House of Finance

SAFE

Policy Center

Günter Beck, Hans-Helmut Kotz and Natalia Zabelina

Euro Area Macro-Financial Stability: A Flow-of-Funds Perspective

White Paper No. 29

SAFE | Sustainable Architecture for Finance in Europe
A cooperation of the Center for Financial Studies and Goethe University Frankfurt

House of Finance | Goethe University
Theodor-W.-Adorno-Platz 3 | 60323 Frankfurt
Tel. +49 69 798 33684 | Fax +49 69 798 33910
policy_center@safe.uni-frankfurt.de | www.safe-frankfurt.de

Euro Area Macro-Financial Stability: A Flow-of-Funds Perspective

Günter W. Beck[1] Hans-Helmut Kotz[2] Natalia Zabelina[3]

August 16, 2015

Abstract

The global financial crisis (as well as the European sovereign debt crisis) has led to a substantial redesign of rules and institutions – aiming in particular at underwriting financial stability. At the same time, the crisis generated a renewed interest in properly appraising systemic financial vulnerabilities. Employing most recent data and applying a variety of largely only recently developed methods we provide an assessment of indicators of financial stability within the Euro Area. Taking a "functional" approach, we analyze comprehensively all financial intermediary activities, regardless of the institutional roof – banks or non-bank (shadow) banks – under which they are conducted. Our results reveal a declining role of banks (and a commensurate increase in non-bank banking). These structural shifts (between institutions) are coincident with regulatory and supervisory reforms (implemented or firmly anticipated) as well as a non-standard monetary policy environment. They might, unintendedly, actually imply a rise in systemic risk. Overall, however, our analyses suggest that financial imbalances have been reduced over the course of recent years. Hence, the financial intermediation sector has become more resilient. Nonetheless, existing (equity) buffers would probably not suffice to face substantial volatility shocks.

Keywords: Bank and non-bank financial intermediation, shadow banking, financial stability, systemic risk, financial regulation.

[1]University of Siegen and SAFE. E-mail: beck@safe.uni-frankfurt.de.

[2]Corresponding author. SAFE and Center for European Studies, Harvard University, E-mail: kotz@safe.uni-frankfurt.de.

[3]SAFE and University of Siegen. E-mail: natalia.zabelina@uni-siegen.de.

1 Introduction and motivation

Crises put analytical concepts as well as regulatory institutions to test. And the Great financial Crisis (GFC), as it has become known, administered a particular forceful challenge – to prevailing analytical views as well as the regulatory framework and supervisory procedures. All the three of them were found wanting, in need of a substantial re-appraisal. As concerns the regulatory framework, the tone was set with the FSB blueprint for reform, published in September 2009 and endorsed at the Pittsburgh G20 summit in the same month. This led to a very substantial redesign of rules and institutions of which it is literally impossible to keep abreast.

The GFC and its subsequent iteration, viz. sovereign debt instability in the Euro Area's periphery, has forced European policymakers to embark on institutional innovations which seemed still much too ambitious to ponder in 2009. Most importantly, banking policy, in (long overdue) parallel with monetary policy, has been (largely) Europeanized with the establishment of the Banking Union. Admittedly, lacking an ultimate pan-Euro Area backstop, the set-up is still incomplete. However, the three-pillared structure of a Single Supervisory Mechanism, a Single Resolution Mechanism as well as an harmonized deposit insurance now in place goes far beyond what the de Larosière Report ventured to suggest in 2009.

In addition, the regulatory software has been comprehensively re-configured and updated: Building on Basel III principles, capital requirements have been increased and, a first, with the Net Stable Funding ratio as well as the Liquidity Coverage Ratio, liquidity criterions introduced (CRD/CRR IV). The market infrastructure for over-the-counter (OTC) derivatives, i.e. clearing, settlement and data repositories are meanwhile under the purview of a new regulation (EMIR). Alternative investment vehicles, in particular hedge funds, have to adapt to AIFM-rules. And a fundamentally over-hauled directive covering the prudential rule-set for insurance firms, that is, Solvency II, is in place.

All in all, ever since the crisis broke, almost 50 initiatives have been tabled by the EU Commission.[1] Obviously, banking has been given particular attention. Here, the bulk of reform measures have been implemented. In terms of impact, insurance companies and pension funds and – to a considerably smaller degree – other investment funds also have to face-up to new rules of the game. In the so-called shadow banking sector[2], only a few selective regulatory changes have been introduced

[1] The European Commission provides a broad overview of all implemented and currently ongoing regulatory efforts on the following website: http://ec.europa.eu/finance/general-policy/policy/map_reform_en.htm.

[2] Given its established use, we will also employ the term "shadow banking" often. Nevertheless,

but no comprehensive reform-package has been devised, to date though.[3]

Combined with its high degree of innovativeness, it can be expected that the extensive amendments in the regulatory landscape will significantly impact activities within the financial-intermediation sector, including unintended and potentially unwarranted side effects such as substitution away from more heavily (banks) towards less or differently regulated entities (non-bank banks). To capture these developments, we take a comprehensive approach, i.e., we account for all financial intermediaries, discharging largely identical functions, if under different institutional guises. Hence, we take a "functional finance" perspective, as developed in particular by Robert C. Merton (see Merton, 1995, but also Merton and Bodie, 2004). This line of reasoning starts from functions (viz. services offered), takes them as a given. And from this angle we try to appraise institutional evolutions – hence, it is institutions that change. "Financial innovation ... sometimes appears to threaten the stability of the system, by providing the means to circumvent institutionally based regulation at low cost" (Merton, 1995, page 10). And, quite obviously, lots of what has been going on in non-bank banking amounted precisely to such circumvention activity. Thus, we zero-in on potential risks, systemic externalities, associated with how different institutions discharge those identical functions.

Risks, therefore, emanate from how banking functions, in particular credit intermediation, are performed. Legally, (commercial) banks are usually defined as institutions which grant loans and accept deposits. In doing this, they offer liquidity and payments services, transform assets, manage risks and perform screening and monitoring functions (Freixas and Rochet, 2008, Hartmann-Wendels et al., 2013). Banks, thus, provide crucial services for the public. Their safety and soundness is hence of the essence. Potential negative externalities with major adverse consequences are the standard justification for regulation and supervision.

Banks' functional substitutes, that is: nonbank banks, discharge to a large degree similar functions. However, while, from a functional angle, one cannot tell a difference, they often are subject to less binding, or different, rules. Defining (institutional) features, specific to non-bank banking, might therefore add to the level of systemic risk.[4] First, shadow banks provide intermediation services without recourse to a

we have to confess some reluctance in using this notion. Following Tobin and Brainard (1963), our preferred expression for bank-type activities not subject to regular banking regulation is "non-bank banking."

[3]In September 2013, the European Commission published an overview of measures that had either already been taken or were under review in the context of the regulation and supervision of European shadow banks (see European Commission (2013), for details). This communication is part of a regulatory effort with an eye on setting up a comprehensive framework also for this sector.

[4]See Adrian (2014) for a more detailed exposition of these issues.

public backstop facility (deposit insurance, discount window). When in trouble they are hence run-prone, particularly so, given their depositor structure dominated by institutional investors. Second, long credit intermediation chains, across multiple institutions, imply agency problems and a potentially increased default probability. Third, in times of stress, opacity and complexity of the system/instruments, produces "flight-to-quality" phenomena. Fourth, holdings of assets, particularly sensitive to high-impact events, are regularly not properly priced. Such risks are neglected (Gennaioli et al., 2013). Fifth, against a background of low volatility – think of the Great Moderation – shadow banks boost their leverage and vice versa. This means pro-cyclicality. Finally, the high degree of connectedness of nonbank banking with other financial sub sectors opens the gate to contagion.

The primary purpose of the very substantial financial stability policy efforts mentioned above is, evidently, to contain and manage systemic risks associated with the activities of the various financial intermediaries. Taking a macro-oriented perspective, the major objective of this study is to gauge how these risks have developed in recent years. In doing so, we make use of recent theoretical, methodological as well as data-related progress.

Accompanying the regulatory innovations, numerous scholarly efforts have been undertaken – and often with very much a practical or policy focus – to improve our understanding of potential financial-stability threats as an upshot of financial intermediaries' activities. For example, with regard to the topic of "shadow banking" – largely ignored until the financial crisis – excellent recent academic work include, amongst others, studies by Adrian and Shin (2009), Gorton and Metrick (2012), Bakk-Simon et al. (2012), Claessens et al. (2012), Gennaioli et al. (2013), Claessens and Ratnovski (2014), Adrian (2014), Deutsche Bundesbank (2014) and IMF (2014). These new insights – together with the corresponding, more established perspectives on traditional banking[5] – will provide important guidance for our analyses as well as the interpretation of results obtained.

Methodologically, the financial crisis made blatantly obvious the distinct need to improve our abilities in understanding systemic risk. Meanwhile, considerable progress has been accomplished such that nowadays a variety of approaches exists to deal with this issue. Bisias et al. (2012), providing a comprehensive exposition, list 31 different lines of attack, concluding that "because systemic risk is a multifaceted problem in an ever-changing financial environment, any single definition is likely to fall short, and may create a false sense of security as financial markets evolve in

[5]See, e.g., Freixas and Rochet (2008), Degryse et al. (2009) and Hartmann-Wendels et al. (2013).

ways that escape the scrutiny of any one-dimensional perspective." Therefore, in our study, we combine, somehow eclectically, simple balance-sheet based risk measures with more sophisticated methods as proposed by Gray et al. (2007). These authors apply option-pricing based contingent claims analysis (CCA), originally developed for assessing firm-level default risk, to measure the riskiness (distance to distress) of entire sectors of the economy.

In terms of data, enormous efforts have been made to reduce data gaps, following the recommendations given in financial Financial Stability Board (2011). Within the European Union (EU), the implementation of ESA 2010, i.e., the latest internationally compatible EU accounting framework, implemented in September 2014, allows, inter alia, for a more detailed description of the interlinkages between the shadow-banking system and banks. Most importantly, it also uncovers ties with the nonfinancial private sector, difficult to capture with predecessor version (ESA 1995). In our analysis, we make use of this up-to-date flow-of-funds (as it used to be called) data base whereas existing studies (known to the authors) date back some years. Given the raft of regulatory measures implemented over the last few years, this should have had an impact on the financial landscape such that the use of most recent data should reveal new developments.

While we think that the data underlying our analyses as well as the various analytical tools deployed are well suited for the purpose of examining the stability of financial intermediaries from a macro or systemic perspective, we are aware of the limitations of any model-based assessment. Such restrictions arising from data, parameter and model uncertainty are of course not specific to macro-financial stability. In monetary economics, for example, they have been contemplated at least since the 1960s[6]. A widely held consensus is that[7]

> "... All models are drastic simplifications of the economy, and data give a very imperfect view of the state of the economy. Therefore, judgmental adjustments in both the use of models and the interpretation of their results - adjustments due to information, knowledge, and views outside the scope of any particular model - are a necessary and essential component in modern monetary policy ... (see Svensson, 2005, page 3)"

In this sense, we consider our findings as a potentially interesting input for the policy-

[6] See Bernanke (2007) for a short overview of major contributions to this literature in the field of monetary economics.

[7] An early reference, emphasizing the importance of judgment in a situation of decisions making under uncertainty includes Friedman (1993), additional, more recent references comprise Bernanke (2004) or Draghi (2014).

making process – but, admittedly, an insufficient one. The policy of financial stability is inherently (and inevitably) discretionary. It requires considerable judgmental input (as well as the contribution from competing models).

To highlight one of our findings, we detect a decline of traditional banking in the Euro Area. Given co-incidental regulatory (and supervisory) innovations, this, we surmise, could morph into a trend. More specifically, we provide evidence of incentive-driven "substitution effects" between the banking (MFI) and the non-bank banking (OFI) sector. Based on the simple risk metrics, building on sectoral balance-sheet data, we document a decline in the MFI sector, largely compensated by an increase in the activities of OFIs. Consequently, the overall size of the financial intermediation sector has barely moved. Similarly, a substitution has taken place with respect to lending businesses of these two sectors.

When comparing our estimates of inter-sectoral connectedness between the most recent sample period and the pre-crisis phase, we observe that absolute values have remained fairly stable for MFIs and ICPFs whereas they have risen considerably for OFIs. These findings, evidently, translate into relatively larger losses for OFIs and unchanged amounts for MFIs and ICPFs when we simulate the consequences of shock scenarios. Relative to total assets, losses have declined though.

CCA measures indicate that the resilience of all sub-sectors of financial intermediation has increased over the recent years. However, simulation exercises indicate that this apparent stability depends in a highly nonlinear manner on the evolution of asset price volatility. In other words, heightened uncertainty could abruptly translate into substantial risks to stability. Moreover, at the end of the sample period, there are signs of a slight increase in sectoral default probabilities.

Overall, on comparative terms, our accounting-based indicators, while useful, for supervisory monitoring, are less informative than risk-adjusted measures. The latter, which can be intuitively linked to contemporaneous developments financial markets, perform substantially better. Also, they tend to be leading, that is, pointing to problematic dynamics before these become plainly obvious.

Nonetheless, risk-based indicators have to be evaluated in light of "outside-model" information, i.e., judgment. For example, somewhat counterintuitively, our results for the ICPF sector suggest its resilience having returned to pre-crisis level. But, clearly, against the context of the pre-vailing low-interest environment, institutional asset managers (with pre-defined payment obligations) are potentially up to considerable stability challenges.[8] They do not show directly in our chosen approach.

[8]See, for example, OECD (2015) for a most recent study.

Overall, our analyses suggest that while the financial intermediation sector has become more resilient over the course of recent years a number of potential cracks show – in need of careful monitoring.

The rest of this paper is structured as follows. In Section 2, we present and discuss our data. Section 3 provides simple, single-sector balance-sheet risk measures. An analysis of recent developments in the degree of interconnectedness within the financial system is presented in Section 4. Section 5 briefly outlines the CCA concept and then provides a risk-based assessment, highlighting implications for financial stability. Section 6 summarizes and concludes.

2 Data

At the core of our empirical analysis are the Euro Area's quarterly economic and financial accounts data.[9] They capture income and spending flows, their logical corollary, viz. financial flows as well as the resulting changes in stocks of financial assets and liabilities, all in nominal terms. And, by brute force of accounting principles, a consistent and closed system of flows between sectors and their respective balance sheets (stocks) arises. As de Rougemont and Winkler (2014) emphasize, the flow-of-funds approach enforces consistency in three dimensions: uses and sources have to match, between sector flows balance, and, flows result in (precisely) equivalent changes in stocks. While this might appear obvious, even pedestrian, honoring these constraints is not a stronghold of conventional models.

More specifically, we primarily employ financial balance-sheet data from the ECB's (and Eurostat's) Euro Area accounts data ("Quarterly Sector Accounts") which offer consistent and comprehensive information on the income, spending and financing decisions as well as balance sheets of all sectors in the Euro Area. Financial and non-financial statistics are compiled by national institutions and the Eurosystem. The data is quarterly, ranging from 1999 until Q4/2014, thus covering the pre-crisis, crisis and post-crisis periods.[10]

Data are provided for different domestic sectors as well as a catch-all construct, the rest-of-the-world (ROW) sector. The sectors are defined institutionally, integrating entities with similar (economic) characteristics and behavior. They include non-financial corporations (NFC), financial corporations (FC), general government (GG)

[9] For a detailed exposition, see in particular de Rougemont and Winkler (2014) on whom we largely rely.

[10] See also ECB and Eurostat (2007) as well as ECB (2012) for further background information on these data.

and households and non-profit institutions serving households (HH). For the financial corporations sector, data can be further disaggregated into monetary financial institutions (credit institutions and money market funds, short MFI), insurance corporations and pension funds (ICPF) as well as other financial institutions (OFI). Since the implementation of ESA 2010 (see below), the ICPF data are in addition separately available for insurance corporations and pension funds. Also, OFI data can be distinguished between investment funds (other than money market funds) and OFIs without investment funds. Moreover, transactions and financial claims between euro-area/EU28 residential sectors and non-euro-area/EU28 sectors are recorded in the ROW accounts.

Financial data per sector are available in aggregate form (total financial assets/liabilities) as well as for numerous asset classes. The latter include monetary gold and SDRs, currency and deposits, debt securities, loans, equity, insurance, pensions and standardized guarantee schemes, financial derivatives and employee stock options as well as other accounts receivable/payable. Debt securities and loans, moreover, can be distinguished on the basis of their (original) maturity.

The conceptual framework underlying the Euro Area Accounts is derived from the European System of National and Regional Accounts (ESA). In 2014, ESA 2010 replaced ESA 1995. Data based on the new system became available at the beginning of 2015 and are underlying the analysis performed in this paper.

Flow-of funds data have been typically tabulated with sectors in columns and rows covering the respective markets (or instruments) in which sectors interact (Tobin and Brainard, 1963 and Barwell and Burrows, 2014).[11]Columns can be understood as budget constraints, they have to add-up (to balance), i.e., spending has to be funded. And rows must show market clearing, i.e. add-up to zero. This holds obviously true for EAA. They provide a framework of (compiling) data, not a model (Winkler, 2010). But, at a minimum, they do allow "asking meaningful questions" (Constancio, 2014). In particular, they should enable us to obtain valuable insights into potential financial vulnerabilities building at a macro level. To arrive at our results, we employ a working hypothesis similar to the one used by other authors such as Gray et al. (2007) or Castrén and Kavonius (2009). More specifically, we consider the sectors of the Euro Area economy as capturing the average behavior of the individual entities comprising the respective sector. This sector perspective is a natural aggregation device since, to reiterate, sectors are defined by entities with similar characteristics and economic behaviors. Financial accounts data of a particular sector, for instance,

[11]Semmler (2011) has integrated in an interesting way these views in more conventional models.

are hence read as the balance sheet of a representative agent. To these constructs we apply concepts and methods developed to monitor risks at the micro level, i.e., the level of single entities and groups of entities.

Following this idea, we will first provide balance-sheet based statistics which are regularly employed to assess potential risks emanating from the activities of a given financial entity. In a second step, we will analyze the degree of interconnectedness between the sectors of the Euro Area economy and will then provide an assessment of potential risks emanating from there.[12]

3 Simple balance-sheet risks measures

As a starting point of our analysis, we first provide some simple descriptive statistics, derived from balance-sheet information. They should allow for a preliminary appraisal of potential risks deriving from the activities of financial intermediaries.[13] Our analysis reports results since 1999, thus covering both the pre-and post-crisis periods. As we will argue below, this allows us to obtain an idea of the indicator qualities of each reported measure. Following our comprehensive approach, we report results for MFIs, ICPFs, OFIs as well as for the overall financial sector.

The measures which we employ comprise information about (i) size, (ii) asset maturity risk, (iii) asset liquidity risk, (iv) credit risk and (v) leverage, results being presented in Figure 1. In terms of size, measured by the ratio of total assets to Euro Area GDP, we can see that the growth of financial corporations has come to a halt in the recent three years after having experienced an enormous expansion in the decade before the financial crisis. Total assets of all financial corporations slightly exceeded six times Euro Area's GDP in 2014, which in absolute terms amounts to some 61 trillion euros. Disaggregated data show a dynamics of individual sectors characterized by a strong (upward) co-movement until the financial crisis, and clearly diverging evolutions since then. As has been documented before[14], the activity level of OFIs, often taken as a proxy for shadow-banking,[15] is not only very substantial, but has

[12]Of course, we are aware of shortcomings in using flow-of-funds data for the purpose of our analysis. An obvious disadvantage is that aggregated data mask potentially significant vulnerabilities at the sub-sector level, arising from heterogeneity of entities over which aggregates are construed (think of tail risk, for example). Another shortcoming is that no price information on the assets is available which is crucial for our risk analysis. In Section 5, we will discuss how we deal with this latter challenge.

[13]Measures provided are similar to those of IMF (2014). However, the latter report focusses selectively on two periods whereas we consider an extended sample period.

[14]See in particular Bakk-Simon et al. (2012) and IMF (2014).

[15]This is done mostly due to existing data constraints, see, e.g., European Commission (2013).

experienced considerable growth both before and after the financial crisis. Currently, OFI measure up to slightly more than two times Euro Area GDP. Concurrently, MFIs which had grown substantially until the financial crisis, exhibit a drop in size. It is here where deleveraging (in particular through shedding assets) shows. However, this leaves the Euro Area nonetheless bank-dominated. Unlike in the U.S., banks are still considerably more important than OFIs (amounting to a slightly more than 3 times Euro Area's GDP). The ICPF sector in turn has exhibited moderate but steady growth and now amounting to around one times Euro Area's GDP. Considering their respective dimensions, it is obvious that potential problems in each sector should impact the stability of the financial sector as a whole, i.e., each sector is large enough to potentially be of systemic importance.

Liquidity risk is measured as one minus the ratio of the sum of currency and deposits, securities other than shares (debt securities) and mutual fund shares to total assets. Both for the overall sector and the subsectors considered this ratio indicates a steady decline of risk over the whole sample period. The only exception is the MFI sector, having experienced a slight increase recently. Remarkably, indicators do not flash any potential trouble in the pre-crisis period. A similar picture is obtained for our measure of asset maturity risk, computed as the ratio of long-term assets (long-term loans, long-term securities and equity and shares) over total assets. In all sectors, it exhibits relative constancy or even a decline in the run-up to the financial crisis with levels being around 80% in the OFI and ICPF sector and slightly above 50% in the MFI sector. In recent years, this measure has increased in all sectors.

Concerning credit risk, approximated by the ratio of loans to total assets, a fairly heterogeneous picture emerges. While the aggregate numbers have been rather stable (with a mild tendency to decline), data for the OFI sector showed a clear trend to rise before the crisis, stagnated afterwards and have slightly declined over the last two years. In the MFI sector, more or less exactly the opposite dynamics has occurred indicating potential substitution effects between the OFI and the MFI sector. In the ICPF sector, credit risk has exhibited a steady and clearly pronounced downward movement.

The measure for leverage (constructed as the ratio of total assets to equity and shares) shows considerable differences in the dynamics and levels across sectors. Figures are considerably higher for the MFI and ICPF sectors compared to the ones for the OFI sector throughout the sample period. Moreover, while leverage has risen substantially for the former two sectors until a few years ago it has shown relative constancy for the OFI sector. Lastly, while the numbers for the OFI sector currently

are at a level comparable to that before the crisis period they are still significantly above this threshold for the MFI and ICPF sectors (even though a decrease has occurred lately).

In sum, statistics presented in this subsection provide a first idea about dynamics having occurred in the financial-intermediation sector in recent years. However, as our reference to the pre-crisis period shows, they are of limited use to detect impending risks to this sector.

4 Trends in sectoral financial interconnectedness

European Commission (2013) motivates the regulatory interest in the shadow-banking sector at the EU level with the fact that "in addition to risks associated with circumventing existing rules and the fact that these [shadow banking] entities/activities can foster the surreptitious accumulation of high levels of debt in the financial sector, shadow banking needs to be monitored because of its size, its close links to the regulated financial sector and the systemic risk that it poses."

While we have provided some crude estimates of the size (and additional balance-sheet risk measures) of the shadow-banking sector (proxied by the size of the OFI sector) and the other financial-intermediation sectors above, the objective of this section is to address the second aspect mentioned in the quote by the European Commission, in need of particular monitoring, namely the inter-sectoral linkages within the financial sector.

In doing so, we again build from the economic sectors as defined by ESA 2010 and employ balance-sheet data collected by the ECB to derive estimates of the extent of financial interconnectedness. In other words, the analysis should enable us to obtain an idea of the dynamics of the mutual financial relationships between the financial sectors, the sectors representing the "real" side of the Euro Area's economy (HH, NFCs and GG) and the Rest of the World (ROW). Including the non-financial sectors has considerable benefits for the purpose of our study. This has been clearly pointed out, e.g., in IMF et al. (2009), where the IMF, the BIS and the FSB emphasize the pertinence of considering linkages of the financial sector to the real side of the economy by defining

> "... systemic risk as a risk of disruption to financial services that is (i) caused by an impairment of all or parts of the financial system and (ii) has the potential to have serious negative consequences for the real economy. Fundamental to the definition is the notion of negative externalities from a disruption or failure in a

financial institution, market or instrument. All types of financial intermediaries, markets and infrastructure can potentially be systemically important to some degree."

The approach we take closely follows Castrén and Kavonius (2009) but extends their study with respect to two dimensions. First, our analysis employs the most recently available EEA data, thus capturing developments which have occurred in the post-crisis period, characterized by very substantial financial regulatory reforms as well as, concurrently, unconventional monetary policy efforts. Secondly, we account for differences in importance of the three major sub-sectors of the financial-intermediation sector for financial stability as well as their interplay.

4.1 Estimates of intersectoral financial interconnectedness

For the purpose of our study we regard the economy of the Euro Area as a network consisting of economic sectors, linked by mutual asset holdings. In network analysis,[16] the objects of a network, in our case the economic sectors, are referred to as nodes (or vertices) and connections between them, in our case the mutual asset holdings, are denoted as links (or edges). This network structure, consisting of mutual holdings of securities of a given asset class k, lends itself naturally to a matrix representation. Denoting the holdings of assets of type k which sector i holds with respect to sector j as x_{ij}^k, matrix X^k can be written as:

$$X^k = \begin{bmatrix} x_{1,1}^k & \dots & x_{1,j}^k & \dots & x_{1,N}^k \\ \vdots & \ddots & \vdots & \iddots & \vdots \\ x_{i,1}^k & \dots & x_{i,j}^k & \dots & x_{i,N}^k \\ \vdots & \iddots & \vdots & \ddots & \vdots \\ x_{N,1}^k & \dots & x_{N,j}^k & \dots & x_{N,N}^k \end{bmatrix}, \tag{1}$$

where the row and column indices i and j denote the sectors of the economy as well as the total numbers of sectors, N, corresponds to seven in our case.[17]

The entries of a given row i of this matrix, denoted by x_{ij}^k (with $i = 1, 2, \dots, N$), represent the amount of assets of type k which sector i holds with respect to sector j. With A_i^k standing for sector's i overall amount of assets of type k, we have

[16] See, e.g., Kolaczyk and Csárdi (2014) for an excellent exposition.

[17] The sectors of the economy are given by $(i,\ j) \in \{NFC,\ HH,\ MFI,\ ICPF,\ OFI,\ GG,\ ROW\}$.

$$A_i^k = \sum_{j=1}^{N} x_{ij}^k, \quad \forall i = 1, 2, \ldots, N \text{ and } N = 7.$$

The entries of a given column j of this matrix, denoted by x_{ij}^k (with $j = 1, 2, \ldots, N$), represent the amount of liabilities of type k which sector j holds with respect to sector i. Denoting sector's j overall amount of liabilities of type k by L_j^k, we have

$$L_j^k = \sum_{i=1}^{N} x_{ij}^k, \quad \forall\ j = 1, 2, \ldots, N \text{ and } N = 7.$$

To measure the degree of interconnectedness between two economic sectors, given by $x_{i,j}^k$ in the matrix above, we make use of the financial-accounts data introduced in Section 2. Unfortunately, comprehensive, detailed bilateral balance-sheet data are not published, only the total amount of assets/liabilities of a given asset class is provided for each sector. In other words, bilateral asset/liability holdings have to be estimated. To do so, we rely on an approach commonly applied in the literature under these circumstances (see, e.g., Upper and Worms, 2004, or Castrén and Kavonius, 2009). More specifically, we employ the so-called maximum entropy approach, building on the assumption that sectors diversify their asset holdings as evenly as possible across the sectors of the economy. The intuition underlying this procedure is that – in the absence of information about bilateral financial exposures – no defensible ex-ante assumption about the asset distribution of a given sector can be made. Another, more practical motivation would be that institutions minimize tracking error – which comes with a high degree of similarity in positions taken. In technical terms, applying this approach amounts to maximizing the entropy of matrix X^k.[18]

Estimates of bilateral exposures of total assets for the first quarter of 1999 are portrayed in Table 1, where entries represent the corresponding items of the (7 x 7) square matrix, X, considered above. Please note that unlike in most micro-oriented applications values in the diagonal are non-zero, given that we work with data not consolidated at the sectoral level. This implies that entities of a particular sector do hold assets of other entities of the same sector.

An alternative, frequently used method of representing the same network is to deploy network graph techniques. Network graphs (see in particular Kolaczyk and Csárdi (2014, Chapter 2.2)) are geometric structures consisting of a set of nodes as well as a links. Data in Table 1 thus translate into the network graph presented

[18] A very good exposition of the procedure including a more detailed discussion of the overall approach is given in Upper (2011, Section 4.2).

in Figure 2, where nodes represent the economic sectors and the links capture the degree of financial interconnectedness across sectors. The extent of intra-sector inter-connectedness can be read from the size of node; the magnitude of cross-sector interconnectedness being reflected by the thickness of the respective link.

As both Table 1 and Figure 2 illustrate, the MFI sector plays a central role in the economy: the degree of intra-sectoral relationships is by far the largest amongst all sectors. Moreover, its connectedness with all other economic sectors is the most sizeable for any of the other sectors. Compared to MFIs, OFIs played a significantly less important role in 1999. Nevertheless, data for 1999 already show that OFIs (nonbank banking) were not a quantité négligeable, in particular with respect to domestic firms and households but also MFIs.

To obtain some idea of the dynamics of the degree of inter-sectoral financial connectedness, Figure 3 plots the network graphs for the first quarter of 1999, the period before the breakout of the financial crisis (second quarter of 2007) as well as the last quarter for which data is available (fourth quarter of 2014).[19] The evolution in relative importance of bilateral exposures is captured by normalizing the overall amount of assets held. The network graphs show a considerable dynamics in who-to-whom numbers, in particular with respect to the relative role played by the MFI and the OFI sector. Whilst the amount of assets of the MFI sector in particular with respect to domestic firms, other domestic MFIs and OFIs has increased enormously between 1999 and 2007, figures have remained quite stable since then. On the other hand, the analogous data for the OFI and the ICPF sector show a continuous increase in both sub-periods. Overall, results document that the relative importance of the OFI and the ICPF sector has increased, with the OFI sector evolving particularly dynamic.

The finding of an increasing degree of interconnectedness especially of the OFI sector is further strengthened by explicitly considering the dynamics of this relationship over the sample period (see Figure 4). While absolute figures for the amount of assets held by OFIs from other sectors are still considerably smaller than those for the MFI sector (upper panels), the two lower panels illustrate that the degree of interconnectedness of the OFI sector has considerably increased, both before and after the crisis. For MFI, however, a significant decline in within-sector and a stagnation of cross-sector interconnectedness is evidenced since the crisis broke. This of course mirrors the almost literal freezing of un-secured interbank lending being substituted by the ECB which lend its balance sheet (unconventionally) to

[19] The data underlying these network plots are given in Tables 1, 4 and 5, respectively.

substitute for the missing interbank

In the next subsection, we will examine the dynamics which the given degree of interconnectedness implies for the propagation of an adverse economic shock, either hitting the NFC or the HH sector, i.e. emanating from the "real" economy.

4.2 Propagation of financial shocks

Estimated who-to-whom data can be used to perform an illustrative assessment of how shocks to one sector of the economy affect the other sectors via the mutual balance-sheet relationships.[20] The major idea underlying the quantitative thought experiments conducted below can be illustrated as follows. Assume our economy consists of three sectors A, B and C which are interconnected via cross-holdings of assets such as loans or debt and/or securities holdings. Now assume, that in period 0 sector A, experiences a drop in its income, causing a deficit which shows in its profit and loss account. Imposing the assumption that the sectors of the economy are subject to mark-to-market balance-sheet valuation, losses of sector A will induce a reduction in the value of its equity. Assuming that sectors B and C hold shares of sector A this leads to subsequent losses in the net financial wealth of both sector B and sector C which have to be deducted from their respective equity. However, this drop in the value of B's and C's equity will again be reflected in declining asset values of those sectors which own the equity issued by B and C, leading to a further adjustment in net financial wealth and shareholder equity positions. This process continues until some of the sectors either report offsetting positive earnings, or, alternatively, the shock reaches a sector that either dis-connected from other sectors or is not subject to mark-to-market accounting.

Following Castrén and Kavonius (2009), we consider two different shock scenarios: in the first case, we assume that the nonfinancial corporation sector experiences an income loss leading to a 20% reduction in the sector's asset value. This will induce a propagation mechanism as outlined in the previous paragraph. In the second scenario, we consider a 15% impairment of loans extended to the household sector. This shock will, in a first round, affect the profit-and-loss accounts of those sectors having extended loans to households. In further rounds, the contagion process will be as described above.

The numerical results of the two scenarios are reported in Table 2. To set results for the last sample period for which the experiment is conducted (Q4/2014) into

[20] An exposition of the underlying mechanisms leading to these contagion effects is given in Kiyotaki and Moore (2002) and Shin (2008), a similar experiment as ours has been conducted by Castrén and Kavonius (2009).

perspective, we also report outcomes for the pre-crisis period Q2/2007. We report losses only for two periods, namely the shock and after-shock period, given that the underlying ceteris-paribus condition becomes less and less reliable the further we move away from the initial period.

Considering the effect of the income shock to the NFC sector, we see that the greatest losses are experienced by the NFC, the HH, the OFI and the ROW sectors due to the relatively large proportion of shares they hold in this sector. Somewhat surprisingly, the MFI sector is affected only relatively mildly. Comparing outcomes between 2007 and 2014, we observe a slight decrease in the shock effects (when related to total assets).

The effect of the impairment of loans extended to the HH sector is relatively small for all sectors in the shock period apart from the MFI sector. The latter outcome results from the large volume of loans which banks extended to households. In the after-shock period, losses in all sectors but the MFI sector increase, particularly as an upshot of the sizeable drop in the value of the MFI's equity, implying corresponding revaluation losses of other sectors' shareholders. Comparing results between 2007 and 2014 we only observe minor changes in the shock effects.

Even though the analysis of this subsection provides some interesting insights into potential contagion effects of adverse economic shocks hitting one particular sector it has a major drawback: it ignores any consequences arising from changed risk considerations. But they do regularly play a decisive role, particularly in crises periods. The approach considered in the next section overcomes this shortcoming by combining the findings from this section with results obtained from employing contingent claims analysis at the sectoral level.

5 Shock transmission: accounting for sectoral default probabilities

The assessment of the effects of negative economic shock in the previous section was based on the "book values" of assets and liabilities. However, as Gray et al. (2007) convincingly argue, such an approach is only sensible in a deterministic world. There, the value of equity of a firm/sector reduces to the accounting "net worth" which equals a deterministic asset value minus a (historic) measure of the book value of debt. To motivate the inclusion of risk considerations into the macro-financial analysis of shock transmissions, Gray et al. (2007, page 13) provide the following, illustrative analogy to a single-firm setting:

> " ... Risk managers would find it difficult to analyze the risk exposure of their firm or financial institution by relying solely on the income and cash flow statements, and not taking into account (mark-to-market) balance sheets or information on their institution's derivative or option positions. Country risk analysis that relies only on macroeconomic flow-based approach is deficient in a similar way, given that the traditional analysis does not take into account the volatility of assets... "

In the following, we thus employ contingent-claims analysis (CCA) at an economic sector level and combine the balance-sheet information of the flow-of-funds data with proxies for the respective sectors' equity volatility. Thus, we replace each sector's "traditional accounting balance sheet" (Jobst and Gray, 2013) by a "risk-adjusted (CCA) balance sheet." Repeating afterwards the shock simulation scenario of the last section allows us to provide risk-based assessments of the consequences of these shock scenarios.[21]

5.1 Contingent-claims analysis

CCA represents a generalization of the option pricing theory pioneered by Black and Scholes (1973) and Merton (1973). It has been used comprehensively to value contingent claims, i.e., financial assets whose payoff depends on the future value of other assets. CCA rests on Robert Merton's ingenious insight that the position of stock owners can be understood as holding a call option on the firm which they will only exercise (i.e. buy back the firm from its creditors) is larger than its debt. The required debt payment is effectively the strike price of this call. In a similar, actually exactly corresponding vein, bondholders have written a put. And rational stockholders default whenever the value of assets falls below a well-defined barrier (Merton, 1974), at least in theory.[22]

The intuition underlying this idea can be illustrated using Figure 5 which is taken from Gray et al. (2007, Figure 1a). On the y axis, the value of a firm's total assets, denoted by A_t, is plotted. Returns are assumed to follow a stochastic process given by:

$$\frac{dA}{A} = \mu_A dt + \sigma_A \varepsilon \sqrt{t}, \tag{2}$$

[21] Similar exercises have been conducted by Castrén and Kavonius (2009) for the Euro Area, Silva et al. (2011) for Portugal and Plašil and Kubicová (2012) for the Czech Republic.

[22] For excellent expositions, see Hull (2012) or Saunders and Allen (2010).

where μ_A denotes the drift rate, σ_A represents the standard deviation of the asset returns and ε is an i.i.d. normally distributed increment with mean zero and unit variance. Promised payments of the firm correspond to the face value of its debt. For a given initial asset value, A_0, a certain probability distribution of the values of$A$ in period T arises, reflecting uncertainty about that period's realization of A. As can be seen in the graph, with a certain probability, denoted as "actual probability of default", the firm will not be able to fully serve its debt obligations because the realized asset value A_T is smaller than B, the promised payments. Given the assumption of normally distributed increments, the probability that this occurs is given by:

$$P\left(A_T \leq B\right) = P\left(A_0 \exp\left[\left(\mu_A - \sigma_A^2/2\right)T + \sigma_A \varepsilon \sqrt{T}\right] \leq B\right) = P\left(\varepsilon \leq -d_{2,\mu}\right) = N\left(-d_{2,\mu}\right),$$

with

$$d_{2,\mu} = \frac{\ln\left(A_0/B\right) + \left(\mu_A - \sigma_A^2/2\right)T}{\sigma_A \sqrt{T}}$$

and $N(\cdot)$ representing the cumulative normal distribution. This shows the probability of debt repayment depending on the value of the firm's assets at T. It is risky due to the volatility in the prices of the firm's assets.

To price the value of the debt, CCA assumes that there exists a (European) put option on the firm's assets with a strike price equal to the face value of the debt at maturity T. Given that this put option can be employed to serve as a guarantee against default, in the absence of arbitrage opportunities the value of the debt plus the value of the guarantee, i.e., the price of the put option, is equal to the value of the default-free value of the debt. Considering on the other hand the situation of equity holders it is clear that the value of equity also depends on the value of the total assets at period T: it corresponds to the difference between the value of total assets and the face value of debt if the former is larger and is zero otherwise. In other words, equity has the same payoff as an implicit call option on the firm's total assets with strike price equal to the face value of debt and maturity T.

Following Gray et al. (2007), we make use of this perspective in evaluating liabilities of economic sectors which we consider to represent either a portfolio of individual entities or one large entity. Liabilities, equity and total assets are then related to the aggregate balance sheet of this sector and are approximated as described below.

In the following, a more formal exposition of the approach will be given.[23] Denoting a sector's total assets in a particular period by A, its junior claims (equity) by J and the value of its risky debt by D, we have[24]

$$A = J + D. \tag{3}$$

As outlined above, the junior claims of a sector are interpreted as an implicit call option on the assets, with an exercise price equal to the promised payments, B, maturing in T periods. The risky debt, D, is equivalent in value to default-free debt minus a guarantee against default. This guarantee is calculated as the value of a put on the assets with an exercise price equal to B as follows:

$$D = Be^{-rT} - P, \tag{4}$$

where P denotes the put price. The value of the junior claims is then computed using the Black-Scholes-Merton formula for the value of a call and is given by:

$$J = AN\left(d_1\right) - Be^{-rT}N\left(d_2\right), \tag{5}$$

with

$$d_1 = \frac{\ln\left(\frac{A}{B}\right) + \left(\mu_A + \frac{\sigma_A^2}{2}\right)T}{\sigma_A\sqrt{T}} \tag{6}$$

$$d_2 = d_1 - \sigma_A\sqrt{T}, \tag{7}$$

where σ_A denotes the implicit volatility of a sector's assets. Following Castrén and Kavonius (2009) and Gray et al. (2007), the real drift of the asset, μ_A, is related to the risk-neutral asset drift, r, by $\mu_A = r + \lambda\sigma_A$, where λ denotes the market price of risk.[25] To obtain – back out – the unknown implicit values of a sector's assets, A, and its assets' volatility, σ_A, we additionally use

$$\sigma_J J = N\left(d_1\right) A\sigma_A \tag{8}$$

and solve Equations (5) and (8) for A and σ_A using a standard nonlinear optimization routine.

[23] This exposition closely follows Gray et al. (2007).

[24] For notational ease, we have dropped time indices. The current time period, t, is set equal to 0.

[25] See Gray et al. (2007, Annex: Extensions of the Merton Model) for more details on the derivation of this relationship.

5.2 Evidence on sector-level default risk indicators

To apply the model we need data on the volume of junior claims, J, their volatility, σ_J , and the value of the default barrier, B, for each sector. The values we use for this purpose correspond to the ones employed by Castrén and Kavonius (2009) who for their part essentially follow MKMV (2003) and Gray et al. (2007).[26]The values for the junior claims (i.e. equity, that is, claims on residual income) and the default barrier are obtained from the flow-of-funds data. Junior claims are defined as the sum of equity and net financial wealth (defined as a sector's total assets minus total liabilities). For the government sector, junior claims correspond to government debt securities issued plus the government net financial wealth position.

The default barrier, B, is computed as the sum of a sector's short-term liabilities plus one half of its long-term liabilities where short-term liabilities are given by currency and deposits, short-term loans and debt securities, derivatives instruments and other accounts and receivables and long-term liabilities include long-term debt securities and loans, mutual fund shares, net equity of households in life insurance and pension fund reserves and pre-payments of insurance premia.

The volatilities of junior claims, σ_J , for the MFI and the ICPF sector are given by the implied volatilities of the relevant sector-level stock indices. For the OFI sector, the implied volatility of the financial services sub-sector stock index is used. In case of the NFC sector, the average implied volatility using data from all individual non-financial corporate sectors is taken. For the government and the household sectors, we employ the ECB's Composite Indicator of Systemic Stress for the bond market and for the ROW sector the implied volatility of the CBOE's VIX stock index is taken. Finally, we adopt the convention that λ, i.e. the market price of risk, is fixed at 0.45, corresponding to the global long-term average value as calculated by Moody's KMV.[27]

Computed debt ratios (measured by the ratios of the default barriers B to the implied asset values A) exhibit distinctively different patterns across the three financial sectors (Figure 6). Throughout the sample period, it has been the highest for MFIs and by far the lowest for OFIs with the values for the ICPF sector being in between. For the MFI sector, not surprisingly, the debt ratio has been above 90% throughout the sample period, reaching a maximum of almost one (99.5%) at the nadir of the crisis. Since 2009, the value has steadily declined, reaching 93% most recently. This corresponds to the lowest value observed since 2004. It might

[26]We have also conducted some sensitivity analyses, available upon request.

[27]Results turn out not to be very sensitive to smaller changes in this value.

be plausibly surmised that this has been the result of tougher regulations as well as markets calling for more self-insurance. Asset shedding and deleveraging on the side of banks are compatible with this. However, as mentioned above, this value is still much larger than those for the other two sectors.

The numbers for ICPFs are the most volatile, fluctuating between 80% and 90%. They exhibit two local maxima: the first occurs in the period of the financial crisis, the second is reached in the fourth quarter of 2011. While the background for the emergence of the former is obvious, the latter very likely reflects negative developments which the insurance sectors experienced in 2011 and which included the write-off of Greek government bonds, the Japanese earthquake and of course the overall weak economic situation in the Euro Area at that time.[28] Again, this is a direct upshot of long-term bonds being the preferred investment habitat of insurance companies. Since then, the debt ratio has steadily declined reaching a value of slightly below 80% in the fourth quarter of 2014. This value corresponds to the global minimum in the overall sample period.

Figures for the debt ratio in the OFI sector show a remarkable constancy: throughout the sample period, they have remained very close to 60% and thus have been much lower than those for the other two sectors.

The implied asset volatilities, σ_A (Figure 7) again exhibit a stable order between the sectors. However, this time, values are normally by far the highest – and thus least favorable – for OFIs and lowest for MFIs with the values for ICPFs being again in between. While there exist enormous differences in the dynamic variation of values across sectors, some common patterns can be observed: In all sectors, there is an upward trend from 2004 until the end of 2008 followed by an up-and downward movement in the subsequent years and signs of a stabilization and (slight) decrease after the 3rd quarter of 2012. Towards the end of the sample period, a renewed increase seems to have occurred.

Not surprisingly, volatilities reach maximum values during the peak of the financial crisis at the end of 2008, where the increase was particularly pronounced for OFIs. Interestingly, already in 2005, a steady increase in volatilities occurs which gained momentum in the middle of 2007 when clear indications of deeper problems in the U.S. subprime markets became too obvious to disregard. A second local maximum is reached in 2010, i.e., the time period characterized by the eruption of the Greek debt crisis. Again, OFIs exhibit the most pronounced increase. However, MFIs are affected much more long-lasting given their intensive interconnections with governments via

[28] For more background on the development of the ICPF sector in 2011, see ECB (2011).

their holdings of public bonds. This is, of course, the infamous doom loop which the Banking Union is supposed to address. The (so far) last local maximum occurs at the end of 2011 and the beginning of 2012 when the Euro Area experienced a deep crisis of confidence and debates about a break-up where prevalent. Here, again OFIs are affected most, whereas MFIs experience a much less pronounced and long-lasting rise. The enormous drop in the asset volatility of OFIs (and to a somewhat smaller degree) ICPFs in the last quarter of 2012 reflects the reestablished confidence in the euro after the famous "whatever-it-takes" speech by the President of the ECB, Mario Draghi.[29]

The distance-to-distress measures ($d2$), presented in Figure 8, exhibit at least four noteworthy features: first, values for all three sectors move remarkably in parallel. They exhibit a continuous downward trend from 2004 until the end of 2008 when they reach their respective global minima in the considered sample period, reaching from 2 for the MFI and ICPF sectors to around 3 for the OFI sector. From the beginning of 2009 onwards until around the mid of 2011, values increase but decline again afterwards. Since the third quarter of 2012, they experience a considerable upward trend with a small decline in all sectors in the last period covered. Secondly, and most interestingly, default probability in the OFI sector has always been lowest throughout the sample period and almost always highest for the MFI sector (apart from some phases at the beginning of the sample period). Thirdly, variations in default probabilities are much more pronounced in the OFI sector than in the other two sectors. Fourthly, only in the ICPF sector the default measure has reached its level from the pre-crisis period whereas it is still or again below this level both in the MFI and OFI sector.

Overall, the findings obtained from the CCA provide instructive insights. All movements in the computed risk indicators can be intuitively traced back to developments in the Euro Area which can account for these changes both qualitatively and quantitatively. Most interestingly, problematic events are not only indicated "ex post", but tendencies towards a deteriorating situation can regularly be detected already some time in advance. In this respect, the observable drop in distance-to-distress values which occurred in the last two sample periods merits careful monitoring.

5.3 Shock propagation

In this subsection, we repeat the simulation exercises of Section 4.2 where we analyzed the implications of a negative 20% profit shock to firms and a 15% impairment of

[29] See Draghi (2012).

loans extended to households. However, we additionally consider an increase in the volatility of each sector's equity value which regularly occurs in crisis periods. In this context, we consider two diferent scenarios which we call baseline crisis and high-volatility crisis scenario, respectively. In the former case, we assume that volatility of junior claims increases by 15%, in the latter we assume that volatility of junior claims in each sector takes the value it had during the peak of the global financial crisis (Q4/2008).

The intuition underlying the conducted thought experiments can now be described as follows: assuming that the economy is hit by a negative firm-profit shock we observe an immediate impact on the equity of the NFC sector via the profit-and-loss account and as a consequence a reduction in the market value of its shares ("equity channel"). This effect corresponds to the one described in Section 4.2. Similarly, an impairment in loans also has the same effects as those present in the case when only levels of the bilateral exposure were considered.

However, there is now a second transmission channel, a "risk channel": the reduction in a sector's equity (plus the exogenously set increase in its volatility) can change the risk profile of the sector by increasing its probability to default. If this occurs, losses are incurred not only by those sectors that hold shares of the sector hit by the shock, but also by all other sectors that are in a creditor position relative to this sector. This is because under mark-to-market pricing, any decrease in the repayment likelihood will lead to an adjustment of the creditor sectors' claims by the amount which is expected not to be paid back.

The reduction in the share prices of the "owner sectors" (equity channel) and the potential write-offs of other claims induced by the changed risk profile of the shock sector by the "creditor sectors" (risk channel) will in turn induce a fall in the market prices of these sectors' shares and a potential change in their probability of default in the after-shock period. As a consequence, write-offs in the then affected "owner" and "creditor" sectors have to take place. This process will in principal repeat in consecutive periods either until the shock has been fully absorbed by the system or until one or several sectors, having depleted their resources, are no longer capable of absorbing the original negative shock and the system as a consequence collapses.

The resulting loss numbers of the baseline crisis scenario (upper panel of Table 3) clearly illustrate the significance of the risk channel: both for the profit shock and the loan shock the implied losses significantly increase for all sectors both in the shock and the after-shock period. In the case of the profit shock, losses in period 1 now range from 0.62% (MFIs) to 6.20% (HH) of total assets compared to the range

of 0.41% (MFIs) to 5.54% (HH) reported for the setup without risk (Section 4.2). For the loan shock, the assets losses now amount to values between 0.39% and 1.65% which compares to values between 0.04% and 1.46% for the non-risk-weighted case. As outlined above, this marked increase in losses is due to the fact that sectors, besides incurring losses as a result of a fall in the market prices of their shareholdings (i.e, the equity channel), run up further losses due to risky bilateral exposures (i.e., the risk channel).

These two channels are moreover mutually reinforcing given that a decrease in equity of a particular sector in a given period increases its default probability leading to additional equity losses in creditor sectors in subsequent periods. The quantitative importance of this mechanism is clearly evidenced by the values reported for the after-shock period ($t = 2$). For the profit-shock case, the range of losses shifts upwards from between 0.34% (MFIs) and 4.62% (HH) to between 0.59% (MFIs) and 5.73% (HH). For the loan-shock, the increase is even more pronounced: rather than ranging from 0.12% (MFIs) to 1.68% losses now amount to values between 0.36% (MFIs) and 2.70% (HH).

If one assumes that uncertainty reaches its financial-crisis level (high-volatility crisis scenario), losses experienced increase as expected considerably (see lower panel of Table 3). Whereas the increases in the first period are of a "purely" quantitative nature, the figures for the second period represent a qualitative change: loss figures in almost all sectors now increase rather than decrease compared to their values in the shock period. In other words, the increase in the volatility of junior claims has a substantial impact on the default property of most sectors leading to considerably larger write-offs of creditor sectors.

To gain some intuition on the relationship between our default measure of a sectors and its risk exposure, Figures 9 to 11 plot the sensitivity of the distance-to-default values of the three financial sectors with respect to their leverage ratios and the volatility of their junior claims. The graphs show changes in the leverage ratio (measured by the ratio of junior claims to total assets) being more or less linearly related to changes in the distance-to-default measures in all three sectors (and also in the neighborhood of the leverage ratio observed in Q4/2014). In contrast, this relationship is highly is highly non-linear with respect to the volatility of junior claims (see Figure 9), implying that relatively small increases in volatility lead to significant changes in the default probability and thus expected losses for creditor sectors. The reported loss numbers for the high-volatility crisis scenario even point to the possibility of a "non-converging" shock dynamics as described by Haldane

(2009):

> " ... interconnected networks exhibit a knife-edge, or tipping point, property. Within a certain range, connections serve as a shock-absorber. The system acts as a mutual insurance device with disturbances dispersed and dissipated [. . .] But beyond a certain range, the system can flip the wrong side of the knife-edge. Interconnections serve as shock-amplifiers, not dampeners, as losses cascade. The system acts not as a mutual insurance device but as a mutual incendiary device. Risk-spreading - fragility - prevails."

Unlike the scenario outlined here, the figures for the period following the after-shock phase indicate a sizeable decline though. [30]

Overall, results from this subsection illustrate how important the explicit consideration of the risk dimension is for the proper assessment of the stability of the financial system. As has become clear, conclusions can change significantly, depending on the level of risk present in the economy.

6 Summary and conclusions

To provide an assessment of recent trends in the stability of both bank and non-bank financial intermediaries within the Euro Area we employ up-to-date financial accounts data and extend and complement existing studies in various dimensions. Taking a functionally rather than institutionally oriented perspective of the financial system, we focus on the activities of financial institutions rather than the institutions themselves. As a consequence, we undertake a comprehensive analysis of the financial-intermediation sector comprising the activities of MFIs, ICPFs and OFIs and are thus, e.g., able to capture substitution effects between financial institutions caused by the far-reaching regulatory changes which have occurred ever since the GFC. Moreover, applying a variety of methods – part of which were only recently developed – to a sample period encompassing the pre-crisis, the crisis and after-crisis period we not only conduct an assessment of the current stance of stability of the financial sectors considered but also provide some indications on the usefulness of the individual measures for policy purposes.

Our main findings are as follows. We can confirm previously made propositions of some noteworthy "substitution effects" between the banking (MFI) and the "shadow-banking" (OFI) sector. Based on simple risk metrics derived from sectoral

[30] Data are available from the authors upon request.

balance-sheet data, we document that there has occurred a decline in the MFI sector which has been compensated mostly by an increase in the activities of OFIs, leaving the overall size of the financial intermediation sector relatively constant. Similarly, a substitution has taken place with respect to the loan-granting activities of these two sectors. As a result, a certain shift of risk in the system from the MFI to the OFI sector has taken place. These findings derived from balance-sheet measures are confirmed by our estimates of the dynamics of the degree of financial interconnectedness between economic sectors.

Secondly, while the accounting-based measures do not appear to be useful as indicator variables for financial supervisors, our risk-adjusted measures are. Their movements can be straightforwardly linked to economically significant changes in regulatory or monetary background conditions in an intuitive manner and they tend to point to problematic dynamics before these have become plainly obvious.

Thirdly, our risk-adjusted measures indicate that the resilience of all financial sectors has increased in recent years. However, only the ICPF sector has reached its pre-crisis stability level so far. Moreover, asset volatility is shown to play a very important role, implying that increased uncertainty in financial markets can lead to sudden and substantial deteriorations in terms of stability. Moreover, there are signs of a slight increase in default risks occurring at the end of the sample period.

References

Adrian, T. (2014). Financial stability policies for shadow banking. Federal Reserve Bank of New York Staff Report No. 664.

Adrian, T. and Shin, H. S. (2009). The shadow banking system: Implications for financial regulation. Federal Reserve Bank of New York Staff Report No. 382.

Bakk-Simon, K., Borgioli, S., Giron, C., Hempell, H., Maddaloni, A., Recine, F., and Rosati, S. (2012). Shadow banking in the euro area: An overview. ECB Occasional Paper No. 133.

Barwell, R. and Burrows, O. (2014). Growing fragilities? Balance sheets in the great moderation. In Winkler, B., van Riet, A., and Bull, P., editors, A flow-of-funds perspective on the financial crisis - Volume II: Macroeconomic imbalances and risks to financial stability, chapter 3, pages 40–109. Palgrave Macmillan.

Beck, G. W., Kotz, H.-H., and Zabelina, N. (2015). Assessing the size and structure

of bank and non-bank ("shadow") banks in the euro area employing a functional approach. Manuscript. SAFE.

Bernanke, B. S. (2004). The logic of monetary policy. Remarks before the National Economist Club, Washington, D.C., December 2, 2004.

Bernanke, B. S. (2007). Monetary policy under uncertainty. Speech delivered at the 32nd Annual Economic Policy Conference, Federal Reserve Bank of St. Louis (via videoconference).

Bisias, D., Flood, M. D., Lo, A. W., and Valavanis, S. (2012). A survey of systemic risk analytics. Office of Financial Research Working Paper No. 0001.

Black, F. and Scholes, M. (1973). The pricing of options and corporate liabilities. The Journal of Political Economy, pages 637–654.

Castrén, O. and Kavonius, I. K. (2009). Balance sheet interlinkages and macro-financial risk analysis in the euro area. ECB Working Paper Series No. 1124.

Claessens, S., Pozsar, Z., Ratnovski, L., and Singh, M. (2012). Shadow banking: Economics and policy. IMF Staff Discussion Note.

Claessens, S. and Ratnovski, L. (2014). What is shadow banking? IMF Working Paper - WP/14/25.

Constancio, V. (2014). Forward. In Winkler, B., van Riet, A., and Bull, P., editors, A flow-of-funds perspective on the financial crisis - Volume II: Macroeconomic imbalances and risks to financial stability. Palgrave Macmillan.

de Rougemont, P. and Winkler, B. (2014). The financial crisis in the light of the euro area accounts: selected issues. In Winkler, B., van Riet, A., and Bull, P., editors, A flow-of-funds perspective on the financial crisis - Volume II: Macroeconomic imbalances and risks to financial stability, chapter 6, pages 155–198. Palgrave Macmillan.

Degryse, H., Kim, M., and Ongena, S. (2009). Microeconometrics of banking: methods, applications, and results. Oxford University Press, USA.

Deutsche Bundesbank (2014). The shadow banking system in the euro area: overview and monetary policy implications. Monthly Report, March 2014, pp. 15 - 34.

Draghi, M. (2012). Speech delivered at the Global Investment Conference in London, July 26, 2012.

Draghi, M. (2014). Monetary policy communication in turbulent times. Speech delivered at the Conference De Nederlandsche Bank 200 years: Central banking in the next two decades.

ECB (2011). Financial Stability Review. December 2011.

ECB (2012). Handbook on quarterly financial accounts for the euro area - sources and methods.

ECB and Eurostat (2007). Quarterly euro area and European Union account for institutional sectors (European sector accounts). Background document.

European Commission (2013). Shadow banking – Addressing new sources of risk in the financial sector. Communication from the Commission to the Council and the European Parliament - /* COM/2013/0614 final */.

Financial Stability Board (2011). Shadow banking: Scoping the issues. Publication by the Financial Stability Board.

Freixas, X. and Rochet, J.-C. (2008). Microeconomics of Banking, Second Edition. Cambridge [Mass]: The MIT Press.

Friedman, B. M. (1993). The role of judgment and discretion in the conduct of monetary policy: Consequences of changing financial markets. In Changing Capital Markets: Implications for Monetary Policy. Federal Reserve Bank of Kansas City, Federal Reserve Bank of Kansas City.

Gennaioli, N., Shleifer, A., and Vishny, R. W. (2013). A model of shadow banking. The Journal of Finance, 68(4):1331–1363.

Gorton, G. and Metrick, A. (2012). Securitized banking and the run on repo. Journal of Financial Economics, 104(3):425–451.

Gray, D. F., Merton, R. C., and Bodie, Z. (2007). New framework for measuring and managing macrofinancial risk and financial stability. NBER Working Paper Series No. 13607.

Haldane, A. G. (2009). Rethinking the financial network. Speech given at the Financial Student Association, Amsterdam.

Hartmann-Wendels, T., Pfingsten, A., and Weber, M. (2013). Bankbetriebslehre. Springer-Verlag.

Hull, J. (2012). Risk Management and Financial Institutions,+ Web Site, volume 733. John Wiley & Sons.

IMF (2014). Global Financial Stability Report - risk taking, liquidity, and shadow banking: Curbing excess while promoting growth.

IMF, BIS, and FSB (2009). Guidance to assess the systemic importance of financial institutions, markets and instruments: Initial considerations: Report to the G-20 Finance Ministers and Central Bank Governors; October 2009. Available at: http://www.imf.org/external/np/g20/pdf/100109.pdf.

Jobst, A. A. and Gray, D. F. (2013). Systemic contingent claims analysis–estimating market-implied systemic risk. IMF Working Paper - WP/13/54.

Kiyotaki, N. and Moore, J. (2002). Balance-sheet contagion. American Economic Review, pages 46–50.

Kolaczyk, E. D. and Csárdi, G. (2014). Statistical analysis of network data with R, volume 65. Springer.

Merton, R. C. (1973). Theory of rational option pricing. The Bell Journal of Economics and Management Science, pages 141–183.

Merton, R. C. (1974). On the pricing of corporate debt: The risk structure of interest rates. The Journal of Finance, 29(2):449–470.

Merton, R. C. (1995). A functional perspective of financial intermediation. Financial Management, 24(2):23–41.

Merton, R. C. and Bodie, Z. (2004). The design of financial systems: towards a synthesis of function and structure. NBER Working Paper Series No. 10620.

MKMV (2003). Modeling default risk. Moody's KMV, Moody's Analytics (http://www.mkmv.com).

Plašil, M. and Kubicová, I. (2012). Contingent claims analysis and the inter-sector transmission of credit risk. Czech National Bank: Financial Stability Report, pp. 129–139.

Saunders, A. and Allen, L. (2010). Credit risk management in and out of the financial crisis: New approaches to value at risk and other paradigms, volume 528. John Wiley & Sons.

Semmler, W. (2011). Asset prices, booms and recessions: financial economics from a dynamic perspective. Springer Science & Business Media.

Shin, H. S. (2008). Risk and liquidity in a system context. Journal of Financial Intermediation, 17(3):315–329.

Silva, N., Ribeiro, N., and Antunes, A. (2011). Towards a cca-based systemic risk indicator. Banco de Portugal, Financial Stability Report-Novembro.

Svensson, L. E. (2005). Monetary policy with judgment: Forecast targeting. NBER Working Paper Series No. 11167.

Tobin, J. and Brainard, W. C. (1963). Financial intermediaries and the effectiveness of monetary controls. The American Economic Review, pages 383–400.

Upper, C. (2011). Simulation methods to assess the danger of contagion in interbank markets. Journal of Financial Stability, 7(3):111–125.

Upper, C. and Worms, A. (2004). Estimating bilateral exposures in the German interbank market: Is there a danger of contagion? European Economic Review, 48(4):827–849.

Winkler, B. (2010). Cross-checking and the flow of funds. In Stark, J. and Papademos, L., editors, Enhancing monetary analysis (Frankfurt am Main: European Central Bank, pages 355–80. European Central Bank.

7 Tables

Table 1: Approximated who-to-whom data for the first quarter of 1999

	NFC	HH	MFI	ICPF	OFI	GG	ROW
NFC	2007.15	464.88	2280.68	514.60	1226.85	794.52	778.04
HH	3006.07	696.24	3415.72	770.70	1837.42	1189.94	1165.25
MFI	3871.80	896.76	4399.43	992.66	2366.59	1532.63	1500.84
ICPF	892.38	206.69	1013.99	228.79	545.46	353.24	345.92
OFI	2191.17	507.50	2489.77	561.78	1339.33	867.36	849.37
GG	542.47	125.64	616.40	139.08	331.58	214.74	210.28
ROW	1726.62	399.91	1961.92	442.67	1055.38	683.47	669.30

Notes: Table 1 contains who-to-whom data for the various sectors of the euro area economy in the first quarter of 1999. The who-to-whom data are estimated from total assets/liabilities data employing the RAS algorithm. Data source: ECB, euro area accounts.

Table 2: Propagation of shocks to firms profits and loans extended to households

	Shock to profits of NFC sector				Impairment of loans to the HH sector			
	2007Q2		2014Q4		2007Q2		2014Q4	
	$t = 1$	$t = 2$	$t = 1$	$t = 2$	$t = 1$	$t = 2$	$t = 1$	$t = 2$
NFC	661	521	646	538	108	191	131	195
HH	487	384	377	314	3	141	3	114
MFI	169	133	127	106	455	49	455	38
ICPF	200	157	245	204	26	58	27	74
OFI	650	512	765	637	119	188	156	231
GG	105	83	115	96	16	30	38	35
ROW	494	389	641	534	91	143	112	194
	$t = 1$	$t = 2$	$t = 1$	$t = 2$	$t = 1$	$t = 2$	$t = 1$	$t = 2$
NFC	2.51	1.98	2.24	1.86	0.41	0.73	0.45	0.68
HH	8.19	6.46	5.54	4.62	0.05	2.37	0.04	1.68
MFI	0.58	0.46	0.41	0.34	1.57	0.17	1.46	0.12
ICPF	3.11	2.44	2.92	2.43	0.40	0.90	0.32	0.88
OFI	4.21	3.31	3.48	2.90	0.77	1.22	0.71	1.05
GG	1.46	1.16	0.95	0.80	0.22	0.42	0.31	0.29
ROW	3.51	2.76	3.20	2.66	0.65	1.02	0.56	0.97

Notes:

1) Table 2 reports sectoral losses of equity induced by an initial (period $t = 1$) 20% shock to profits of the NFC sector (columns 2 to 5) and an impairment of 15% of the loans extended to the HH sector (columns 6 to 9).

Table 3: Propagation of shocks to firms profits and loans extended to households: Risk weighted

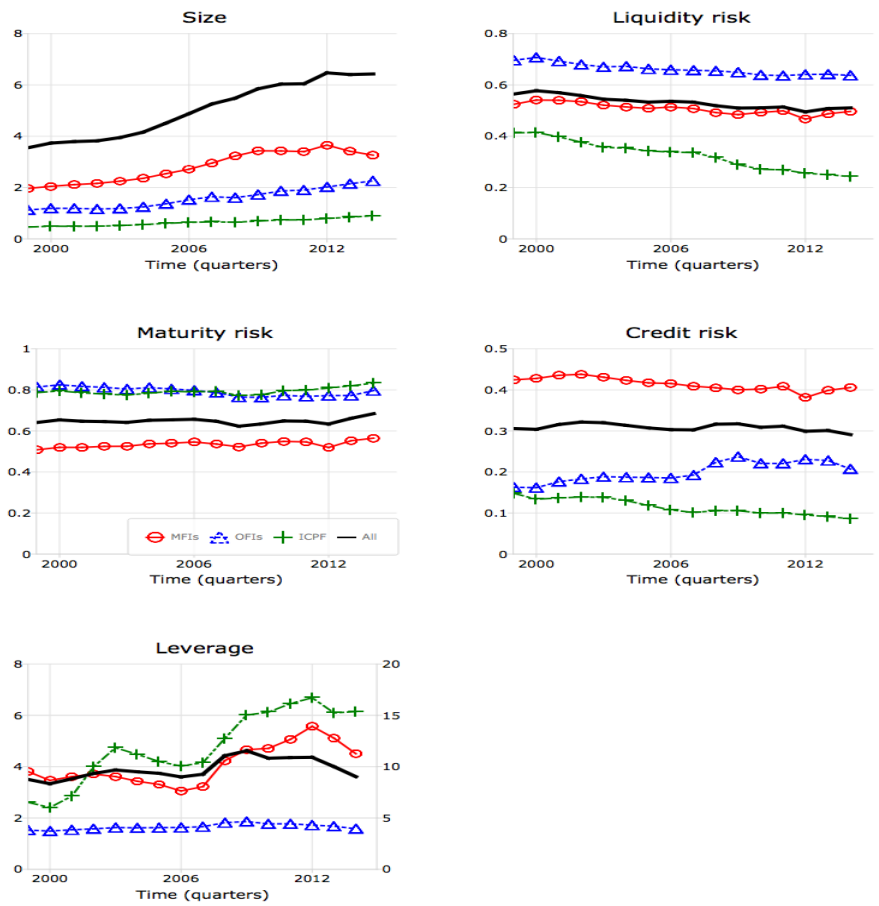
	Shock to profits of NFC sector				Impairment of loans to the HH sector			
	Baseline crisis scenario							
	Losses (absolute/rel. to total assets)				Losses (absolute/rel. to total assets)			
	$t = 1$		$t = 2$		$t = 1$		$t = 2$	
NFC	687	2.38	630	2.18	169	0.58	280	0.97
HH	422	6.20	390	5.73	45	0.66	184	2.70
MFI	194	0.62	186	0.59	517	1.65	112	0.36
ICPF	264	3.15	243	2.89	44	0.53	110	1.31
OFI	812	3.70	745	3.39	201	0.91	331	1.51
GG	125	1.03	115	0.95	47	0.39	52	0.43
ROW	687	3.43	631	3.15	155	0.77	283	1.41
	High-volatility crisis scenario							
	Losses (absolute/rel. to total assets)				Losses (absolute/rel. to total assets)			
	$t = 1$		$t = 2$		$t = 1$		$t = 2$	
NFC	742	2.57	757	2.62	215	0.74	384	1.33
HH	481	7.07	495	7.28	95	1.40	269	3.95
MFI	282	0.90	299	0.96	592	1.89	201	0.64
ICPF	289	3.45	296	3.53	66	0.78	153	1.82
OFI	876	3.99	894	4.07	254	1.16	453	2.06
GG	138	1.14	141	1.17	59	0.48	74	0.61
ROW	748	3.73	765	3.82	206	1.03	392	1.96

Notes:

1) Table 3 reports sectoral losses of equity induced by an initial (period $t = 1$) shock to profits of the NFC sector (columns 2 to 5) and an impairment of loans extended to the HH sector (columns 6 to 9) when risk considerations are taken into account.

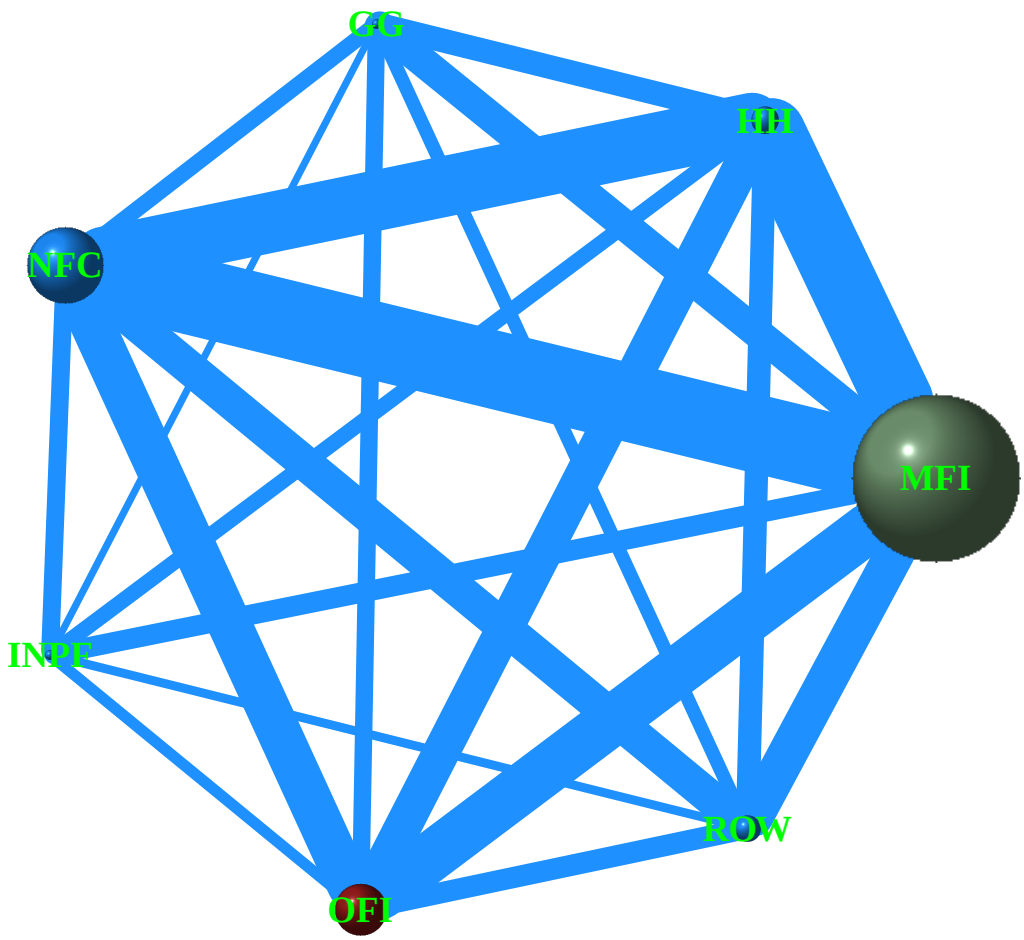
8 Figures

Figure 1: Balance-sheet risks of financial intermediaries

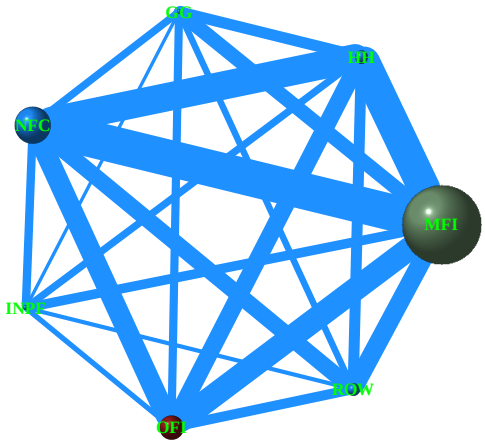


Notes: Figure 1 plots various risk measures of activities of financial intermediaries employing sectoral balance-sheet data. Size is measured as the ratio of the sector's total assets to Euro Area GDP. Asset liquidity risk corresponds to one minus the ratio of currency and deposits, securities other than shares and mutual fund shares to total assets. Asset mature risk is computed as the ratio of long-term assets (long-term loans and securities and assets) to total assets. Credit risk reflects the ratio of loans to total assets. Leverage is computed as the ratio of total assets to shares and other equity (the right y axis contains the numbers for the MFI and the ICPF sector, whereas the left y axis those for the other sectors). Data source: ECB, Euro Area accounts.

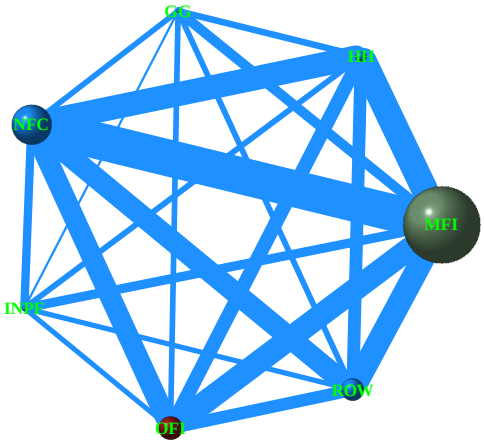
Figure 2: Network graph representation of the euro-area who-to-whom data, 1999Q1



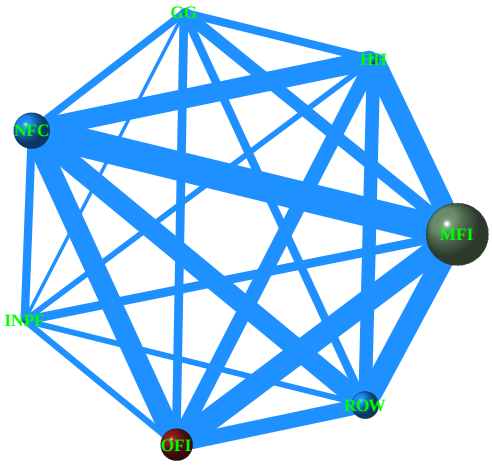
Notes: Figure 2 contains a graphical visualization of the who-to-whom data for the various sectors of the Euro Area economy presented in Table 1. The who-to-whom data are estimated from total assets/liabilities data employing the RAS algorithm. Data source: ECB, Euro Area accounts.



(a) 1999Q1



(b) 2007Q2

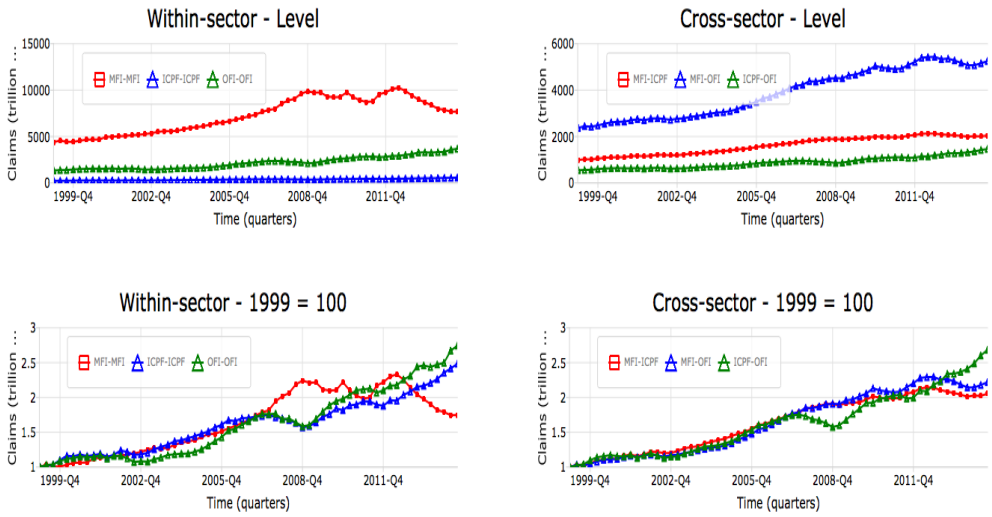


(c) 2014Q4

Notes: Figure 3 contains a graphical visualization of the who-to-whom data for the various sectors of the Euro Area economy for 1999, 2007 and 2014. The who-to-whom data are estimated from total assets/liabilities data employing the RAS algorithm. A detailed description including more detailed results is available in Beck et al. (2015). Data source: ECB, Euro area accounts.

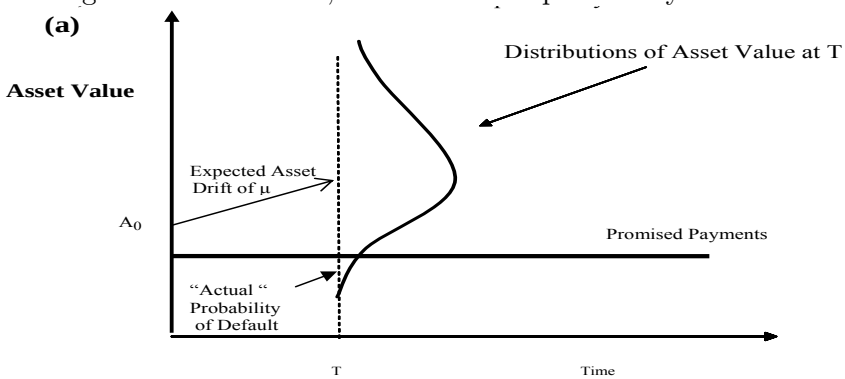
Figure 3: A comparison of financial interconnectedness: 1999, 2007 and 2014

Figure 4: Interconnectedness within the financial sectors



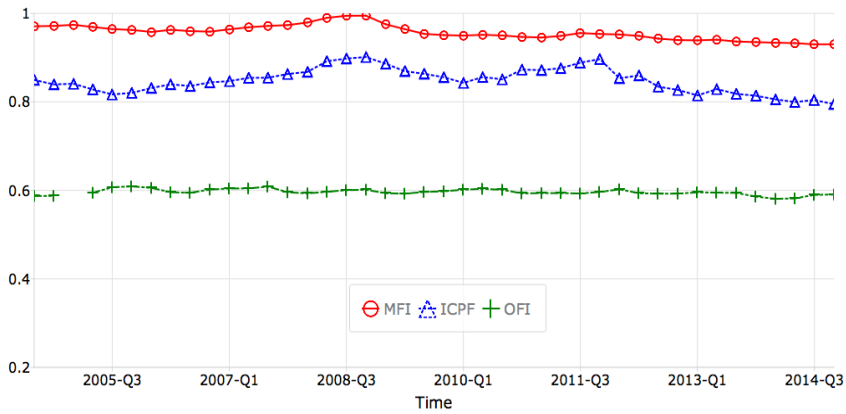
Notes: Figure 4 plots the dynamics of the amount of assets held by entities of the MFI, OFI and INS sector with respect to other entities of the respectively same sector (left panels) or the two other sectors (right panels). The who-to-whom data are estimated from total assets/liabilities data employing the RAS algorithm. A detailed description including more detailed results is available in Beck et al. (2015). Data source: ECB, Euro area accounts.

Figure 5: Asset value, debt value and probability of default



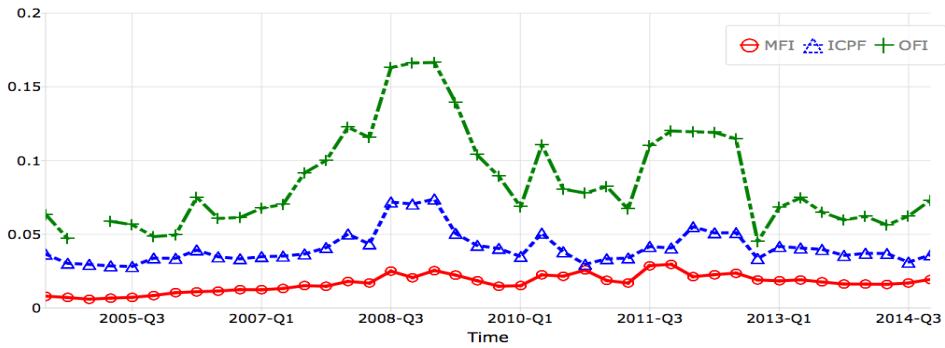
Notes: Figure 5 plots the distribution of the future value of a firm assuming a given drift μ and normally distributed increments. The promised payments corresponds to the face value of the firm's debt. The figure is taken from Gray et al. (2007, Figure 1 a).

Figure 6: Implied debt/asset ratios



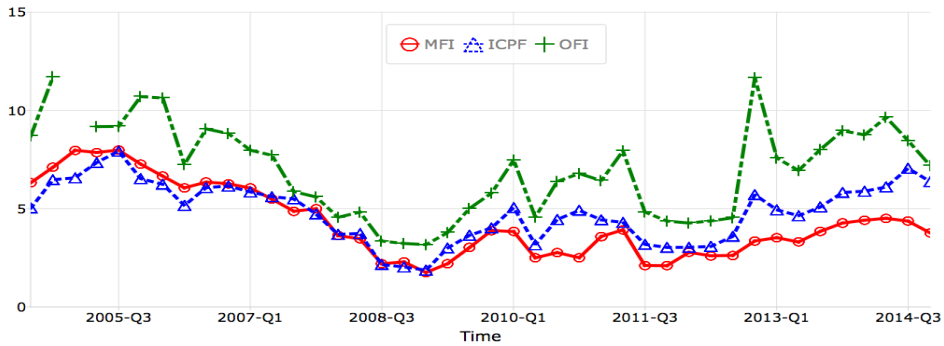
Notes: Figure 6 plots the ratio of debt (the default barrier B) to the computed implied asset values, A, for monetary financial institutions, insurance companies and pension funds and other financial institutions.

Figure 7: Implied asset volatilities



Notes: Figure 7 plots implied asset volatilities for monetary financial institutuions, insurance companies and pension funds and other financial institutions.

Figure 8: Distance to distress



Notes: Figure 8 plots the distance-to-distress measures ($d2$) for monetary financial institutions, insurance companies and pension funds and other financial institutions.

A Appendix - Additional tables

Table 4: Approximated who-to-whom data for the second quarter of 2007

	NFC	HH	MFI	INPF	OFI	GG	ROW
NFC	3988.45	900.89	4396.92	976.37	2342.71	1087.88	2133.43
HH	4637.49	1047.50	5112.43	1135.26	2723.93	1264.91	2480.60
MFI	7122.38	1608.77	7851.80	1743.55	4183.49	1942.67	3809.77
INPF	1619.40	365.78	1785.24	396.43	951.19	441.70	866.22
OFI	4017.18	907.38	4428.58	983.40	2359.58	1095.71	2148.79
GG	821.20	185.49	905.30	201.03	482.35	223.99	439.26
ROW	4103.77	926.94	4524.04	1004.60	2410.44	1119.33	2195.11

Notes: Table 4 contains who-to-whom data for the various sectors of the euro area economy in the first quarter of 1999. The who-to-whom data are estimated from total assets/liabilities data employing the RAS algorithm. Data source: ECB, Euro area accounts.

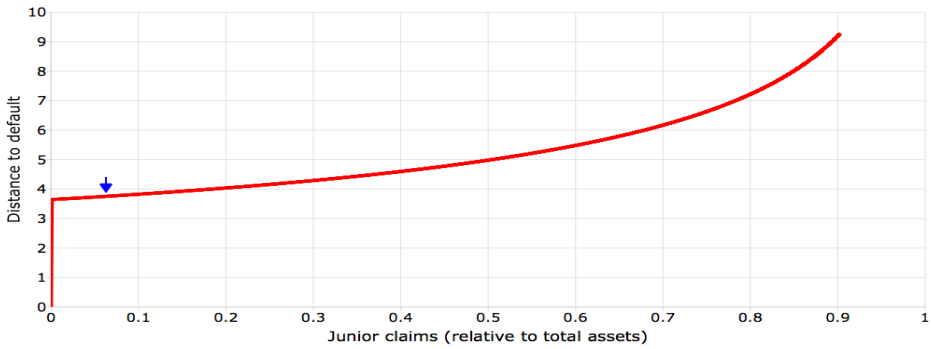
Table 5: Approximated who-to-whom data for the forth quarter of 2014

	NFC	HH	MFI	INPF	OFI	GG	ROW
NFC	4302.51	1013.30	4657.55	1249.46	3270.79	1797.55	2984.90
HH	4687.71	1104.02	5074.53	1361.32	3563.61	1958.48	3252.13
MFI	7009.77	1650.90	7588.20	2035.65	5328.85	2928.62	4863.08
INPF	1986.94	467.95	2150.89	577.01	1510.48	830.12	1378.45
OFI	5025.43	1183.56	5440.12	1459.39	3820.35	2099.58	3486.43
GG	1051.07	247.54	1137.80	305.23	799.03	439.13	729.19
ROW	4819.33	1135.02	5217.01	1399.54	3663.67	2013.47	3343.45

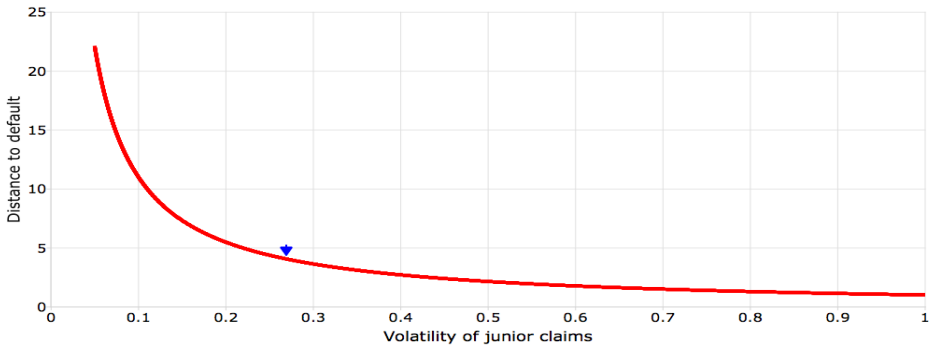
Notes: Table 5 contains who-to-whom data for the various sectors of the euro area economy in the first quarter of 1999. The who-to-whom data are estimated from total assets/liabilities data employing the RAS algorithm. Data source: ECB, Euro area accounts.

B Appendix - Additional figures

Figure 9: Sensitivity of distance-to-distress measure: MFIs



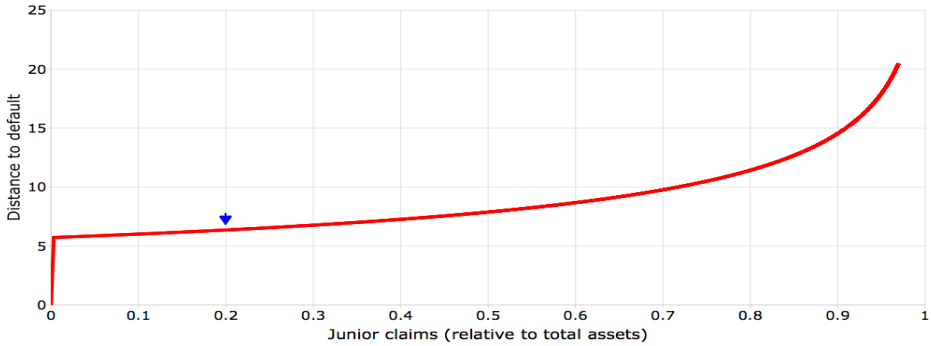
a) Sensitivity with respect to level of junior claims



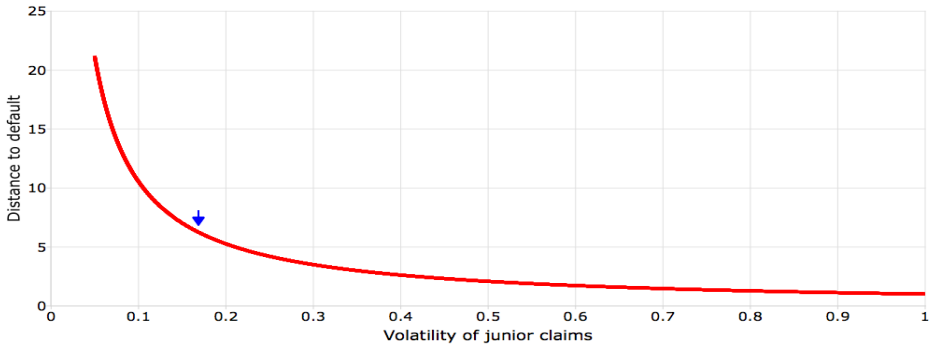
b) Sensitivity with respect to volatility of junior claims

Notes: Figure 9 plots the sensitivity of the distance-to-distress measures ($d2$) for MIFs with respect to changes in the level of junior claims and the volatility of junior claims . In the first case, the volatility of junior claims takes its actual value as observed in 2014Q4, in the second case, the level of junior claims takes its actual value as observed in 2014Q4). The debt level corresponds to the one observed in 2014Q4. The blue inverted triangle indicates the value actually observed in 2014Q4.

Figure 10: Sensitivity of distance-to-distress measure: ICPFs



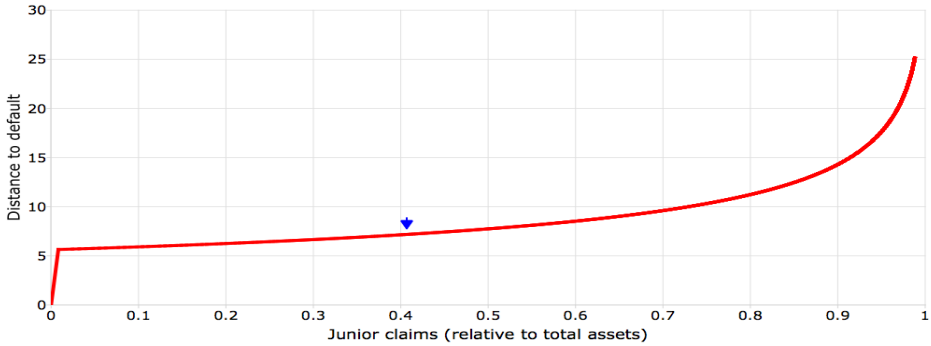
a) Sensitivity with respect to level of junior claims



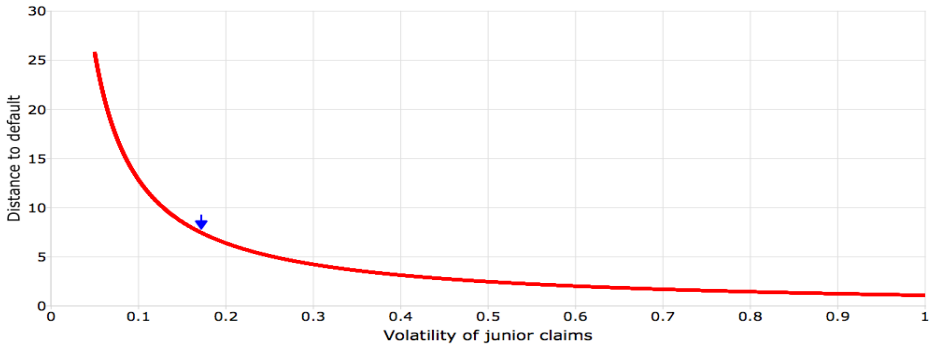
b) Sensitivity with respect to volatility of junior claims

Notes: Figure 10 plots the sensitivity of the distance-to-distress measures ($d2$) for ICPFs with respect to changes in the level of junior claims and the volatility of junior claims . In the first case, the volatility of junior claims takes its actual value as observed in 2014Q4, in the second case, the level of junior claims takes its actual value as observed in 2014Q4). The debt level corresponds to the one observed in 2014Q4. The blue inverted triangle indicates the value actually observed in 2014Q4.

Figure 11: Sensitivity of distance-to-distress measure: OFIs



a) Sensitivity with respect to level of junior claims



b) Sensitivity with respect to volatility of junior claims

Notes: Figure 11 plots the sensitivity of the distance-to-distress measures ($d2$) for OFIs with respect to changes in the level of junior claims and the volatility of junior claims . In the first case, the volatility of junior claims takes its actual value as observed in 2014Q4, in the second case, the level of junior claims takes its actual value as observed in 2014Q4). The debt level corresponds to the one observed in 2014Q4. The blue inverted triangle indicates the value actually observed in 2014Q4.