banks-specific data which reflect pre-crisis and post-crisis conditions were identified in the literature. Among them, we can quote: bank size, bank capitalization, bank funding structure and bank activities (Liikanen, 2012; Laeven and al., 2016).

Bank size: Absolute and Systemic Size

The recent financial crisis has triggered a debate on the optimal banks size, because banks have increased substantially over the last two decades, giving rise to financial giants that combine lending and trading activities and more engaged in market-based activities. Many studies justified "the race for size" in the banking sector by scale and scope economies. However Berger and Mester (1997) underline that bank size is beyond the line of economic efficiency. Why this race for size? According to Demirgüç-Kunt and Huizinga (2010), one reason could be the increased sensitivity of executive compensation to bank size. Another reason could be the benefits of funding costs they derive from “Too big to Fail”. There are doubts about the country ability to bail these large systemic banks due to the significant pressure on public finances in case of financial distress.

The race for size has been encouraged by the existence of too big to fail subsidies, leading to excessive risk-taking by banks. A key concern for regulators is the identification of Systemically Important Financial Institutions, so-called SIFIs for better resolution and contingent capital requirements (Farhi and Triple, 2012; Kashyap, Rajan, and Stein, 2010; and

Stein, 2013). The Basel III agreements advocate incremental measures such as an additional surcharge of up to 2.5% capital on large banks due to the negative externalities they generate. Using a sample of 412 deposit-taking institutions from 56 countries, Laeven and al., (2014) show that systemic risk increases with bank size.

We use two proxies which reflect absolute and systemic size. This distinction was emphasized by Demirgüç-Kunt and Huizinga (2010), which show that the bank value (Market-to-book ratio) increases with absolute size and decreases with systemic size. Thus, large banks face to a conglomerate discount of 22.3% due to their systemic size. They also have strong incentives to reduce their size in order to remove the valuation discount. Ceteris paribus, the decrease of bank's systemic size will allow a decrease in the bank absolute size, leading to a lower premium received. This latter being estimated in average at 34%. On the one hand, the systemic size allows to emphasize the rapid growth of bank liabilities to GDP; and on the other hand, it illustrates a common practice which consists to extend banks-deposit insurance to total bank liabilities by bail-outs

Bank capitalization: The Tier 1 Ratio

In the mid-80s, the Basel Committee on Banking Supervision (BCBS) introduced a risk management approach for the capital regulation in order to evaluate the safety and the banks soundness. Both, regulators and researchers tried to improve the bank's ability to deal with credit and market risks in the unstable financial environment.

However, the global financial crisis revealed the weaknesses associated with the risk-weighted capital framework (Brei and Gambacorta, 2015). At the earliest signs of disturbances, the solvency ratio showed its shortcomings because banks were undercapitalized. This popular ratio found to be pro-cyclical, manipulated (Internal risk models), difficult to measure and verify due to its complexity and the opacity of the risk weighting methods (Mariathasan and Merrouche, 2014).

The porosity between illiquidity and insolvency during the financial turmoil has led to an improvement of capital requirements in order to strengthen banks' resilience to potential shocks. Basel III allowed a strengthening of solvency ratio (The Tier1 ratio) and introduced a new measure of capital adequacy (the non-weighted leverage ratio). Some studies investigated the effectiveness of the leverage ratio and risk-weighted ratio in predicting bank risks. These found that the Tier 1 ratio which is the risk-weighted capital does not significantly predict default risk, contrary to the non-weighted leverage ratio which is a better predictor (Blundell-Wignall and Roulet, 2013; Demirgüç-Kunt and al., 2013).

Bank funding structure (Deposit ratio) and Bank activities (Loans ratio, Non-interest income, Trading, Derivatives, Diversification ratio)

Financial globalization has increased competition between banking and non-banking financial intermediaries. Over the years, the share of deposits and equity, respectively relative to total bank assets has steadily decreased. In contrast, the share of others sources of funding has continued to grow: thus, banks became dependent on wholesale funding liquidity. How banks do they fund? In our study, we use the Deposit ratio which is a source of stable funding to understand the bank's funding structure. Traditional banks activities are vital for economy, they are generally provided by retail banks that collect deposits. These are based on customer relationship and net margin is the main source of profit of retail banks.

Due to weak lending income (economic agents with a preference for holding securities) and to rebuild their margins, banks have invested in more profitable activities: trading and derivatives. During the pre-crisis period, the share of net income typically associated with traditional banking activities decreased, while the share of other income sources increased with significant differences between states and banks. This reflects differences in business models. Nonetheless, based on Markowitz (1959), the yield is an increasing function of risk. According to Demirgüç-Kunt and Huizinga (2010), the expansion of activities generating non-interest income led to increased risk diversification but at very low levels, beyond which predominate the inefficiencies associated to induced risks.

The analysis of non-interest income gives us a glimpse of the importance of non-traditional activities in the bank balance sheet. Although certain non-interest incomes are not related to market activities, this measure remains a good proxy. When we simultaneously observe a lower share of loans and a high share of noninterest income, this reflects an increased involvement of banks in market activities.

In our study, diversification reflects the focus of a bank on its traditional intermediation activities. According to the modern portfolio theory (Markowitz, 1959; Sharpe, 1964), diversification optimizes the efficiency of a portfolio through risk pooling. From this concept, the assumption that diversification is conducive to financial stability was widespread as evidenced by Diamond, 1984; Boyd and Prescott, 1986. However the financial crisis revealed that over-diversification leads to homogenization of bank portfolios making them more vulnerable to systemic risk, which is not diversifiable (Acharya, 2009; Goldstein and Pauzner, 2004). Indeed, in a context of deep markets, financial institutions become so large that their portfolio is ultimately a market approximation. In addition, common exposures become excessive making them very vulnerable to systemic fragilities. Thus, there is an endogenous shock and a lack of diversity of diversified portfolios (Haldane, 2010).

3. Econometric strategy

In this section, we examine econometrically the relationship between banks' systemic risk and individual risk.

Standard measures of individual risk such as VaR, volatility, expected losses, were ineffective as early warning signals to forecast the Great Recession. In addition, measurements of systematic risk such as covariance, beta, had low explanatory and predictive powers. Thus, facing the negative externalities suffered by the real economy, as well as the increasing of moral hazard due to the spectacular bankruptcies and significant losses incurred by financial institutions, one priority: contain the systemic risk because financial system is vulnerable to macroeconomic shocks.

Using market and accounting data, we follow Acharya, Engle and Richardson (2012), to construct our systemic risk measure, while the individual risk is directly computed from banks' balance sheet and income statement. Our baseline specification takes the following form:

$$SRISK_{i,t} = \alpha + \beta_1 Zscore_{it} + \sum_{k=1}^{n} \gamma_k X_{it} + \lambda Dummy_{it} + \theta_i + \delta_t + \varepsilon_{it}$$

Where i and t are respectively bank and time period indicators. $SRISK_{i,t}$ represents one of our measures of systemic risk. $Zscore_{it}$ is the individual risk. The vector X_{it} comprises a parsimonious set of bank control variables. θ_i is an individual specific effect, δ_t is an unobserved time effect included to capture common time-varying factors, and ε_{it} is the random error term. $Dummy_{it}$ indicates the change in accounting treatment. It is equal to 0 if the bank uses accounting standards "GAAP" and it is equal to 1 as soon as bank adopts "IFRS" standards.

Our sample is an unbalanced panel data with cross-sectional and time-varying dimension. This sample is composed of 83 banks over the period 1999-2013. These banks have different sizes and nationalities; the heterogeneity issue of data is acute. Moreover, examining whether the individual bank risk-taking contributes to the systemic risk raises the question of endogeneity bias.

More specifically, bank's soundness affects the stability of the entire system and financial stability is crucial for banks' individual health. This reverse causality could eventually introduce an estimation bias, even if the direction is ambiguous. We use the Durbin-Wu Hausman specification test developed by Durbin, 1954; Wu, 1973, and Hausman, 1978; to address the problem of endogeneity. This test evaluates the consistency of an estimator to a less efficient alternative, but known to be consistent (OLS). We reject the null hypothesis and we conclude that there is a problem of endogeneity. Thus, the use of a 2SLS approach is consistent. The existence of an endogenous bias is supported by the endogeneity tests in Tables 3 and 4. Moreover, the Granger Non-causality test in Heterogeneous Panels, implemented by Dumitrescu and Hurlin (2012) emphasizes a bidirectional causality between systemic and individual risk. Most studies used the lagged explanatory variables as a common strategy to face the challenges of causal identification; however, this latter could lead to incorrect inferences (Bellemare, Masaki, Pepinsky, 2015). To address this potential endogeneity issue, we use Dynamic panel data models. We consider an instrumental variable (IV) approach using the two-stage least squares estimator (2SLS). We consider three instrumental variables: Cost to income, Overheads cost and Net income to Risk Weighted Assets. In this investigation, we are interested in the sign and significance of the estimated coefficient β_1.

Although the instrumental variables method allows to deal with problems of endogeneity and measurement error, it bring additional challenges of bias and precision. Indeed, it may be difficult to find variables that can serve as valid instruments (the excluded instruments should be correlated with endogenous regressors, but uncorrelated with the disturbances). For this reason, we conduct several tests to gauge the validity of our instruments. Among these: Sargan-Hansen test of overidentification restrictions, underidentification test, redundancy test and endogeneity test. These are all valid.

The shortcomings of an instrumental variable approach lead us to check the robustness of our estimates. We implement three different robustness tests. First, we use the MES restricted-form as alternative measure of SRISK and the two-stage least squares estimator. Second, we use the LSDV approach with the lagged explanatory variables and Country Fixed Effects. Finally we implement the GMM approach (Arellano and Bond, 1991). However, we use the upgraded version developed by Blundell and Bond (1998) to both take into account the difference and level equations. The GMM estimator is a second best identification strategy compared to IV approach in case of endogeneity of the explanatory variables. We assume that systemic risk at time t is related to systemic risk at time t-1. This specification takes the following form:

$$SRISK_{i,t} = \alpha + \beta_1 SRISK_{i,t-1} + \beta_2 Zscore_{it} + \sum_{k=1}^{n} \gamma_k X_{it} + \lambda Dummy_{it} + \theta_i + \delta_t + \varepsilon_{it}$$

4. Results

In this section, we present the results of our empirical analysis. We successively highlight the estimated effects of individual risk on systemic risk, with bank-specific indicators as control variables. The results have a great interest from a perspective of economic policies / regulation. The last sub-section will present the results from a series of robustness tests.

4.1 Main results: Individual risk and systemic risk

Table 3 shows the estimated effects of individual risk-taking on systemic risk over the period 1999-2013. Various regressions are detailed, all derived from our previous regression specification. Column (4) includes only medium banks (i.e., banks whose assets are included in the closed interval € [1-100] billion). Column (5) includes only large banks (i.e., banks with assets in excess of € 100 billion). Other columns report results for all banks in the sample.

All regressions are estimated with an instrumental variable (IV) approach, using the two-stage least squares estimator (2SLS) with fixed-effects. We consider three instrumental variables: Cost to income, Overheads cost and Net income to Risk Weighted Assets. We check the validity and the reliability of our instruments from the overidentification test (Hansen J test), the underidentification test, the redundancy test and the endogeneity test. All instruments are valid and the model is correctly specified with valid F-stat and R-squared higher than 40 percent.

In this investigation, we are interested in the sign and significance of the estimated coefficient β_1. For all specifications, we can observe a negative and significant relationship between the Z-score and the SRISK. The Z-score indicator is inversely related to the probability of a bank's insolvency. A higher Z-score implies a lower probability of insolvency and lower risks. In other words, the lower the individual bank risk-taking (as measured by Z-score), the lower the systemic risk (as measured by the SRISK).

Our strong empirical results suggest that riskier banks contribute more to systemic risk. These findings are consistent with previous studies on the implementation of a macro-prudential framework (Hanson and al., 2010. Kashyap and al., 2011; Bisias and al., 2012). These results emphasize the fallacy of composition prior the crisis. Indeed, the sum of the risks borne by financial institutions does not reflect the global risks borne by the entire system, but it is an important addition. One explanation is the endogenous nature of risks. It is also the fact that the consideration of individual factors (size, leverage) that are potential sources of systemic fragilities in the computation of our systemic risk indicator allows to take into account a part of individual risk-taking.

The estimated effects obtained from our control variables are consistent with the Basel III regulatory framework. We find that Size per se is an independent factor that drives systemic risk. This result is consistent with the additional surcharge capital advocates by the Basel committee for large banks. Banks' addiction to stable funding sources (Deposits) less contribute to systemic risk while market-based activities contribute more to systemic risk (as measured by Noninterest income and trading). The solvency ratio fails to be a good capital cushion in order to increase the systems resilience to potential adverse shocks. This observation justify the implementation of leverage ratio which is not manipulated. However it could encourage the banks risk-taking due to non-weighted risks. Both the solvency ratio (Tier 1 ratio) and the leverage ratio are complementary and non-substitutable.

For our sample of large banks (column 5) systemic risk is driven by size and more trading activities. According to Boot and Ratnovski (2012), in deep markets with the time-inconsistency and risk shifting problems, market activities are more profitable and banks grow by turning away from their traditional activities, but do excessive investments in markets activities, leading to a capital misallocation. Thus, for medium and large banks we observe that the diversification ratio which reflects the focus of a bank on its traditional intermediation activities less contribute to systemic risk.

4.2 Robustness Tests

The shortcomings of an instrumental variable approach lead us to check the robustness of our estimates. We implement three different robustness tests. First, we use the MES restricted-form as alternative measure of SRISK and the two-stage least squares estimator with fixed effects (Table 4). Second, we use LSDV approach with the lagged explanatory variables and Country Fixed Effects (Table 5). However, LSDV approach is inconsistent in presence of endogeneity problems because even if we use the lagged explanatory variables, this issue may not solve. Finally we implement the GMM approach (Table 6). The GMM estimator is a second best identification strategy compared to IV approach in case of endogeneity of the explanatory variables.

For all specifications, we can observe a negative and significant relationship between the Z-score and the SRISK (Table 4, 5, 6). The Z-score indicator is inversely related to the probability of a bank's insolvency. Thus, riskier banks contribute more to the financial system vulnerabilities through the SRISK. The individual risk-taking as measure of the financial system soundness as a whole remains suboptimal because of the endogenous nature of risks. This finding is consistent with the fallacy of composition.

The results observed for the control variables are coherent with the Basel III regulatory framework.

5. Concluding remarks

In this paper we have examined the relationship between systemic risk and individual risk for a large set of European Union listed banks over the period 1999-2013. The increased involvement of banks in market activities is a fundamental changes which affected the banking and financial industry over the last decades with the growing and complex interactions between all market participants. Additionally, banks increased their size beyond the economically efficient point in order to become 'too big to fail,' and take advantage of cheaper funding. In a context marked by deep and internationalized markets, trading became scalable. The risk related to the entire system cannot be considered at the individual level due to its endogenous nature. The combination of all previous factors creates inefficiencies characterized by systemic weaknesses. If the banking sector was not the only source of vulnerabilities, he was at the heart of recent financial disturbances that peaked in 2008 and escalated into a full-blown economic crisis (Liikanen, 2012).

Our investigation relies on the fallacy of composition. Most fundamentally, the global financial downturn revealed the fallacy of composition that strong individual financial institutions collectively ensure the safety and soundness of the entire system. We examine whether the individual bank risk-taking affects the bank's contribution to the deterioration of the soundness of the system as a whole. In other words, we investigate if the individual bank soundness is more conducive to financial stability.

Our strong empirical results suggest that riskier banks contribute more to systemic risk. Thus, individual bank soundness increases the banking system resilience to potential shocks. On the one hand, this finding seems to challenge the traditional bottom-up approach. Indeed, our outcome emphasizes the fallacy of composition prior the crisis. Nevertheless, it shows that even if the sum of the risks borne by financial institutions does not reflect the global risks borne by the entire system, it is an important addition. On the other hand, this result justifies the calibration of micro-prudential tools for macro-prudential purposes; taking into account individual factors that are sources of systemic instabilities and a part of individual risk-taking.

We point out other significant findings. Size per se is an independent factor that drives systemic risk. Banks that more invest in market-based activities contribute more to systemic risk while the addiction on stable funding sources contributes more to financial stability. The solvency ratio fails to be a good capital cushion in order to increase the systems resilience to potential adverse shocks. These results are consistent with the Basel III regulatory framework, which advocates additional surcharge of up to 2.5% capital for large banks, the implementation of stress tests, liquidity and leverage ratios. The leverage ratio is complementary and not substitutable to the solvency ratio, because it encourages the banks risk-taking due to non-weighted risks.

To the best of our knowledge, we are the first study to address both the bottom-up and top-down approaches in the financial stability analysis. The assumption being that the sum of the risks borne by financial institutions does not reflect the global risks borne by the entire system, but it is an important addition. Even if the individual risk contributes to the financial system vulnerabilities, it remains suboptimal because of the endogenous nature of risks. Thus, the financial soundness indicators should be considered in a macro-prudential logic for better efficiency of regulation. The latter should be an optimal mix of micro- and macro-prudential policy. This paper takes a narrower approach and our findings are in line with previous studies on macro-prudential concept.

References

Acharya, V. V. (2009). A theory of systemic risk and design of prudential bank regulation. *Journal of financial stability*, *5*(3), 224-255.

Acharya, V., Engle, R., & Richardson, M. (2012). Capital shortfall: A new approach to ranking and regulating systemic risks. *The American Economic Review*, *102*(3), 59-64.

Acharya, V. V., Pedersen, L. H., Philippon, T., & Richardson, M. (2017). Measuring systemic risk. *Review of Financial Studies*, *30*(1), 2-47.

Acharya, V., Engle, R., & Richardson, M. (2012). Capital shortfall: A new approach to ranking and regulating systemic risks. *The American Economic Review*, *102*(3), 59-64.

Acharya, V. V., & Yorulmazer, T. (2006). Limited liability and bank herding. Mimeo, London Business School, 2006.

Aglietta, M., & Scialom, L. (2014). *For a renewal of Financial regulation Manufacturing Markets: Legal, Political and Economic Dynamics* (No. hal-01410758).

Allen, F., & Gale, D. (2004). Competition and financial stability. *Journal of Money, Credit, and Banking*, *36*(3), 453-480.

Anginer, Deniz & Demirguc-Kunt, Asli & Zhu, Min, 2012. "How does bank competition affect systemic stability ?," Policy Research Working Paper Series 5981, The World Bank.

Arcand, J. L., Berkes, E., & Panizza, U. (2015). Too much finance?. *Journal of Economic Growth*, *20*(2), 105-148.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*, *58*(2), 277-297.

Ariss, R. T. (2010). On the implications of market power in banking: Evidence from developing countries. *Journal of Banking & Finance*, *34*(4), 765-775.

Banulescu, G. D., & Dumitrescu, E. (2015). *Which are the SIFIs? A component expected shortfall approach to systemic risk*. *Journal of Banking & Finance*, *50*, 575-588.

Beck, T., De Jonghe, O., & Schepens, G. (2013). Bank competition and stability: cross-country heterogeneity. *Journal of Financial Intermediation*, *22*(2), 218-244.

Bellemare, M. F., Masaki, T., & Pepinsky, T. B. (2015). "Lagged Explanatory Variables and the Estimation of Causal Effects," MPRA Paper 62350, University Library of Munich, Germany, revised 23 Feb 2015.

Benoit, S., Colletaz, G., Hurlin, C., & Perignon, C. (2013). *A theoretical and empirical comparison of systemic risk measures. HEC Paris Research Paper No*. FIN-2014-1030.

Berger, A. N., Hancock, D., & Humphrey, D. B. (1993). Bank efficiency derived from the profit function. *Journal of Banking & Finance*, *17*(2), 317-347.

Berger, A. N., Klapper, L. F., & Turk-Ariss, R. (2009). Bank competition and financial stability. *Journal of Financial Services Research*, *35*(2), 99-118.

Berger, A. N., & Mester, L. J. (1997). Inside the black box: What explains differences in the efficiencies of financial institutions?. *Journal of Banking & Finance*, *21*(7), 895-947.

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, *87*(1), 115-143.

Blundell-Wignall, A., & Roulet, C. (2013). Business models of banks, leverage and the distance-to-default. *OECD Journal: Financial Market Trends*, *2012*(2), 7-34.

Bisias, D., Flood, M. D., Lo, A. W., & Valavanis, S. (2012). A survey of systemic risk analytics. *US Department of Treasury, Office of Financial Research*, (0001).

Board, F. S. (2009). Guidance to assess the systemic importance of financial institutions, markets and instruments: initial considerations. *Report to G20 finance ministers and governors*.

Board, F. S. (2011). Policy measures to address systemically important financial institutions. *On-line paper: http://www.financialstabilityboard.org/publications/r_111104bb. pdf*.

Boot, A. W., & Ratnovski, L. (2012). Banking and trading. *Amsterdam Law School Research Paper*, (2012-85).

Borio, C., (2003). Towards a macro-prudential framework for financial supervision and regulation?. *CESifo Economic Studies*, *49*(2), 181-215.

Borio, C., Furfine, C., & Lowe, P. (2001). Procyclicality of the financial system and financial stability: issues and policy options. *BIS papers*, *1*, 1-57.

Boyd, J. H., & De Nicolo, G. (2005). The theory of bank risk taking and competition revisited. *The Journal of Finance*, *60*(3), 1329-1343.

Boyd, J. H. *De Nicolò. G., Jalal, AM (2006), Bank Risk Taking and Competition Revisited: New Theory and New Evidence*. IMF Working Paper 06/297.

Boyd, J. H., & Prescott, E. C. (1986). Financial intermediary-coalitions. *Journal of Economic Theory*, *38*(2), 211-232.

Boyd, J. H., & Runkle, D. E. (1993). Size and performance of banking firms: Testing the predictions of theory. *Journal of Monetary Economics*, *31*(1), 47-67.

Brei, M. and Gambacorta, L. (2015). Are bank capital ratios pro-cyclical? New evidence and perspectives. 61st Panel meeting of Economic Policy, Bank of Latvia.

Brunnermeier, M. K., Crockett, A., Goodhart, C. A., Persaud, A., & Shin, H. S. (2009). *The fundamental principles of financial regulation* (Vol. 11). London: Centre for Economic Policy Research.

Brownlees, C. T., & Engle, R. (2012). Volatility, correlation and tails for systemic risk measurement. *Available at SSRN*, *1611229*.

Brownlees, C., & Engle, R. F. (2016). SRISK: A conditional capital shortfall measure of systemic risk. *Review of Financial Studies*, hhw060.

Chant, J. (2003). Financial stability as a policy goal. *Essays on financial stability*, Technical report 95, Bank of Canada.

Cihák, M. M., & Hesse, H. (2007). *Cooperative banks and financial stability*. IMF Working Papers 07/2,International Monetary Fund.

Čihák, M., Demirgüç-Kunt, A., Feyen, E., & Levine, R. (2012). "Benchmarking financial systems around the world," Policy Research Working Paper Series 6175, The World Bank.

Craig, B., & Dos Santos, J. C. (1997). The risk effects of bank acquisitions. *Economic Review-Federal Reserve Bank of Cleveland*, *33*(2), 25.

Crockett, A. (1997). Why is financial stability a goal of public policy?. *Economic Review-Federal Reserve Bank of Kansas City*, *82*(4), 5.

Crockett, A. (2000). Marrying the micro-and macro-prudential dimensions of financial stability. *BIS speeches*, *21*.

De Haan, J., & Oosterloo, S. (2006). Transparency and accountability of central banks in their role of financial stability supervisor in OECD countries. *European Journal of Law and Economics*, *22*(3), 255-271.

Demirgüç-Kunt, A., & Detragiache, E. (2011). Basel Core Principles and bank soundness: Does compliance matter?. *Journal of Financial Stability*, *7*(4), 179-190.

Demirguc-Kunt, A., Detragiache, E., & Merrouche, O. (2013). Bank capital: Lessons from the financial crisis. *Journal of Money, Credit and Banking*, *45*(6), 1147-1164.

Demirguc-Kunt, A., & Huizinga, H. (2010). Are banks too big to fail or too big to save?. *International Evidence from Equity Prices and CDS Spreads. World Bank Policy Research Working Paper*, *5360*.

Demsetz, R. S., Saidenberg, M. R., & Strahan, P. E. (1996). Banks with something to lose: The disciplinary role of franchise value. *Economic Policy Review*, *2*(2).

Diamond, D. W. (1984). Financial intermediation and delegated monitoring. *The Review of Economic Studies*, *51*(3), 393-414.

Dodd-Frank Wall Street Reform and Consumer Protection Act, Pub. L. No. 111–203, § 619, 24 Stat. 1376 (2010) (Dodd-Frank Act)

Dumitrescu, E. I., & Hurlin, C. (2012). Testing for Granger non-causality in heterogeneous panels. *Economic Modelling*, *29*(4), 1450-1460.

Durbin, J. (1954). Errors in variables. *Revue de l'institut International de Statistique*, 23-32.

European Central Bank (ECB), 2010, "Financial networks and financial stability," Financial Stability Review, 2010, 155–160.

Farhi, E., & Tirole, J. (2012). Collective moral hazard, maturity mismatch, and systemic bailouts. *The American Economic Review*, *102*(1), 60-93.

Financial Stability Board, 2010. *Reducing the moral hazard posed by systemically important financial institutions: interim report to G20 leaders*.

Fu, X. M., Lin, Y. R., & Molyneux, P. (2014). Bank competition and financial stability in Asia Pacific. *Journal of Banking & Finance*, *38*, 64-77.

Fungáčová, Z., & Weill, L. (2013). How market power influences bank failures: Evidence from Russia. *Economics of Transition*, *21*(2), 301-322.

Goldstein, I., & Pauzner, A. (2004). Contagion of self-fulfilling financial crises due to diversification of investment portfolios. *Journal of Economic Theory*, *119*(1), 151-183.

Gropp, R., Vesala, J. M., & Vulpes, G. (2004). Market indicators, bank fragility, and indirect market discipline. *Economic Policy Review*, Federal Reserve Bank of New York, issue Sep, pages 53-62.

Group of Ten, 2001, "Report on Consolidation in the Financial Sector: Chapter III. Effects of consolidation on financial risk. Bank for International Settlements: Basel, Switzerland.

Hall, A. R. (2005). *Generalized method of moments* (pp. xii+-400). Oxford: Oxford University Press.

Haldane, A. G. (2010). The $100 billion question. *Revista de Economía Institucional*, *12*(22), 83-110.

Hansen, L. P. (2012). *Challenges in identifying and measuring systemic risk* (No. w18505). National Bureau of Economic Research.

Hanson, S. G., Kashyap, A. K., & Stein, J. C. (2010). A macroprudential approach to financial regulation. *Chicago Booth Research Paper*, (10-29).

Hausman, J. A. (1978). Specification tests in econometrics. *Econometrica: Journal of the Econometric Society*, *46(6),* 1251-1271.

Hoggarth, G., Reis, R., & Saporta, V. (2002). Costs of banking system instability: some empirical evidence. *Journal of Banking & Finance*, *26*(5), 825-855.

Kapadia, S., Drehmann, M., Elliott, J., & Sterne, G. (2012). Liquidity risk, cash flow constraints, and systemic feedbacks. In *Quantifying Systemic Risk* (pp. 29-61). University of Chicago Press.

Kashyap, A. K., Berner, R., & Goodhart, C. A. (2011). The macroprudential toolkit. *IMF Economic Review*, *59*(2), 145-161.

Kashyap, Anil K., Raghuram Rajan, and Jeremy C. Stein, 2010, "Rethinking capital regulation," In: Federal Reserve Bank of Kansas City Symposium on Maintaining Stability in a Changing Financial System, 2008, pp. 431-471, Federal Reserve Bank of Kansas City, Kansas City.

Keeley, M. C. (1990). Deposit insurance, risk, and market power in banking. *The American Economic Review, 80(5)*, 1183-1200.

King, R. G., & Levine, R. (1993). Finance and growth: Schumpeter might be right. *The quarterly journal of economics, 108(3)*, 717-737.

Laeven, M. L., Ratnovski, L., & Tong, H. (2016). "Bank size, capital, and systemic risk: Some international evidence," Journal of Banking & Finance, Elsevier, vol. 69(S1), pages 25-34

Leroy, A., & Lucotte, Y. (2017). *Is there a competition-stability trade-off in European banking?.* Journal of International Financial Markets, Institutions and Money, 46, 199–215.

Liikanen, E. (2012). High-level Expert Group on reforming the structure of the EU banking sector. *Final Report, Brussels*, *2*.

Marcus, A. J. (1984). Deregulation and bank financial policy. *Journal of Banking & Finance*, *8*(4), 557-565.

Mariathasan, M., & Merrouche, O. (2014). The manipulation of Basel risk-weights. *Journal of Financial Intermediation*, *23*(3), 300-321.

Markowitz, H. (1952). Portfolio selection. *The Journal of Finance*, *7*(1), 77-91.

Mishkin, F. (2007). Systemic risk and the international lender of last resort. *BIS Review*, *109*, 1-7.

Moussa, A. (2011). *Contagion and systemic risk in financial networks* (Doctoral dissertation, Columbia University).

Pais, A., & Stork, P. A. (2013). Bank size and systemic risk. *European Financial Management*, *19*(3), 429-451.

Rosengren, E. S. (2010, March). Asset bubbles and systemic risk. In *remarks to the Global Interdependence Center's Conference on Financial Interdependence in the World's Post-Crisis Markets, Philadelphia*.

Roy, A. D. (1952). Safety first and the holding of assets. *Econometrica: Journal of the Econometric Society*, 431-449. Volume ?

Schinasi, G. J. (2004). Defining financial stability, IMF Working Paper No. WP/04/187, October.

Schaeck, K., & Čihák, M. (2010). Competition, efficiency, and soundness in banking: An industrial organization perspective. *European banking center discussion Paper*, (2010-20S).

Schoenmaker, D. (2011). The European banking landscape after the crisis. *DSF policy paper*, (12).

Sharpe, W. F. (1964). Capital asset prices: A theory of market equilibrium under conditions of risk. *The Journal of Finance*, *19*(3), 425-442.

Stein, J. C. (2014). Regulating large financial institutions. *What have we learned*, 135-142.

Vander Vennet, R. (2002). Cost and profit efficiency of financial conglomerates and universal banks in Europe. *Journal of Money, Credit, and Banking*, *34*(1), 254-282.

Vickers, J. (2012). Some economics of banking reform. *Rivista di Politica Economica*, *4*, 11-3

Wu, D. M. (1973). Alternative tests of independence between stochastic regressors and disturbances. *Econometrica: Journal of the Econometric Society*, 41(4), 733-750.

Appendix

Table A: Banks covered in our study.

Bank (83 banks)	Country	Large banks	Bank	Country	Large banks (43)
Erste Group Bank AG	AUT		National Bank of Greece SA	GRC	
Raiffeisen Bank International AG	AUT		Eurobank Ergasias SA	GRC	3
Bank für Tirol und Vorarlberg AG	AUT	3	Alpha Bank AE	GRC	
BKS Bank AG	AUT		General Bank of Greece SA	GRC	
UniCredit Bank Austria AG (Bank Austria Creditanstalt)	AUT		OTP Bank Plc	HU	0
Dexia SA	BEL	1	Bank of Ireland	IRL	
Deutsche Bank AG	DEU		Allied Irish Banks plc	IRL	3
Commerzbank AG	DEU	3	Permanent TSB Plc	IRL	
Hypo Real Estate Holding AG	DEU		UniCredit SpA	ITA	
Danske Bank A/S	DNK		Intesa Sanpaolo	ITA	
Jyske Bank A/S (Group)	DNK		Banca Monte dei Paschi di Siena SpA	ITA	
Sydbank A/S	DNK		Unione di Banche Italiane Scpa-UBI Banca	ITA	
Spar Nord Bank	DNK		Banca popolare dell'Emilia Romagna	ITA	
Vestjysk Bank A/S	DNK		Banca Popolare di Milano SCaRL	ITA	
BankNordik P/F	DNK		Banca Carige SpA	ITA	4
Laan & Spar Bank A/S	DNK		Banca Popolare di Sondrio Societa Cooperati	ITA	
Jutlander Bank A/S	DNK		Credito Emiliano SpA-CREDEM	ITA	
Nordjyske Bank A/S	DNK		Banca popolare dell'Etruria e del Lazio Soc. c	ITA	
Fynske Bank A/S	DNK	1	Banco di Desio e della Brianza SpA	ITA	
Oestjydsk Bank A/S	DNK		Banca Popolare di Spoleto SpA	ITA	
Skjern Bank	DNK		Banca Profilo SpA	ITA	
Salling Bank A/S	DNK		IW Bank SpA	ITA	
Nordfyns Bank A/S	DNK		Espirito Santo Financial Group S.A.	LUX	1
Totalbanken A/S	DNK		KBL European Private Bankers SA	LUX	
DiBa Bank A/S	DNK		ING Groep NV	NLD	
Sparekassen Fyn af 1846 A/S	DNK		Van Lanschot NV	NLD	3
Eik Banki P/F	DNK		SNS Reaal NV	NLD	
Selskabet af 1. september 2008 A/S	DNK		RBS Holdings NV	NLD	
Swedbank As	EE	0	Banco Comercial Português. SA-Millennium	PRT	1
Banco Santander SA	ESP		Banco BPI SA	PRT	
Banco Bilbao Vizcaya Argentaria SA	ESP		Nordea Bank AB (publ)	SWE	
Banco de Sabadell SA	ESP	4	Skandinaviska Enskilda Banken AB	SWE	4
Banco Popular Espanol SA	ESP		Svenska Handelsbanken	SWE	
Bankinter SA	ESP		Swedbank AB	SWE	
Aktia Bank Plc	FIN	0	HSBC Holdings Plc	UK	
OP Corporate Bank plc	FIN		Barclays Plc	UK	
BNP Paribas	FRA		Royal Bank of Scotland Group Plc	UK	
Crédit Agricole S.A.	FRA		Lloyds Banking Group Plc	UK	7
Société Générale SA	FRA	5	Standard Chartered Plc	UK	
Natixis SA	FRA		Arbuthnot Banking Group Plc	UK	
Crédit Industriel et Commercial SA - CIC	FRA		Bradford & Bingley Plc	UK	
			Santander UK Plc (Abbey National plc)	UK	

Note: Large banks have assets that exceed € 100 billion (up to 2 trillion) in one year.
Schoenmaker(2011) suggests that European banks can be split according to their size into three groups (Small, Medium and Large banks).
Small banks have assets of less than € 1 billion, while Medium banks have assets ranging from €1 billion to €100 billion.

Table B. Notes on Variables and Data Sources

Data	Description	Sources
Log(SRisk)	Measure of bank's individual contribution to systemic risk. It is computed as an extension of the MES to reflect the bank's commitments. It is a Long-run indicator.	Datastream(2014), BDF(2014) and Own Calculations
MES	Measure of bank's individual contribution to systemic risk. It is a Short-run indicator.	Datastream(2014), BDF(2014) and Own Calculations
Log(Z-score)	Ratio of the sum of equity capital to total assets and ROA to standard deviation of ROA (ROA is computed by Pre-tax Profit to Total Assets).	Bankscope(2014)
Log(Assets)	The logarithm of Total Assets reflect the bank's absolute size.	Bankscope(2014)
Tier 1 Ratio	Regulatory Tier 1 capital Ratio computed as ratio of regulatory Tier1 Capital to Risk Weighted Assets.	Bankscope(2014)
Deposits Ratio	Ratio of Total Deposits to Total Assets. .	Bankscope(2014)
Loans Ratio	Ratio of Net Loans to Total Assets. It is the primary role of the bank: the intermediation activity. It is based on collecting deposits and providing loans.	Bankscope(2014)
Noninterest	Other Operating Income to operating income	Bankscope(2014)
Trading	Trading represents the amount of Trading liabilities to total assets.	Bankscope(2014)
Derivatives	Ratio of Derivatives liabilities to total assets.	Bankscope(2014)
Diversification	Share of interest income squared plus the share of noninterest income squared. When the ratio is low the bank is diverse	Bankscope(2014)
Systemic Size	Total Liabilities to GDP. It is bank's relative value.	Bankscope(2014), WDI(2014)
Liquid Assets	Liquid Assets to Deposits and Short Term Funfing	Bankscope(2014)
Instruments:		
Overheads cost	Sum of Personnel expenses and Other operating expenses to Total non interest expenses	Bankscope(2014)
Cost to income	Overheads cost to Total income	Bankscope(2014)
Net income/RWA	Net Income to Risk-Weighted Assets	Bankscope(2014)

Note: GDP is defined as Gross Domestic Product corresponding to fiscal year. ROA is the Return on Assets. MES is the Marginal Expected Shortfall developed by Acharya et al. (2010). Log(Z-score)=Log(1+Z-score).

Table C. The expected impact of bank's individual soundness and control variables (Bank and Country level) on systemic risk

Data	Description	Expected Sign on Srisk
Log(Z-score)	Most stable banks contribute to the stability of the entire system if this soundness is driven by stable factors that aims to finance real economy (take deposits and provide credits). Nevertheless, when the bank's profitability is driven by a dependence to wholesale funding and investment in Short-Term and Risky activities, financial system is threatened because it becomes vulnerable to potential shocks. While risky activities are more profitable, they create dependencies in the system and reduce the bank's ability to deal with shocks.	+/-
Log(Assets)	Banks justify consolidation and concentration movements by economies of scale and economies of scope achievements. However, big banks are difficult to manage and supervise. This creates moral hazard problem and the capture of regulators. Absolute size provides to banks a "Too Big To Fail" status. According to some studies, average cost curve has a U-shape. This result confirms that the size of some banks is suboptimal.	+
Tier 1 Ratio	Regulatory Tier 1 capital Ratio is the core measure of a bank's financial strength from a regulator's point of view. Solvency is a major factor that can affect the risk. It's a capital cushion that enables banks to deal with any planned or not shocks. Individual banks are stronger when they are most capitalised; Tier1 avoids bank runs. However, their systemicity could be explained by banks' participation in activities which requiert high consumption of equities and its procyclicality.	+/-
Deposits Ratio	The financial crash of 2008 reflected banks' increasing reliance on short-term wholesale funding as means to grow their balance sheets. Banks' asset and liability structures are highly vulnerable to market shocks. Deposit ratio captures the bank's dependence on a stable funding source. it aims to limit excess maturity mismatch in the banking sector and reduce financial instability.	-
Loans Ratio	In the upper stage of the financial cycle, the period of high growth causes swelling of credit, an increase in banks' profitability and an improvement of banks'soundness. However, if this expansion is driven by weaknesses from financial engineering (Originate to distribute), risk transfer mechanisms alter the bank's core business (less incentive to reduce ex-ante or ex-post information asymmetries). In times of disruptions, these shortcomings lead to a surge in nonperforming loans, an uncertainty about risk allocation (due to interconnections it fuels) and contribute to financial instability.	+/-
Noninterest	Noninterest income allows the shift of banks toward market-based activities. It enables to relate a highly leveraged company, but few viable investment projects with another that offers investment opportunities but subject to credit constraints. More profitability and efficiency of the bank are expected; but time inconsistency and risk transfer problems encourages banks to invest more in risky activities. Large banks contribute more to systemic risk when they engage more in market-based activities.	+/-
Trading	Trading is a component of non-interest income. The former allows banks to ensure their market-making function or hedge transactions on behalf of third parties. Thus it allows the market to be fairly liquid to avoid too risky movements. However the increase in depth of the markets and the time inconsistency and risk transfer problems create friction. There is evidence that trading is a drain on the activities of commercial banks as it leads to a misallocation of capital (when used for own account trading activities but the border is blurred).	+/-
Derivatives	Derivatives are a source of non-interest income. Through to new model called "Originate to distribute", they were supposed to spread risk. However, the risk transfer mechanisms severely altered the heart of banking functions, it increased excessive risk taking by increasing and relevant interconnections "Banks-Banks" on the one hand and Banks-Markets" on the other hand.	+
Diversification	Diversification promotes economies of scope coming from production synergies specific to multi-product firms. Risk pooling therefore allows to reduce the risk of bank failure. However, the increase in depth of the markets, the time inconsistency and risk transfer problems create frictions. Excessive diversification leads to a homogenization of bank portfolios making them very vulnerable to systemic risk which is not diversifiable.	+
Systemic Size	Systemic size provides to banks "Too Big To Save" status. It's bank relative size in comparison to the national economy. Thus, it can be expensive for a country to bail it out. As a result: An increase in CDS spreads and a decline of bank shares. Banks will have incentives to deleveraging.	+/-
Liquid Assets	The crisis has highlighted the porosity between liquidity and insolvency. Banking institutions should hold highly liquid assets in order to meet Short-Term liquidity disruptions.	-

Note: It is useful to emphasize that proxies are imperfect. For example: Non-interest income includes fees and commissions; thus, lending fees may contribute to noninterest income, while securitized loans may enter balance sheets as securities (not as loans). Data on banks size remain abstract because off-balance sheet activities, whose significantly increase absolute and systemic relevance of banks are not considered in banks' total assets. Log(Z-score) = Log(1+Z-score).

Table 1. Descriptive Statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Log(SRisk)	1134	21.050	2.834	13.528	26.303
MES	1133	0.034	0.020	0.002	0.2625
Log (Z-score)	1179	3.343	1.023	-3.255	6.336
Log(Assets)	1245	24.279	2.641	17.631	28.968
Tier 1 Ratio	1097	0.101	0.032	0.057	0.222
Deposits Ratio	1233	0.476	0.177	0.010	0.902
Loans Ratio	1239	0.571	0.165	0.037	0.959
Noninterest	1208	0.382	0.147	-0.100	0.796
Diversification	1245	0.775	3.681	0.020	111.20
Systemic Size	1239	0.315	0.449	0.000	2.394
Liquid Assets	1243	0.323	0.292	0.018	5.769
Derivatives	651	0.058	0.079	0.000	0.556
Trading	886	0.092	0.087	0.000	0.558
Instruments:					
Overheads cost	1244	0.024	0.021	0.001	0.333
Cost to income	1240	0.654	0.291	0.192	6.787
Net income/RWA	710	0.004	0.027	-0.305	0.120

Note: Log(Z-score)= Log(1+Z-score)

Table 2. Correlation between Individual Risk, Bank Size, Capital, Activities, Funding

	Log (Z-score)	Log(Assets)	Systemic Size	Deposits Ratio	Loans Ratio	Tier 1 Ratio	Noninterest	Diversification	Liquid Assets	Derivatives	Trading	Cost to income	Net income/RWA
Log (Z-score)	1.0000												
Log(Assets)	-0.0114	1.0000											
Systemic Size	-0.0333	0.5861***	1.0000										
Deposits Ratio	0.0617**	-0.6182***	-0.3872***	1.0000									
Loans Ratio	0.0766***	-0.3548***	-0.2708***	0.3318***	1.0000								
Tier 1 Ratio	-0.1314***	-0.3431***	-0.1018***	0.3421***	-0.0889***	1.0000							
Noninterest	0.0304	0.1045***	0.1152***	-0.1448***	-0.3375***	-0.1235***	1.0000						
Diversification	-0.1733***	-0.0602**	-0.0303	-0.1032***	-0.0999***	-0.0268	-0.4348***	1.0000					
Liquid Assets	-0.0518*	0.2534***	0.1203***	-0.4092***	-0.5429***	-0.0189	0.0706**	0.0857***	1.0000				
Derivatives	-0.1366***	0.5010***	0.2757***	-0.4753***	-0.5781***	0.1398***	0.1683***	0.1724***	0.3323***	1.0000			
Trading	0.0848**	0.0234	0.0236	-0.1797***	-0.4328***	0.0445	0.1920***	0.0244	0.7244***	0.2767***	1.0000		
Cost to income	-0.3128***	-0.0950***	-0.0375	-0.0249	-0.2437***	0.0799***	-0.1593***	0.1178***	0.1134***	0.2030***	0.0404	1.0000	
Net income/RWA	0.5157***	0.0877**	0.0573	0.0578	-0.1253***	0.0026	0.1127***	-0.1996***	0.1767***	-0.0412	0.1219***	-0.3081***	1.0000

Note: The table reports pairwise correlations between various bank characteristics for the sample of banks.
. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.
Source: Bankscope, Datastream, World Bank and own calculations

Table D: Banks with the highest SRISK during different time periods

	G-SIBs 2005	G-SIBs 2008	G-SIBs 2010	G-SIBs 2013
1	Barclays Plc	Royal Bank of Scotland	BNP Paribas	Crédit Agricole
2	BNP Paribas	Deutsche Bank	Royal Bank of Scotland	Deutsche Bank
3	Crédit Agricole	Barclays	Deutsche Bank	BNP Paribas
4	ING Groep	BNP Paribas	Crédit Agricole	Barclays
5	Deutsche Bank	Crédit Agricole	Barclays	Royal Bank of Scotland
6	RBS Holdings	ING Groep	ING Groep	Société Générale
7	Société Générale	HSBC	Société Générale	ING Groep
8	Royal Bank of Scotland	Société Générale	Lloyds Banking Group	Banco Santander
9	Commerzbank	UniCredit	Commerzbank	UniCredit
10	Dexia	Dexia	HSBC	HSBC
11	Natixis	Commerzbank	Banco Santander	Lloyds Banking Group
12	Banco Santander	Banco Santander	UniCredit	Commerzbank
13	HSBC	Natixis	Dexia	Intesa Sanpaolo
14	Danske Bank	Danske Bank	Intesa Sanpaolo	Natixis
15	CIC	Hypo Real Estate	Natixis	Nordea Bank
16	UniCredit SpA	Lloyds Banking Group	Danske Bank	Danske Bank
17	Nordea Bank	Intesa Sanpaolo	Nordea Bank	Banco Bilbao Vizcaya Argentaria
18	SEB	Nordea Bank	Banco Bilbao Vizcaya Argentaria	Dexia
19	Hypo Real Estate	Banco Bilbao Vizcaya Argentaria	CIC	Banca Monte dei Paschi
20	Lloyds Banking Group	SEB	Banca Monte dei Paschi	CIC

Note: Computed from our global sample of stock exchange-listed banks.

Source: Bankscope, Datastream and own calculations

Table 3. Individual Risk as Determinant of Systemic Risk Contribution

	2SLS, fe robust	2SLS, fe robust	2SLS, fe robust	2SLS, fe robust	2SLS, fe robust
Dependent Variable	SRISK	SRISK	SRISK	SRISK	SRISK
Z-score	-0.211***	-0.211***	-0.204***	-0.450***	-0.186***
	(0.0655)	(0.0649)	(0.0601)	(0.141)	(0.0517)
Assets	1.260***	1.164***	1.289***	1.476***	1.105***
	(0.0899)	(0.0990)	(0.0609)	(0.141)	(0.130)
Deposits Ratio	-0.636**	-0.578**	-0.740***	-0.600	0.547
	(0.280)	(0.282)	(0.282)	(0.530)	(0.619)
Loans Ratio	0.666**	1.015***	0.833***		
	(0.310)	(0.380)	(0.264)		
Tier 1 Ratio	-0.378	-0.842		2.845	-2.102
	(1.143)	(1.141)		(1.796)	(1.532)
Noninterest	0.516***	0.538***	0.611***		
	(0.151)	(0.154)	(0.145)		
Dummy_IFRS	-0.293***	-0.344***	-0.222***	-0.555***	0.441**
	(0.0928)	(0.0912)	(0.0731)	(0.159)	(0.188)
Systemic Size		0.407***			
		(0.145)			
Liquid_Ratio		0.219		-0.216	
		(0.135)		(0.239)	
Diversification				-1.327***	-0.0463**
				(0.361)	(0.0216)
Derivatives					0.135
					(0.705)
Trading					1.367***
					(0.438)
Time dummies	YES	YES	YES	YES	YES
Observations	1000	1000	1076	415	312
R-squared	0.730	0.733	0.716	0.438	0.711
Fstat (p.value)	0.0000	0.0000	0.0000	0.0000	0.0000
HansenJ (p.value)	0.826	0.752	0.502	0.110	0.128
Underidentification (p.value)	0.0000	0.0000	0.0000	0.0011	0.0000
Redundancy (p.value)	0.0003	0.0007	0.0000	0.0041	0.0000
Endogeneity test (p.value)	0.0338	0.0358	0.0360	0.0042	0.0013
Instruments	*Cost to income/ Overheads cost*	*Cost to income/ Overheads cost*	*Cost to income/ Overheads cost*	*Cost to income/ Overheads cost*	*Cost to income/ Net inc to RWA*
Groups	83	83	83	48	39

Notes: Dependent variable is SRISK and the estimation period is 1999-2013. Global sample of stock exchange listed banks covers all asset size. Column (4) includes only medium banks (i.e., banks whose assets are included in the closed interval [1-100] € billion. Column (5) includes only large banks (i.e., banks with assets in excess of € 100 billion. Robust standard errors in parentheses indicate significance at the *** 1, **5 and *10 percent levels.

Table 4. Individual Risk as Determinant of Systemic Risk Contribution: Robutness Tests

	2SLS, fe robust	2SLS, fe robust	2SLS, fe robust	2SLS, fe robust	2SLS, fe robust
Dependent Variable	MES	MES	MES	MES	MES
Z-score	-0.0125***	-0.0123***	-0.0134***	-0.0107***	-0.0168***
	(0.00208)	(0.00208)	(0.00194)	(0.00242)	(0.00229)
Assets	0.00465***	0.00542***	0.00447***	0.00192	0.00937**
	(0.00147)	(0.00164)	(0.00144)	(0.00200)	(0.00374)
Deposits Ratio	0.00543	0.00434	0.00698	-0.00361	0.00722
	(0.00995)	(0.0101)	(0.0100)	(0.00858)	(0.0218)
Loans Ratio	0.00969	0.00983			
	(0.00674)	(0.00866)			
Tier 1 Ratio	0.116***	0.118***	0.110***	0.145***	-0.0170
	(0.0235)	(0.0228)	(0.0230)	(0.0347)	(0.0438)
Noninterest	-0.00488	-0.00584			
	(0.00449)	(0.00453)			
Dummy_IFRS	-0.00432***	-0.00453***	-0.00402***	-0.000717	-0.00512
	(0.00138)	(0.00144)	(0.00144)	(0.00185)	(0.00606)
Systemic Size		-0.00489			
		(0.00392)			
Liquid Assets		0.00217	-0.00124	-0.000914	
		(0.00532)	(0.00444)	(0.00562)	
Systemic Size			-0.00115*	-0.00118	-0.00222***
			(0.000666)	(0.00538)	(0.000663)
Derivatives					0.0153
					(0.0222)
Trading					-0.0113
					(0.0169)
Time dummies	*NO*	*NO*	*NO*	*NO*	*NO*
Observations	999	999	999	414	312
R-squared	0.308	0.314	0.278	0.164	0.400
Fstat (p.value)	0.0000	0.0000	0.0000	0.0000	0.0000
HansenJ (p.value)	0.816	0.722	0.914	0.777	0.817
Underidentification (p.value)	0.0000	0.0000	0.0000	0.0005	0.0000
Redundancy (p.value)	0.0002	0.0005	0.0000	0.00563	0.0000
Endogeneity test (p.value)	0.0165	0.0186	0.0026	0.0183	0.0002
Instruments	*Cost to income/ Overheads cost*	*Cost to income/ Overheads cost*	*Cost to income/ Overheads cost*	*Cost to income/ Overheads cost*	*Cost to income/ Net inc to RWA*
Groups	83	83	83	48	39

Notes: Dependent variable is MES and the estimation period is 1999-2013. Global sample of stock exchange listed banks covers all asset size. Column (4) includes only medium banks (i.e., banks whose assets are included in the closed interval [1-100] € billion. Column (5) includes only large banks (i.e., banks with assets in excess of € 100 billion. Robust standard errors in parentheses indicate significance at the *** 1, **5 and *10 percent levels.

Table 5. Individual Risk as Determinant of Systemic Risk Contribution: Robustness Tests

	LSDV, robust	LSDV, robust	LSDV, robust	LSDV, robust
Dependent Variable	SRISK	SRISK	SRISK	SRISK
Z-score	-0.0835***	-0.143***	-0.133***	-0.0776**
	(0.0226)	(0.0202)	(0.0375)	(0.0334)
Assets	1.034***	1.051***	1.016***	1.034***
	(0.0152)	(0.0140)	(0.0324)	(0.0452)
Deposits Ratio	-0.701***	-0.731***	-0.839***	-0.996**
	(0.188)	(0.204)	(0.285)	(0.453)
Loans Ratio	0.604***			
	(0.203)			
Tier 1 Ratio	-0.881	1.208	-0.159	0.674
	(1.251)	(0.889)	(1.452)	(1.605)
Noninterest	0.182			
	(0.159)			
Liquid Assets	0.0642	-0.216**	-0.610***	-0.0488
	(0.113)	(0.0982)	(0.196)	(0.179)
Systemic Size				
Diversification		-0.0153***	-0.0115*	0.303
		(0.00457)	(0.00656)	(0.238)
Derivatives				-0.143
				(0.416)
Trading				-0.348
				(0.489)
Constant	-3.990***	-3.702***	-2.719***	-3.442***
	(0.494)	(0.417)	(0.836)	(1.225)
Year Fixed Effects	*YES*	*NO*	*NO*	*NO*
Country Fixed Effects	*YES*	*YES*	*YES*	*YES*
Observations	924	924	361	291
R-squared	0.964	0.961	0.846	0.873

Notes: Dependent variable is SRISK and the estimation period is 1999-2013. Global sample of stock exchange listed banks covers all asset size. Column (3) includes only medium banks (i.e., banks whose assets are included in the closed interval [1-100] € billion. Column (4) includes only large banks (i.e., banks with assets in excess of € 100 billion. Robust standard errors in parentheses indicate significance at the *** 1, **5 and *10 percent levels.

Table 6. Individual Risk as Determinant of Systemic Risk Contribution: Robutness Tests

	GMM, robust	GMM, robust	GMM, robust	GMM, robust
Dependent Variable	SRISK	SRISK	SRISK	SRISK
Lag (SRISK)	0.375***	0.363***	0.365***	0.408**
	(0.102)	(0.108)	(0.110)	(0.180)
Z-score	-0.175***	-0.187***	-0.158**	-0.191*
	(0.0538)	(0.0564)	(0.0664)	(0.112)
Assets	0.588***	0.590***	0.536***	
	(0.121)	(0.124)	(0.131)	
Deposits Ratio	-1.876**	-1.773*	-0.910	5.174
	(0.878)	(0.962)	(0.920)	(3.159)
Loans Ratio	0.427			
	(1.101)			
Tier 1 Ratio	2.926	2.701	1.385	-5.003
	(2.204)	(2.206)	(2.016)	(5.246)
Noninterest	-0.363			
	(0.384)			
Liquid Assets	-0.993*	-1.340**	-1.871**	1.444
	(0.570)	(0.517)	(0.780)	(0.871)
Dummy_IFRS	0.0537	0.115	0.208	
	(0.122)	(0.0978)	(0.128)	
Diversification		-0.00751	0.00278	-0.0537
		(0.0267)	(0.0248)	(0.461)
Systemic Size			0.806	1.452**
			(0.574)	(0.537)
Derivatives				5.753***
				(1.616)
Trading				11.64***
				(3.811)
Constant	0.223	0.621	1.371	-2.687
	(1.528)	(1.455)	(1.690)	(3.770)
Observations	945	945	945	320
Hansen	0.281	0.326	0.316	0.563
AR2	0.234	0.157	0.200	0.389
instr	76	76	76	31
Groups	83	83	83	41

Notes: Dependent variable is SRISK and the estimation period is 1999-2013. Global sample of stock exchange listed banks covers all asset size. Column (4) includes only large banks (i.e., banks with assets in excess of € 100 billion. Robust standard errors in parentheses indicate significance at the *** 1, **5 and *10 percent levels.