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SYSTEMIC RISK WITHIN THE GLOBAL FINANCIAL ARCHITECTURE: A CASE STUDY OF EU BANKS

By

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Introduction

The global financial crisis 2007-8 has underscored the need to go beyond the analysis of individual institutions' soundness and assess whether the linkages across institutions may have negative implications. With the financial crisis of 2007/2008, systemic risk took centre stage and challenged our understanding of a financial system that has become highly interconnected and increasingly complex. The financial crisis has simultaneously underlined the importance of systemic risk and the absence of an appropriate framework for assessing, monitoring and regulating it.

One of the most important lessons from this crisis and also the simplest, is the need to safeguard against systemic risk; the financial system needs to be managed as a system (Haldane, 2009). It is very simple but far from obvious before the crisis. During the pre-crisis era there appeared to be a period of stable growth and stable banks: the 'Great Moderation' as it was called (Bernanke, 2004). Also Haldane (2014) argues, the orthodoxy was that safeguarding individual financial firms is a necessary and sufficient condition for system-wide stability. This assumption was the financial stability equivalent of the English aphorism 'look after the pennies and the pounds will look after themselves'. Never taking consideration for the fact that the extra dimension of the inter-relation between financial institutions required a separate safeguard procedure. So Haldane (op. cit.) rightly counter-argues that the crisis has rewritten that orthodoxy. It revealed that the safety of individual banks was neither a necessary nor sufficient condition for systemic stability. Not necessary because, in any well-functioning system, individual banks can and should fail. Not sufficient because, in an integrated web, the chain is only as strong as its weakest link.

In reality the Great Moderation gave way to the Great Recession (Gai and Kapadia, 2010). In Haldane's (2014) viewpoint policymakers had been, to coin another English aphorism, 'penny-wise but pound-foolish'. As addressed in the Rodiguez-Moreno and Pena (2013) contribution the most important financial risk is systemic risk because the problem it causes is not something the market can solve on its own. This gravity of scale has resulted in systemic risk entering public lexicon. Similarly, following on from that period, financial regulation has been fundamentally re-oriented towards the monitoring and management of systemic risk (Haldane, 2014).

Another outcome of the recent financial crisis in terms of the approach to risk management was to change the traditional focus of risk analysis centred on quantitative methods and simulation models, to instead examine the structure and stability of the financial system as a whole, with special attention given to contagion mechanisms which may lead to large scale instabilities in the financial system. A financial crisis is 'systemic' in nature if many banks fail together, or if one bank's failure propagates a contagion causing the failure of many banks. At the heart of reformed bank regulations is the deep-seated concern that social and economic costs of such systemic crises are large. It is thus broadly understood that the goal of prudential regulation should be to ensure the financial stability of the system as a whole, i.e. of an institution not only individually but also as a part of the overall financial system.

This study intends to answer these main questions, in order to build a solution of both theoretical and practical application to help identify and mitigate against systemic risk. (i) What is the definition of systemic risk? (ii) How can systemic risk in the banking network be measured? (iii) What is a suitable analytical tool for assessing and monitoring systemic risk in EU banks, which enable us to visualise the relationship between the financial network topology and systemic risk? (iv) Does the banking network follow a core-periphery structure? (v) What are the effects of microeconomic shocks on the banking structure? Does the banking structure network affect stability of the system? What is the role of aggregate fluctuations and its dependency on network structure? (vi) To what extent were EU banks exposed to systemic risk at a country level during and after the financial crisis of 2007/8? (vii) What is the impact of global financial architecture on systemic risk?

The objective of this study is threefold: to provide an analytical tool for assessing and monitoring systemic risk- with a focus on EU banks; to show the role of structure in assessing systemic risk of financial markets; and finally to assess the processes required to better consolidate a financial market structure and architecture to minimize systemic risk. To achieve this aim, the study uses data in both macro and micro capacities including different cross-border bank exposures, Gross Domestic Product (GDP), banks' balance sheet data, CDSs, LIBOR-OIS, and LIBOR –Tbill spreads.

The study will answer the questions by proposing a definition for systemic risk (question i), analysing the systemic risk measurement approaches (question ii), proposing an analytical tool for assessing and monitoring EU banks' exposure to systemic risk, analysing intercinterconnectedness of EU banks before and after the financial crisis 2007/8 (question iii), testing the core periphery structure of the banking network (question iv), the effect of microeconomic shocks on the banking structure by analysing first and second order connectivity and centrality measures (question v), to what extent EU banks were exposed to systemic risk at the country's level at the time of the financial crisis 2007/8 (question vi) finally analysing the impact on the global financial architecture in terms of inherent associated systemic risk (question vii).

This research comprises of eight chapters, the first chapter is a literature study covering various systemic risk definitions as the financial crisis 2007/8 reminded us that we live in an interconnected world, creating a myriad of efficiency, technological and communication gains. On the flip side, interconnections also bring about systemic volatility which leads to contagion problems within the banking system Chapter 2 is the theoretical framework of the thesis. Network theory in financial market and its limitation is explained in this chapter. Theoretical framework of different approaches to measure systemic risk, network models and contagion risk in banking sector are analysed in chapter 2. The chapter explain theoretical base of the financial system architecture. Chapter three of the study focuses on the research methodologies applied to the study (question iii). Looking at the previous research methodologies, a means of attaining broader in-depth results is proposed. The sources of data and the measurement parameters are discussed. Chapter 4 explains the suitable analytical tool for assessing and monitoring systemic risk in EU banks which in turn enables us to visualise the relationship between the financial network topology and systemic risk. This chapter aims to examine the structure of financial network at an individual country's level using network formation theory and then illustrate the structure of this network. The concept of core-periphery network is empirically tested in the chapter by using the probit regressions testing whether network position can be predicted by individual network variables. This is the same methodology as Craig and Von Peter (2010) used for perfect core periphery structure.. The results confirmed the previous finding in this field (see, for example, Farboodi, (2014)). It shows that interbank relations coming to a core-periphery structure where the fit with 'betweeness' is much better than the fit with cross border exposures. The model indicates that there is a small number of very interconnected banks that trade with many other banks and a large number of banks that trade with a small number of counterparties. One of the key goal of this chapter is to map out the effect of cross-border bilateral exposures and their macroeconomics consequences, as well as evaluate the topology of network and its effect on shocks transmission.

Chapter 4 points out that (i) banking network coming into scale free structure ;(ii) interbank structure follow the core-periphery structure (iii) the composition of banks group within the core sector remains remarkably stable over time. (iv) among centrality measures the fit of Core with 'betweeness' is much better than others; (v) countries with shallow domestic financial markets and concentrated exposures to a few lenders are more prone to synchronized shifts in cross-border flows; (vi) the importance of heterogeneity in network structure and the role of concentration of counterparty exposures in explaining its systemic importance of a banking sector in the economy; (vii) American banks positions in the network changed from fragile section to important and fragile; and(viii)common factors (such as global risk aversion) increasingly drive global financial markets and tend to intensify abruptly during periods of stress, amplifying shock transmission.

Chapter 5 aims to answer important questions such as: What are the effects of microeconomic shocks on the global banking structure? Does the banking structure network affect the system's stability? What is the role of aggregate fluctuations and its dependency on network structure? As well as structural vulnerability and how the effects of microeconomic shocks may not remain confined to where they originate. Chapter 5 explores structural vulnerabilities at the country level, but also look at bilateral exposures within a network context. The study's results illustrate that the contribution of banks' size, size of economy and concentration of counterparty exposures directly correlates to explaining its systemic importance.

This is illustrated by explaining the effect on selected banks. We explained why regional banking structures might be more stable, as this model keeps the shocks where they originate and avoids transmitting the shocks to other sectors. The analysis in chapter 5 attempts to capture systemic risks stemming from common exposures, interbank linkages, funding concentrations, and other factors. To address this assessment we analyse the behaviour of network structure on aggregate volatility. The effect of shock on different structures (ring, complete network and star network) is discussed in details. Our analysis verifies the finding of other studies that the interbank relations that emerge to pool region-specific shocks may at the same time create fragility in response to unanticipated shocks (see, for example, Allen and Gale, 2000). The finding verifies what Haldane (2009) suggests: "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 tip the wrong side of the knife-edge. Interconnections serve as shock-amplifiers, not dampeners, as losses cascade" (p. 9).

We measure the first order and second order interconnectivity of selected network. The first order interconnectivity of the European banks indicates strong connectivity between a small numbers of countries. Aggregated figures since 2005 put UK, Germany, France and US as the most interconnected among the network. However comparing first order interconnectivity of 2014Q1 and 2007Q1 network, indicated that US banks became more interconnected in 2014 compared to the financial crisis time, 2007. In 2014 only the core countries (UK, Germany, France, US) held 65% of the whole network interconnectivity. We then map out aggregated first order and second order interconnectivity and rank the banks at country's level based on first and second order interconnectivity. To gain further evidence the empirical density of first and second order connectivity are calculated.

It was addressed how rings are more stable or more fragile than complete networks by using asymptotic analysis and review the limit when n goes to infinity. In this case the question is equivalent to whether the law of large numbers applies and everything concentrates around its mean and if so how quickly or slowly σ_{agg} converge to zero. We discuss the classic law of large number hold at the speed of $\frac{1}{\sqrt{n}}$, if it is going to be slower it means aggregate volatility would remain for much longer. The analytical framework applied to visualising propagations of idiosyncratic shocks shows that aggregate fluctuations depend on network structure, the nature of interaction over the network between sectors and types of idiosyncratic shocks. The overall result of the chapter underlines the importance of specifying the shock structure before investigating a given network due to incompatibility of a given network and shock structure. In line with recent studies the chapter highlights that there is no single optimal financial architecture.

Chapter 6 aims to answer this research question: To what extent were EU banks exposed to systemic risk at the country level during and after the financial crisis 2007/8? The results illustrate the contribution of banks' sizes, the aggregate size of the economy and the concentration of counterparty exposures to a given country's banks in explaining its systemic importance; also to what extent the banking network depends on a few traditional hubs of activities and the changes of these dependencies over the last nine years. The role of a few traditional hubs such as Swiss banks and British banks and also Irish banks—where the financial sector is fairly new and grew strongly between the 1990s till 2008—take the fourth position in the 2014 EU ranking after completing a financial assistance programme in 2013, and reducing the relative size of its finance sector since 2006 where they had the first position. Dependency of the banking sector of a particular country on cross-border activities is measured by foreign lending ratio in chapter 6. For instance 2014 figures indicate that 40% of Swiss banks activities depended on cross border transaction followed by Dutch and Swedish Banks with 33%. By analysing In-degree concentration index the study shows that concentration of banking network was not changed since the financial crisis of 2007-8. In-degree concentration index on first quarter of 2014 indicates that US, UK and Germany together, resulted in over 70% of the network exposures. The result of comparing the in-degree concentration index with 2007-4Q, shows the same group having over 70% of the network exposure however the UK achieved a more important role in the hub and the market share of US and Germany had slightly diminished. Figures of 2014 indicates that 36% of American banks foreign exposures came from Canadian banks. This means that Canadian banks exposure increased since 2007 and they are heavily exposed to American banks. In the case of British banks the case is even worse at 68% of British banks foreign exposures came from Irish banks. Irish banks increased this ratio from 29% on 2007-Q4 to 68% to stay heavily exposed to British Banks. The results of chapter 6 can help better connect global surveillance with country-level specificities. This chapter contributes to the existent literature by examining the structure of the banking network and developing a framework that explains how interdependencies between banks at country level emerge endogenously by mapping out the banking network. In particular, we develop a framework of network formation for the banking system at country level which could be used by regulators and policymakers.

The focus of chapter 7 is on the impact of global financial architecture on systemic risk. Is there any connection between systemic risk and new global financial architecture? To understand the inherent systemic risk in global financial architecture, chapter 7 explains the features of this architecture using different macroeconomic data. In the conclusion we are suggesting that the systemic risk framework should be expanded and modified to explicitly incorporate financial architecture and financial structure in addition to stability. While financial stability is a central goal, financial structure and architecture should merit the same attention. We analyse the long-run imbalances of finance-dominated capitalism underlying the 2007-8 financial crisis with a focus on developments in the EU and US. We argue that beyond inefficient regulation of the financial sector, the severeness of financial crisis 2007-8 has been mainly caused by features of global financial architectures including rising imbalances, increasing inequalities of income distribution in the world economy associated with finance-dominated capitalism and dollar dominated financial market. In order to avoid a huge systemic risk in the global financial system, we suggest that any policy package of a global financial market deal should consist of re-structuring of the financial market and build up a new global financial architecture based on role and connection of financial market in real economy.

Chapter 8 conclude the thesis with a few recommendations. The study highlights that many of the structural characteristics that contributed to the build-up of systemic risks in banking sectors are still in place today. Our analysis in Chapters 4, 5 and 6 indicate that the structure of the banking system has changed little during 2007-2014. Even though regulation attempts have been made, as discussed in Chapter Seven, there is much to be done. The study explains how the effects of microeconomic shocks may not remain confined to where they originate due to the financial market structure. It is also highlighted that the architecture of the financial network deserves the same attention as individual and interlinkage of individual participants in the market.

Chapter 1: Literature Review

1.1 Introduction

Systemic risk is not a new problem. We know it can lead to economic catastrophe. That is what happened in the 1920s and '30s, 2000s and then 2007-8. European Governments' capital injection into the euro area averaged 230 billion EUR, at the height of the financial crisis 2007/8; with the International Monetary Fund (IMF) estimations (also European Central Bank – ECB) ranged from 220 – 400 billion EUR, using broad balance sheet projections (European Union Report on the Crises, 2009). Similarly, the cost to the US economy is estimated at about $6 trillion to $14 trillion—and possibly twice that—along with untold costs from the "special treatment" bailouts too-big-to-fail banks received, according to analysis from the Dallas Federal Reserve (Atkinson, Luttrell and Rosenblum, 2013). Few years ago around the fifth-year anniversary of the Lehman Brothers' bankruptcy, the central bank analysis took a stark look at the costs left behind by the crisis and the ensuing bailout. Among the lasting damages, the paper cites continuing and pervasive unemployment as well as the opportunity costs that came from $12.6 trillion indirect aid given to the financial sector (Atkinson, Luttrell and Rosenblum, op. cit.).. In September 2009 the total cost of the global financial crisis to G-20 countries for the bailout of the financial system was announced to be around $10.8 trillion[1] (Moreno and Peña, 2013).

However, the cost of the crisis is not limited to the bailouts. Substantial costs are also incurred by the negative evolution of the fundamental macro variables such as GDP growth rate, unemployment rates and government deficits, among others. For instance, the annual GDP growth rate decreased from 3.09% in 2007 to -4.09% in 2009 in the European Union (OECD Statistics), reportedly the sharpest contraction in the history of the European Union. In the US, this rate decreased from 2.14% to -2.45% (Moreno and Peña, 2013, p. 2). With respect to the unemployment rate, it increased from 7.8% in January 2007 to 9.4% in November 2009 in the European Union. In the US, this rate increased from 4.6% to 10% in the same period. Still it is not the whole picture,

[1] However, most of the bailouts are in the form of guarantees to the financial system and hence, governments hope to recover some of the money. Concretely, the IMF estimated global losses to be around $3.4 trillion by October 2009. http://www.imf.org/external/pubs/ft/gfsr/2009/02/pdf/press.pdf

regarding the government deficits,[2] they dramatically increased from 0.8% in 2007 to 6.7% in 2009 in the European Union, and in the same period, US government deficits increased from 1.14% to 9.9%.

Haldane (2010) has tried to work it all out in a paper called 'The $100 billion question', where he notes "But these direct fiscal costs are almost certainly an underestimate of the damage to the wider economy which has resulted from the crisis – the true social costs of the crisis. World output in 2009 is expected to have been around 6.5% lower than its counterfactual path in the absence of a crisis. In the UK, the equivalent output loss is around 10%. In money terms, that translates into output losses of $4 trillion and £140 billion respectively" (p. 3). Haldane (op. cit.) tries to put a global figure on the losses, "Put in money terms, that is an output loss equivalent to between $60 trillion and $200 trillion for the world economy and between £1.8 trillion and £7.4 trillion for the UK. For UK banks, the average annual subsidy for the top five banks (between 2007 and 2009) was over £50 billion - roughly equal to UK banks' annual profits prior to the crisis. At the height of the crisis, the subsidy was larger still. For the sample of global banks, the average annual subsidy for the top five banks was just less than $60 billion per year. These are not small sums." (p. 5)

As would be unravelled later in this study, systemic risk played an important role in the financial crisis of 2007/8. It meant that the banks amongst themselves monopolised the circulation of money. Such that the failure of any one bank will ensure they all go down like dominos. That is why Rodriguez-Moreno and Pena (2013) state that the most important financial risk is systemic risk because the problem it causes cannot be solved by the market alone. In recent years there have been many studies on the role of systemic risk in the global financial crisis but very few put the market structure at their focal point (see, for example, Acemoglu, Ozdaglar and Tahbaz-Salehi, 2013; Alessandri and Gai, 2009; Atik, 2011; and BCBS, 2009)).

Due to the recent financial crisis, understanding systemic risk is becoming the centre of attention in macro-prudential supervisory and regulatory policies. Identifying, assessing and mitigating systemic risks requires a broad and deep understanding and a wide range of tools to process the relevant information. Ingredients for meeting these requirements include market intelligence, data analysis and analytical models and tools.

[2] Government deficits are expressed as a proportion of the GDP.

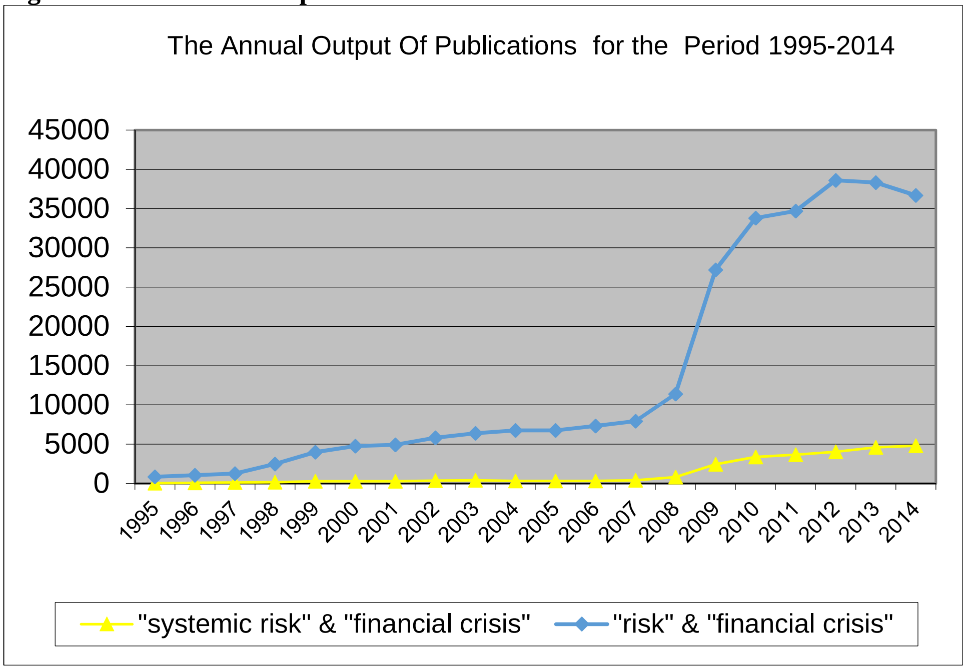
This study identifies, assesses and analyses the systemic risk with the focus on EU banks during the financial crisis of 2007/8. The aim of the study is to provide an analytical tool for identification and assessment of systemic risk by focusing on EU banking data. By measuring systemic risk of a sample of banks between 2005 and 2014, we will analyse the systemic risk in the EU banking system before and after the financial crisis of 2007/8 and at the peak of the crisis. However, as many of these problems come from events related with financial market structure and its adverse effect on the real economy, the study will review the connection between systemic risk and the global financial architecture as well. In line with Schwarcz(2010) we assume institutional systemic risk and market systemic risk should not be viewed in isolation. Institutions and markets can both be triggers and transmitters of systemic risk. Similarly, we will set out to discover how to monitor systemic risk and what the role of the financial market's structure and architecture is in systemic risk. The study aims to identify systemic risk; how it affected the global financial crisis; and the possibility of having an analytical tool for assessing and monitoring systemic risk, in light of structural analysis in EU banks; and also, how systemic risk can be reduced in the future to prevent systemic financial and banking crises.

1.2 : Definition of Systemic Risk

Attention to systemic risk assessment and contagion has dramatically increased with the global financial crisis, although a precise definition of systemic risk is still lacking (see Borio and Drehmann, 2009; and Kaufman and Scott, 2003) for a discussion of the definition, and for a literature survey (see, also, De Bandt, Hartmann and Peydró, 2009).

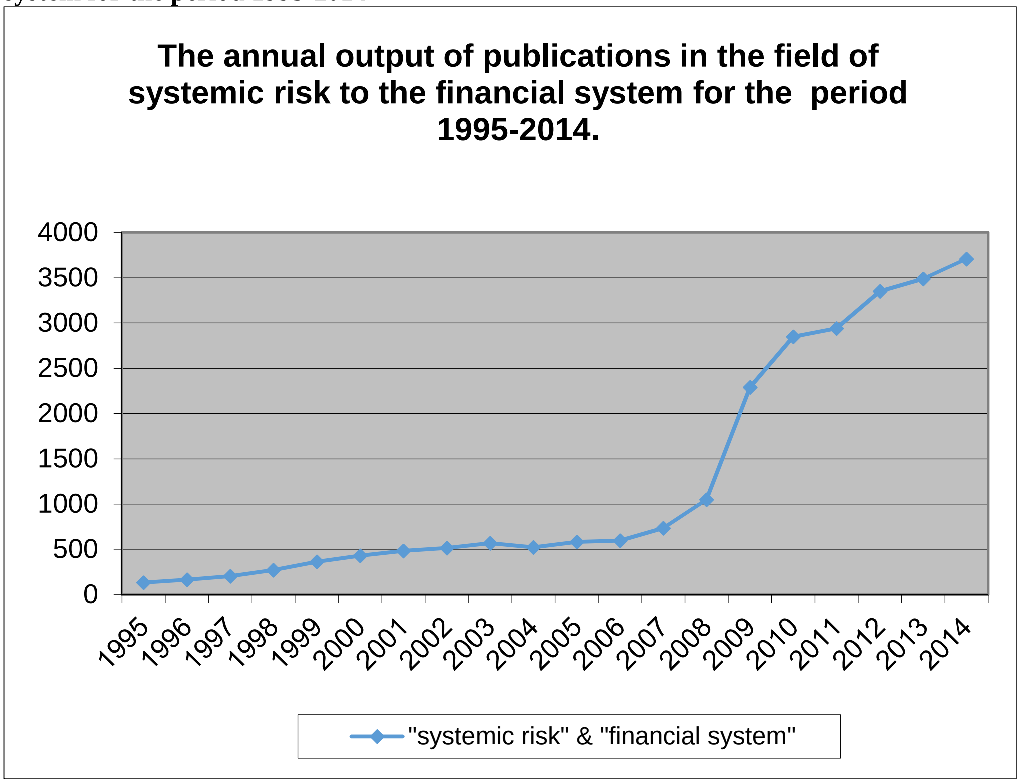
The financial crisis 2007/8 has focused attention on the systemic risk of the financial system and led to an explosion of research in the field. The data displayed in Figure 1 shows the annual output of research publications, as measured by searching on Google Scholar in the Business, Administration, Finance, and Economics subject areas for documents containing both the terms 'systemic risk' and 'financial system'. This data suggests that the literature in the field is growing at a rate in the order of thousands of publications per annum. Although it is not possible for us to keep abreast of all new developments, we have reviewed some of the recent literature in this study. There is similar output for the terms 'systemic risk and financial crisis' and 'risk and financial crisis'. (Figure 1-3)

Figure 1 The Annual Output of Publications for the Period 1995-2014



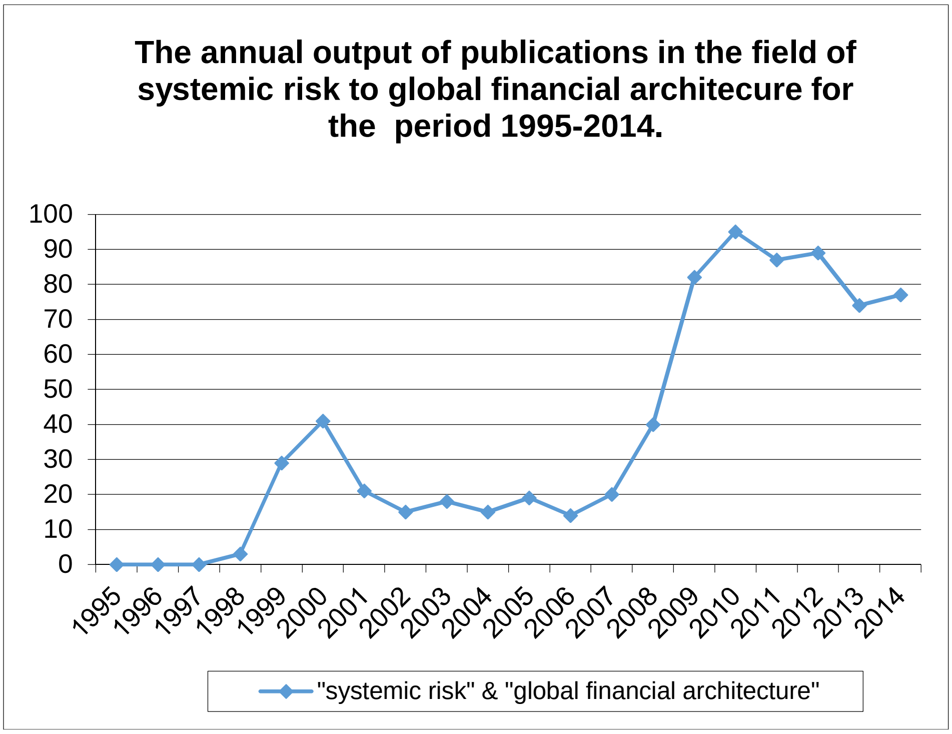
Source: Author's own figure

Figure 2 The annual output of publications in the field of systemic risk to the financial system for the period 1995-2014



Source: Author's own figure

Figure 3 The annual output of publications in the field of systemic risk to global financial architecture for the period 1995-2014



Source: Author's own figure

1.2.1 The Process of Defining Systemic Risk

One of the most feared events in banking is the cry of systemic risk. It matches the fear of a cry of ‘fire!’ in a crowded theatre or other gatherings. But unlike fire, the term systemic risk is not clearly defined (Kaufman and Scott, 2003). In order to safeguard financial stability, we need to clearly understand the definition and source of systemic risk. To properly define the source of systemic risk, a coherent and efficient definition of systemic risk is needed. Defining systemic risk is essential for implementing the most recent proposals for financial reform, including some of those in the chapters in this research.

We start by defining what we mean by ‘system’. A system is a set of interdependent elements that form an integrated evolving entity. Examples include, the banking system with a central bank at the core as opposed to a collection of banks; a solar system as opposed to a cluster of celestial bodies and a nervous system as opposed to a collection of unrelated nervous cells.

Just like a stroke incapacitates the nervous system for example, causing a system event, within the financial system, systemic risk may perhaps arise from:

A. The inability or unwillingness of a central bank to act as a lender and market-maker of last resort since that removes the foundations to a banking system operating under the banking principle.
B. A failure of the real-time gross settlement processor in a payment system brings that system and all connected systems to a meltdown.
C. Hyperinflation reduces a price system to a set of primitive and inefficient bilateral barter operations; and so forth.

In all these cases, the system ceases to fulfil its function properly, resulting in a systemic event. Let us have a brief overview of the concept of systemic risk as generally understood in the policy and financial economics literature, and then consider recent empirical research, case studies, and other attempts to define and measure the term more precisely.

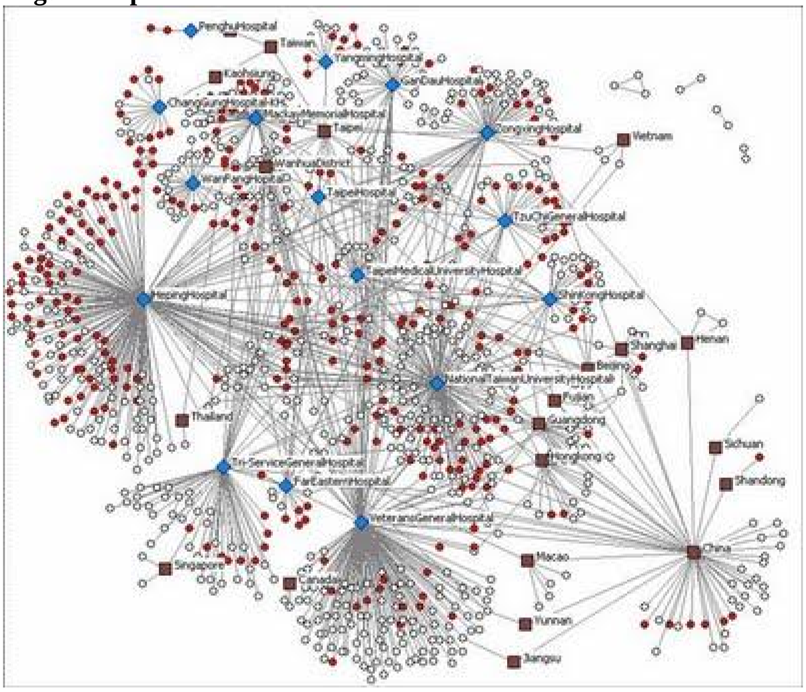
1.2.1.1 The Concept of systemic risk

Any definition of systemic risk must be based on three considerations. The first is the risk of a large triggering event. The second is the risk of propagation of such an event through the financial sector by contagion or a chain reaction. The third is the macro-economic risk that the financial disruption will severely affect the whole economy (Taylor, 2009). Triggering events could stem from financial markets themselves, the public sector, for instance a central bank facing liquidity issues or external shock such as natural disaster. To find some examples of triggering events before the financial crisis 2007/8 we might look at the default by the Russian government in 1998, default by the Argentine government in 2001 or September 11th terrorist attacks which spread chaos through the financial system.

1.2.2 General Definition of Systemic Risk

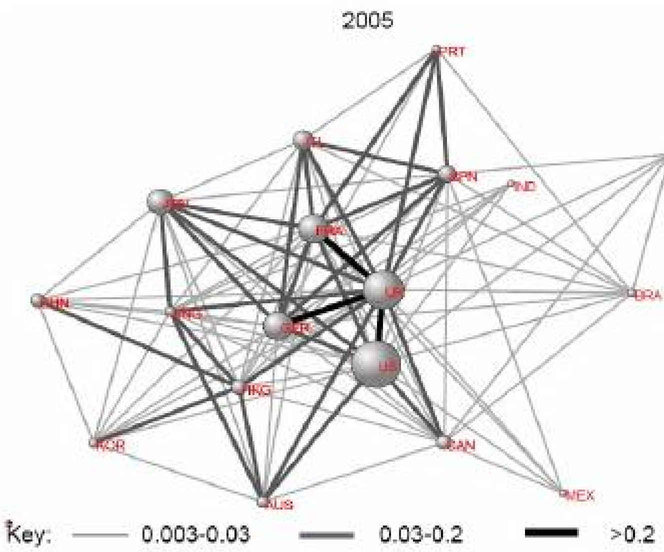
De Bandt and Hartmann (2000) pointed out that systemic risk, in general, was not a phenomenon limited to financial systems. The concept can also be found in the area of health and epidemic diseases. They compare contamination of the population with a disease with the contamination effects that systemic risk has on the economy. Figure 4, reproduced from Sassi (2009), on the blog L'Economie des Nuls, shows the similarities between a modelisation of the 2005 financial landscape and an epidemic disease (SARS in this example):

Figure 4 Epidemic Disease and a Financial Network



SARS Epidemic, Source : reproduced from Sassi (2009)

Figure 5 Global Financial Network 2005



Source: L'Economie des Nuls (2008)

Sassi (op. cit.) also draws further comparisons between systemically affected financial systems and epidemic/contagious diseases by likening people who transmit disease to financially-involved entities and infectious agents to financial risk causes, as seen in Table 1.

Table 1: Comparisons between financial systems and contagious diseases

People who transmit	**Infectious agents**	**Environment**
Banking institutions	Financial Products	Over Confidence
Central Banks	Monetary Mass	Over consumption
Subprime contractors	Negative Savings	American craze for imported products
China	Artificially depressed currency	Non-productive consumption
US government	Government spending	Boom and bust
Northern Rock	Bad news	Lack of autarky in the UK

Source : reproduced from Sassi (2009)

Shiller (2008) further expands the comparison by writing, “Every disease has a contagion rate So it is in the economic and social environment” (p. 37).

1.2.2.1 Flaws in the General Definition of Systemic Risk

The problem with this initial definition of systemic risk is that it is too vague and general. Considering we are concerned with systemic risk within the banking system within this chapter, it is paramount that we arrive at a definition that relates specifically to the banking and financial system. If we were to merely accept a general definition that could apply to anything, we would be neglecting the fact that the banking and financial sector is more susceptible to systemic risk than any other, as well as doing the purpose and point of our study a disservice. We need a definition that recognises that banks are a special case for the following reasons:

A. Banks are particularly vulnerable to systemic risk due to fractional reserve banking
B. Banks are highly leveraged
C. Banks are highly interconnected through direct exposures in the interbank money market.

1.2.3 Systemic Risk as a Consequence of Shock

In terms of the financial system, De Bandt and Hartmann (2000) define systemic risk as the risk of experiencing a systemic event (shock) in the strong sense that will trigger a loss of economic value or confidence in, and attendant increases in uncertainty about, a substantial portion of the financial system that is large enough to, in all probability, have significant adverse effects on the real economy (De Bandt and Hartmann, 2000). Here, systemic events are defined as an event where the release of 'bad news' about a financial institution or a crash of a financial market leads in a sequential fashion to substantial adverse effects in one or several other financial institutions or markets. 'In the strong sense' refers to the categorisation of a systemic event as 'strong' if the institution(s) affected in the second round or later actually fail solely as a consequence of the initial shock, or if the markets affected in the later rounds crash and would not have done so without the initial shock.

Kaufman (2000) defines systemic risk as the consequence of a 'big shock', 'macroshock' or 'common shock' throughout the financial system. Such a shock produces nearly simultaneous, large, adverse effects on most or all of a national economy or system (Kaufman and Scott, 2003). These shocks might involve the failure of a major bank or an international diplomatic development that damages or restricts the trade of one country's banking system in particular.

Nicolò and Kwast (2002) borrow the Group of Ten's definition of systemic risk which also focuses on the 'event' aspect of systemic risk, defining it as the risk that an event (shock) will trigger a loss of economic value or confidence in, and attendant increases in uncertainty about, a substantial portion of the financial system that is large enough to, in all probability, have significant adverse effects on the real economy (Group of Ten, 2001).

1.2.3.1 Flaws in the 'Shock' Definition of Systemic Risk

The major flaw in this definition, however, is that whilst it tells us *how* systemic risk can arise, it does not really go into detail regarding *what* it is. It shows us what systemic risk is a consequence of, without really telling us what systemic risk is in itself. Another problem is how the transmission of effects from a macro-shock to individual units or contagion, occurs and which units are affected are generally unspecified. This definition also makes two major assumptions without evidence:

1. It assumes that economic shocks may become systemic because of the existence of negative externalities associated with severe disruptions in the financial system. In particular, it takes for granted that a negative shock at a single firm or small group of firms must be likely to have contagion effects on other firms.

2. Secondly, the definition assumes that systemic financial events must be highly likely to induce undesirable real effects, such as substantial reductions in output and employment.

As a result of this, this type of definition does not actually clearly define systemic risk for our purpose. Also, this definition implies that systemic risk only happens when one big shock happens, ruling out the impact that an accumulation of 'bad news' events can have. This leads us onto the connection between the concept of 'spillover' and systemic risk.

1.2.4 'Spillover' Definition of Systemic Risk

The sequential fashion in which a single crash can lead to substantial adverse effects for several financial institutions is also commonly referred to as 'spillover effect'. Anand, Gai and Marsili (2012), therefore, defines the term 'systemic risk'" as a term for the idea of such destructive spillovers, as well as citing De Bandt and Hartmann's (2000) definition as described above. As Schwartz (2008) suggests, spillovers can collapse financial systems, "like a row of dominoes" (p. 198). Schneider (2010) uses the same kind of analogy, describing systemic risk as the type of falling-domino problem that allowed mortgage defaults in the United States to lock up the global financial system because of the complex connections among banks, investment companies, insurers and other firms worldwide. Basically, when a domino piece falls down, it falls on the next piece, causing it to fall and in turn knock over other pieces in a chain-or 'knock-on' reaction. An alternative description is 'herd instinct', as used by Kaminsky and Schmukler (1999). The late, ex-Bank of England governor Eddie George described this effect as occurring "through the direct financial exposures which tie firms together like mountaineers, so that if one falls off the rock face others are pulled off too" (p. 1998). This definition is consistent with that of the Federal Reserve (the Fed.) in the payments system: "Systemic risk may occur if an institution participating on a private large-dollar payments network were unable or unwilling to settle its net debt position. If such a settlement failure occurred, the institution's creditors on the network might also be unable to settle their commitments. Serious repercussions could, as a result, spread to other participants in the private network, to other depository institutions not participating in the network, and to the nonfinancial economy generally” (Federal Reserve System Report, 2001, p. 2).

Similarly, the Bank for International Settlements (BIS) defines systemic risk as "the risk that the failure of a participant to meet its contractual obligations may in turn cause other participants to default with a chain reaction leading to broader financial difficulties" (BIS, 1994, p. 177). The emphasis of this type of definition is in correlation with causation.

1.2.4.1 Flaws in the Spillover Definition of Systemic Risk

The main issue with the spillover definition of systemic risk is that it focuses too much on a micro level. It looks too hard at the inter-relation between banks without looking at the bigger picture of the financial system in its entirety. This definition assumes that there will be close and direct connections among institutions or markets, which may not always be the case. It also assumes that rumours or facts about a bank’s performance will always get out before a government can intervene to neutralise the systemic risk. The definition assumes that systemic risk is dependent on hearsay and over-reaction when this is not necessarily the case.

1.2.5 ‘Third Party’ Definition of Systemic Risk

A further definition of systemic risk focuses on more indirect connections than the other definitions do. It emphasizes similarities in third-party risk exposures among the units involved. When one unit experiences adverse effects from a shock, say the failure of a large financial or nonfinancial firm that generates severe losses, uncertainty is created about the values of other units potentially also subject to adverse effects from the same shock. To minimize additional losses, market participants will examine other units, such as banks, in which they have economic interests to see whether—and to what extent—they are at risk. The more similar the risk-exposure profile to that of the initial unit economically, politically, or otherwise, the greater is the probability of loss, and the more likely it is that participants will withdraw funds as soon as possible. This response may induce liquidity problems and even more fundamental solvency problems. This pattern may be referred to as a ‘common shock’ or ’reassessment shock’ effect and represents correlation without direct causation (indirect causation).

Rochet and Tirole (1993) use this type of definition to refer to systemic risk as the propagation of an agent’s economic distress to other agents through financial transactions. They point out that “systemic risk is a serious concern in manufacturing, where trade credit links producers through a chain of obligations, and in the insurance industry through the institution of reinsurance” (p. 126). Moving into banks, they state “the anxiety about systemic risk is perhaps strongest among banks and regulators” (p. 126). For banks mutual claims which, by abuse of terminology we will gather under the generic name of interbank loans or interbank transactions, have grown substantially in recent years. These include intraday debits on payment systems, overnight and term interbank lending in the Fed funds market or its equivalents, and contingent claims such as interest rate and exchange rate derivatives in OTC markets. To the extent that interbank loans are neither collateralized nor insured against, and a bank’s failure may trigger a chain of subsequent failures and therefore force the central bank to intervene to nip the contagion process in the bud. Indeed, it is widely believed by banking experts that industrialised countries adhere to a ‘Too-Big-To-Fail’ (TBTF) policy of protecting uninsured depositors of large insolvent banks.

1.2.5.1 Flaws in the Third Party Definition of Systemic Risk

This definition does not take into account the importance of direct causation when it comes to systemic risk. It dismisses the concept of the domino or knock-on effect, instead implying that systemic risk is merely to do with indirect causation. The definition also fails to take into account that it takes a certain amount of circumstances to bring about systemic risk, the ‘perfect storm’ as it were. It does not differentiate between banks who are vulnerable to systemic risk and those that are resilient to it and as a result misguidance as to prevention is sure.

1.2.6 Broad Definition of Systemic Risk

Some analysts use a broader term to define systemic risk. Mishkin (1995) refers to it as the probability that the informational function of financial markets breaks down: “The likelihood of a sudden, usually unexpected, event that disrupts information in financial markets, making them unable to effectively channel funds to those parties with the most productive investment opportunities" (p.32). Bartholomew and Whalen(1995) define systemic risk as the likelihood of a sudden, unexpected collapse of confidence.

Sheldon's (1998) broad definition of systemic risk is "any disturbance that is sufficiently strong and works itself through the system" (p.6). He says that systemic risk is "the likelihood that the failure of one bank will trigger a chain reaction causing other banks linked to that bank through interbank loans to fail, the so-called domino effect" (p.6). Property Casualty Insurers Association of America (2009) has perhaps the broadest definition, stating that "'Systemic risk' refers to the likelihood and degree of negative consequences to the larger body" (p.1). It then does narrow down the definition for the context of financial institutions. "With respect to federal financial regulation, the systemic risk of a financial institution is the likelihood and the degree that the institution's activities will negatively affect the larger economy such that unusual and extreme federal intervention would be required to ameliorate the effects" (Property Casualty Insurers Association of America, 2009) p.1 . In its 2010 Global Stability Report, the IMF assumes a definition of systemic risk that focuses heavily on the interconnectedness of firms typically affected by systemic risk. It refers to systemic risk as "the systemic linkages that are likely to arise from the complex web of contract relationships across financial institutions" (p. 14).

1.2.6.1 Flaws in the Broad Definition of Systemic Risk

The trouble with a broad definition of systemic risk is that it can be too vague. In the event of this, the definition can lack precision and focus. Too many interpretations of the definition may arise, making it difficult to really understand, measure, analyse, or evaluate systemic risk for what it is, in any real sense. As such, it does not address specific causes nor refer to specific transmission mechanisms. This type of overview is incomplete and subjective. The other problem with this definition is that it focuses exclusively on the transmission mechanism interbank lending relationships provide, ignoring all informational aspects. In other words, with the exception of the vagaries of market returns, this definition assumes certainty, even when there is none.

1.2.7 Theoretical and Conceptual Definitions of Systemic Risk

From a more theoretical point of view, Benink (1995) defines systemic risk as the extent to which there are consequences for the stability of the financial system if it is in a state of fragility. Bartram, Brown and Hund (2007) define systemic risk conceptually as "a failure (seizing) of the global inter-bank payment system or a loss of confidence in banks which results in a global 'bank-run'. For example, payment failures could mean that banks receiving payment on loans (explicit or implicit) would become technically insolvent. Cascading bank insolvencies and bank-runs could cause additional financial and economic spillovers such as rapid credit reduction, and ultimately, macroeconomic contraction" (p. 841).

1.2.7.1 Flaws in theoretical and conceptual definitions of systemic risk

The problem with conceptual definitions of systemic risk is that they are very hard to apply practically. It is difficult to apply a concept or theory on the definition of systemic risk to the real-world actuality of such risk in motion, in a particular bank, at a particular time. Although Bartram, Brown and Hund (2007) give the above-mentioned example to try and justify and rationalise their definition of systemic risk, this example has really nothing to do with real-world banks or the financial system as it historically was or is now.

1.2.8 European Central Bank Definition

The European Central Bank (ECB) defines systemic risk as "the risk that inability of one institution to meet its obligations when due will cause other intuitions to be unable to meet their obligation when due. Such a failure may cause significant liquidity or credit problem and as a result could threaten the stability of or confidence in markets" (Liedtke, 2010, p. 1).

1.2.8.1 Flaws in ECB definition

This definition is vague on several issues. Firstly, it does not specify any institution in particular secondly it is not specific in market determination. It does not make a reference to the size of the inability to meet the obligations or how fast this failure might spread to other institutions. The phrase that the failure may cause significant liquidity or credit problems indicates that liquidity or credit problems are not necessarily the only conduits for systemic risk. The final part could threaten the stability of or confidence in markets implies that a problem that could trigger a potential loss of confidence is enough for the problem to be defined a systemic risk which entails that no real impairment must happen or be at risk of happening – the risk of a potential loss of confidence is enough.

1.2.9 Chairman of Federal Reserve Definition

Bernanke (2009) the ex-chairman of the US federal reserve defines systemic risk thus: "systemic risks are developments that threaten the stability of the financial system as a whole and consequently the broader economy, not just that of one or two institutions" (p. 1). This definition is vague as well, there is no difference between general risk and systemic risks. In this case natural catastrophes, war, terrorism attacks would become systemic risks as they threaten the stability of financial system. This clearly could not be adopted for operational level as it is too broad.

1.2.10 Definition by Group of 10

The definition used by the Group of 10 in 2001 to define systemic risk was concerned directly with financial dimension: "systemic financial risk is the risk that an event will trigger a loss of economic value or confidence in, and attendant increases in uncertainty about, a substantial portion of the financial system that is serious enough to quite probably have significant adverse effects on the real economy" (G10, 2001, p. 130).

The financial crisis 2007/8 is systemic according to this definition. Many major financial institutions and markets collapsed and the financial crisis precipitated a large drop in US and worldwide GNP. Russian and Asian crises of the 1990s were systemic in the parts of the world they affected. The Long Term Capital Management (LTCM) crisis on 1998 might have become systemic but for the actions taken to contain it, although there is a wide range of opinion on this point. Gerald P. Dwyer, director of the Atlanta Fed's Centre for Financial Innovation and Stability consider this to be a reasonable definition in terms of the concerns in mind. However, he also criticises that attendant lack of "the precise definitions and measurement of terms such as confidence" (Dwyer, 2009 p.1)

1.2.11 Financial Sector Propagation Mechanisms

In the financial crisis 2007/8 there is considerable debate about the triggering event. Failure of certain markets or private financial institutions, most commonly Lehman Brothers, can be seen as the main triggering event. However, Taylor (2009) believes a series of government actions and interventions are the most plausible triggering event, including a monetary policy that kept interest rates too low for too long and an ad hoc bailout policy that led to fear and panic. Considering the propagation risk from the original triggering event through the financial system we should distinguish between two types of propagation risks, the first type is direct financial linkage between firms and second kind is where there is no direct financial connection.

The Federal Reserve Board (Federal Reserve Report, 2001) focused on the payments infrastructure as the first type when writing that "systemic risk may occur if an institution participating on a private large dollar payments network were unable or unwilling to settle its net debt position. If such a settlement failure occurred, the institution's creditors on the network might also be unable to settle their commitments. Serious repercussions could, as a result, spread to other participants in the private network, to other depository institutions not participating in the network, and to the nonfinancial economy generally" (p.2). In the second type, a failing institution or some other triggering event causes the balance sheets of a possibly large number of other financial institutions to be significantly impacted because they all have portfolios similar to the failing institution or because they have large exposures to securities that are impacted by the triggering event (Taylor, 2009).

1.2.12 Our Definition of Systemic Risk

Systemic risk is the risk of "breakdowns in an entire system, as opposed to breakdowns in individual parts and components" (Kaufman and Scott, 2003, p.371). Systemic risks are characterized by:

A. modest tipping points combining indirectly to produce large failures
B. risk-sharing or contagion, as one loss triggers a chain of others
C. 'hysteresis', or systems being unable to recover equilibrium after a shock (Goldin, 2014)

Kaufman and Scott (2003) probably have published the most cogent definition of systemic risk, namely;

“Systemic risk refers to the risk or probability of breakdowns in an entire system, as opposed to breakdowns in individual parts or components, and is evidenced by comovements (correlation) among most or all the parts” (p. 371).

Since Kaufman and Scott's (2003) definition of systemic risk as the probability of breakdowns in an entire system, is a reasonably clear one, we can aim focus on this probability of breakdown occurring "through the direct financial exposures which tie firms together” (p. 371). This definition is consistent with that of the Federal Reserve (the Fed) in payment system (Fed, 2001)**.** Similarly, the Bank for International Settlements (BIS, 1994) defines systemic risk as "the risk that the failure of a participant to meet its contractual obligations may in turn cause other participants to default with a chain reaction leading to broader financial difficulties"(p. 177).

Our definition: we chose the global level of systemic risk in the entire network of the banking sector as a focus of study to address the stability of the financial system as whole.

System wide risk, will be defined as the probability of breakdowns in an entire financial system, triggered by failure(s) of a market participant, process or structure due mainly to the interconnecting nature of the financial system (architecture), with adverse effects on the real economy. We have adopted this definition for the thesis as this particular risk exhibits itself in the form of correlated drops in production, defaults or other economic outcomes of interest.

This thesis’ view on systemic risk differs from the rest of relevant literature as it takes the perspective that the heart of the failure rests decidedly on the systemic architecture and not the trigger event. With this definition there are two types of systemic risk, first is domino; failures or distress in some part of the system creates a cascading effect to the rest of the system such that idiosyncratic shocks coming from it spreads like dominoes. The second type is correlated disaster, in this type all or most units in the economy are exposed to the same risk, it might be a rare event(s) and when it occurs they all go down at the same time. Our definition of systemic risk agrees with the consensual concept of contamination and is based on the link between systemic events and systemic crises. We then define systemic risk with a link to the real economy and financial market structures. Here, failure of a participant refers to any single event that triggers the spillover effects of bad news to spread from one financial institution to others. This definition acknowledges that systemic risk can refer both to failure of a participant or the whole structure.

1.3 : Financial Crisis and Systemic Risk in EU Banks

In late 2011, the European financial system appeared to be on the brink of a major crisis. Investors were faced with the possibility of a Greek default while European leaders wrestled with a fiscal situation that had no clear precedent. As contagion fears spread to Italy and Spain, market participants began to consider the worst-case scenarios. One of the greatest concerns was the systemic risk of the European banking system. If a sovereign default were to lead to a failure of a systemically-important European bank, the resulting financial instability could be disastrous. This type of scenario highlights the need for identifying and understanding the contribution of banks to systemic risk in the financial system. Haldane (2011) identifies that serious systemic spillover in particular caused the 2007/8 crisis to spread amongst UK banks. Saporta (2009) describes this spillover as 'potent' and a factor in the amplification of aggregate risk (a type of systemic risk) (For further discussion of aggregate risk and network risk as the two subtypes of systemic risk, see Saporta, 2009) in the case of the UK banks. She claims that individual banks typically fail to take account of the extent to which spillover effects increase systemic risk in other financial institutions. Hartmann (2009) agrees that the crisis was transmitted from the US to UK banks such as RBS by systemic risk, linking the sharp decline of the UK's GDP outlook to the systemic crisis. Shin (2008) claims that signs of the subprime crisis spilling over into UK banks were evident as early as July 2007.

Shin (2008) identifies the sources of Northern Rock's failure as excessively high leverage and maturity mismatch, which are both widely associated with systemic risk (IMF). Saporta (2009) agrees that excessive leverage and maturity transformation were factors. Kartik (2008) points out that it is useful to ask why such maturity transformation took place outside of insured and regulated depository institutions. There is good reason to think that it was precisely to escape the regulation facing the latter. Therefore, unless we are confident that we can detect maturity transformation in all its forms, our best bet may be to allow creditors of unregulated institutions to bear risk, especially of the macroeconomic kind. This may only be possible via credible promises to allow such entities to fail when their risk burden gets overwhelming. In other words, the additional costs of monitoring and regulating may well outweigh any additional benefits of creating yet more actors in the officially insured maturity transformation business.

Shin points towards a specific triggering event on 9th August 2007, BNP Paribas' closing of three off-balance sheet investment vehicles with exposures to US subprime mortgage assets, as another reason for Northern Rock's demise. Furthermore, on 17th March 2008, the day after the news of the US government's bailout of Bear Stearns, UK banks performed badly on the stock markets (The Market Oracle). HSBC dropped by 2%; Royal Bank of Scotland fell by nearly 9%; Barclays slipped by almost 10%; HBOS crashed by 12.5%; A&L saw its share price plunge by more than 7%; and Bradford and Bingley was down by 3.6%. This is consistent with the views discussed above that triggering events cause systemic risk, which in turn causes financial crises. Saporta (2009) identifies another triggering event that impacted negatively on UK banks as the information cascade that led to the short selling of the shares of some of the UK banks in 2008. This supports the point of view that links sources of systemic risk to the financial crisis.

1.3.1 Systemic risk in UK and EU banks

The 2010 IMF (2010) Global Stability Report, suggests that the financial crisis has triggered a rethinking of the supervision and regulation of systemic connectedness. In short, widespread opinion that the crisis was systemic in nature has brought home to roost the urgent need for measures reducing systemic risk. The BoE Systemic Risk Survey (Bank of England Systemic Risk Survey, 2009) found that approximately one-half of respondents believe that the probability of another triggering event affecting UK banks in the short and medium term is likely and that a third or more believe the likelihood to be high or very high (Burls, 2009). However, the result of the same survey in 2014 shows the main risk to the UK financial system identified was from an economic downturn although citation has fallen, 61% of respondents mentioned this risk (-6% point since October 2013). This underlines the need there is to take action now and develop measures to reduce systemic risk in UK banks, in order to avoid another financial crisis in the country. Taking to account the Eurozone difficulties in Greece, Italy and some more it is indeed still likely that another triggering event could set off a further financial crisis in UK banks. Economic downturns in the Eurozone, to which the UK is closely linked, could prove to be precursors to such events. Existing protections against systemic risk have failed to protect banks in the financial crisis because they actually focused too much on banks, not the financial market as a whole (Schwartz, 2008) . General regulatory protections against market failure - primarily disclosure under the securities laws, and the 'market discipline' approach of the current global governments are not directed against systemic risk per se.

Experts and analysts have not needed to ask twice when it comes to proposing their own measures for reducing systemic risk. The 2010 IMF Global Stability Report refers to the overwhelming response as "a flood of regulatory reform proposals" (IMF, 2010, p.9). However, turning these proposals into action has been slower than expected (Williams, 2010), suggesting that consensus has yet to be reached upon the best way forward.

Schwarz (2008) proposes that a more tailored financial-market regulation is needed because systemic risk is somewhat unique.. He argues that it results from a type of tragedy of the commons in which the motivation of market participants "is to protect themselves but not the system as a whole [. . . .] No firm [. . .] has an incentive to limit its risk-taking in order to reduce the danger of contagion for other firms" (p. 206). Even if market participants were able to collectively act to prevent systemic risk, they might not choose to do so because the externalities of systemic failure include social costs that can extend far beyond market participants, such as widespread economic recession leading to poverty, unemployment, and crime. Schwarz (2008) goes on to say that it would be ideal to eliminate the risk of systemic collapse, ab initio. He suggests that this could be achieved by preventing financial panics, since they are often the triggers that commence a chain of market failures. As Schwarz (op. cit.) points out, it is impossible to prevent financial panics because they "can be set off by any number of things" (p.216). In the context of the 2007 and 2008 financial crisis, for example, scholars and politicians talk about imposing 'suitability' requirements on mortgage loans and otherwise restricting 'predatory' lending. But these types of solutions not only potentially increase the cost of credit and restrict its availability but, more importantly, fail to address the next financial crisis, which may be unrelated to home values or mortgages.

Schwarz (2008) also says that a more fundamental, yet targeted, regulatory response to systemic risk is to try to ensure market liquidity. Although ensuring liquidity cannot always prevent financial panics that trigger systemic risk, it can address any systemic problem by diminishing the vicious cycle caused by financial panics. Hartmann et al. (2004) suggest that a framework of macro-prudential supervision is necessary in order to reduce systemic risk and is therefore an important priority for policy. They further define this as public oversight that aims at identifying and containing systemic risks. He also proposes macro-prudential regulation, which would involve public regulations aiming to maintain systemic stability. It is fair to say that such frameworks might help reduce systemic risk in EU banks. In the case of both financial supervision and regulation, the term 'macro-prudential' can be defined as "of or pertaining to systemic prudence, especially to the strengths and vulnerabilities of financial systems" (p. 314). One of the many criticisms levelled at the EU banking system at the height of the crisis was that lack of supervision and regulation had allowed for the build-up of systemic risk to go unnoticed. Saporta (2009), therefore, agrees that prudential regulatory framework needs to have more of a focus on systemic risk and that the potential role for macro-prudential instruments should be assessed. Hartmann et al. (2004) admit that there are challenges in setting up macro-prudential frameworks, namely the current lack of analytical foundations and the difficulty of separating macro-prudential regulation from micro-prudential regulation.

Global financial market participants were directly impacted by its default and numerous repercussions were felt throughout the world, resulting from a plethora of cross-border and cross-entity interdependencies (Haas and Horen, 2012; also Acharya, Drechsler and Schna, 2014). The shock was rapidly spread in Europe, where by the end of September, euro area governments rescued the Belgian-French bank Dexia, demonstrating vividly that these interdependencies generate amplified responses to shocks and increase the speed of contagion in the financial system (Panageas, 2010;Acharya, Gale and Yorulmazer, 2011b; Aiyar, 2012;Acharya and Steffen, 2015). Thus, in the aftershock era, the effects of both interconnectedness and contagion manifested themselves and systemic risk emerged as one of the most challenging aspects (Elliott, Golub and Jackson, 2014; and Acemoglu, Ozdaglar and Tahbaz-Salehi., 2015). The banking industry grappled with one overarching challenge; to measure and reduce systemic risk (for a definition and discussion on systemic risk and contagion see, also, (Acharya, Engle and Richardson 2012); Liang, 2013; and Allen and Carletti., 2013) in order to improve the resilience of the financial system to adverse shocks and to prevent a repetition of the recent crisis.

1.3.2 Systemic risk regulator

How should the law help to control systemic risk, the risk that the failure of financial markets or firms harms the real economy by increasing the cost of capital or decreasing its availability (Steven,Schwarcz, 2008). Many regulatory responses to systemic risk, like the Dodd-Frank Act[3] in the United States, consist largely of politically motivated reactions to the global financial crisis, often looking for wrongdoers (whether or not they exist). But those responses are misguided if they do not address the reality of systemic risk. Shin (2008) proposes reducing systemic risk by enforcing some type of liquidity regulation that imposes constraints on the composition of assets. He argues that when small liquidity buffers are distributed widely in the financial system, spillover effects can be mitigated by amplifying the buffer effects, just as the absence of liquidity buffers will tend to amplify shocks that reverberate inside the system. The rationale behind this is that a bank can survive a run if:

1) it has sufficient liquid assets and cash or
2) it has sufficiently stable (i.e. illiquid) liabilities such as long-term debt.

The Bank of England (Bank of England Systemic Risk Survey, 2009) has pledged to reduce systemic risk in UK banks by re-evaluating the structure of the financial system and improving the framework for financial crisis management and resolution. Getting the central bank involved in regulatory policy, structure of the financial system and perhaps even restoring its regulatory responsibilities could be an effective strategy, as Greenspan, (1997) argued, “Second only to its macro stability responsibilities is the central bank’s responsibility to use its authority and expertise to forestall financial crises (including systemic disturbances in the banking system) and to manage such crises once they occur” (p. 1).

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[3] The Dodd-Frank Act delegates much of the regulatory details to administrative rulemaking, in many cases after the relevant government agencies engage in further study.

Atik (2011) accurately identifies that Basel II will be much scrutinised in the battle to avoid further financial crises by reducing systemic risk. Shin (2008), however, believes Basel II needs to revise its capital requirements figures in the light of the 2007/8 financial crisis. Finally, Basel III which was introduced in 2013 is supposed to strengthen bank capital requirements by increasing bank liquidity and decreasing bank leverage (Ingves, 2013). Similar to the principle behind capital surcharges is the idea that the more an institution poses a systemic risk, the more regulations it should have imposed upon on it. Moss (2010) proposes that governments should keep the more vulnerable organisations in line by enforcing regulations such as higher capital requirements; leverage limits; FDIC-like insurance charges; and, in extreme circumstances, a receivership process to restructure, sell or liquidate a failing company (Thompson, 2009). At the same time, the majority of financial firms that pose no systemic risk should face relatively light regulation, ensuring their continued dynamism and innovation.

This proposal demonstrates an awareness of the fact that if large financial firms believe the government is 'on their side', they are more likely to take risks. "Any belief among financial market participants, especially creditors, that they will be made whole by the public in the event of the failure of the assets they finance (i.e., that they will be 'bailed out') will lead them, all else equal, to (i) take greater risks, even if that means becoming ever more opaque or interconnected, and (ii) grow too large" (Athereya, 2009, p. 7). Athereya (2009) also agrees with this sentiment, pointing out that before the recent crisis, regulators assumed that markets with large numbers of people with enough information and the ability to move money freely would be able to assess the risks of different investments, and look out for themselves. That thinking guided global governmental policy, creating the conditions that allowed millions of Americans to buy homes and borrow money under loose credit terms, which in turn eventually limited to financial crises hitting banks worldwide. Moss (2010) pointed out, after the Great Depression the American President Roosevelt engineered sweeping federal intervention into the country's marketplace, including creation of federal deposit insurance, securities regulation, banking supervision, and the separation of commercial and investment banking under the Glass-Steagall Act.[4] Moss (2010) points out the

[4] For more on the Glass-Steagall Act of 1933 and its contemporary relevance to financial regulation today, see the Bloomberg article 'Wall Street Rules May Fall Short of Glass-Steagall' by Schmidt and

parallels between this historical strategy and his proposals, stating "[the United States] insured and regulated the most systemically dangerous part of the system, the commercial banks, and we exercised a much lighter touch elsewhere, leaving the rest of the financial system to innovate, be dynamic, and do everything that markets do so well" (p. 2).

A further justification for this concept of systemic risk regulation is the broad support that the proposal receives from a wide range of economists, lawmakers and interest groups. In relation to the United States, in March 2008, Treasury Secretary Henry Paulson proposed that the Federal Reserve be empowered as a super regulator to seek out and manage systemic risks. Paulson affirmed his support for the idea in an 18th March 2009, op-ed article in the Financial Times. In January 2009, an international group of leading financiers and academics known as the Group of Thirty (G30) issued a reform blueprint that endorsed the idea.

The variety of linkages and reasons for spillovers will make regulating systemic risk hard (Athreya 2009). We argue that not only are there many ways for financial sector entities to be linked thus creating inefficiencies in the wake of shocks, but also that many contractual choices that create ex-post inefficiency were deliberately aimed at allowing for gains from trade between two parties. We think effective regulation of systemic risk implies re-evaluating the structure and architecture of the financial system. In line with what Schwarcz (2014) indicates an effective regulatory framework to help control systemic risk must look beyond politics and blame. As systemic risk is a form of financial risk, the framework should start with 'micro-prudential' regulation designed to maximise economic efficiency by correcting market failures within the financial system. This part of the framework is additionally important because certain of those market failures can be factors in triggering systemic risk; because systemic risk represents risk to the financial system itself, the regulatory framework must also include the larger 'macro-prudential' goal of protecting the financial system as a 'system'.

1.4 : Systemic Risk and Financial Crisis

First, the definitions of a financial crisis and the singularity of systemic risk as causative is what we will investigate further. The literature surrounding these studies covers

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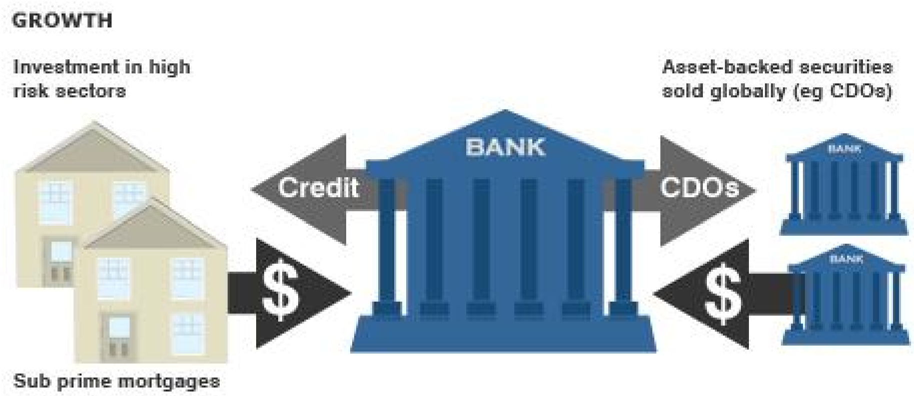
Westbrook (2010), published on 26th May and available at http://www.businessweek.com/news/2010-05-26/wall-street-rules-may-fall-short-of-glass-steagall-update1-.html different types of crises, in different countries and over different time periods such that generalisations are somewhat inevitable. To overcome these limitations, the approach taken here is to identify the causes and symptoms of the financial crisis 2007/08 and how it links with systemic risk. The study covers a broad review of the literature and seeks to categorize systematically the empirical findings of the indicators that most often have been found to be statistically significant as well as using proprietary analysis to come to a thorough conclusion.

1.4.1 The link between systemic risk and financial crises

Haldane (2010), rightly identifies banking as an industry with potential for crises caused by systemic risk. He refers to the banking industry as a 'pollutant' and systemic risk as a 'noxious by-product'. The interconnectedness of banks and their 'too-big-to-fail' nature makes them prime targets for systemic risk (De Paoli, Hoggarth and Saporta 2009). ATIK (2009) agrees that banks share weakness in a systemic manner and therefore systemic risk is a widely recognised feature of the financial system. o illustrate the above points, Hellwig (2008) uses the previously-mentioned US subprime crisis as an example of a triggering event that activated systemic risk in financial institutions worldwide, thus leading to the global financial crisis. Figure 6, reproduced from the BBC illustrates how the subprime crisis led to a global financial crisis.

Figure 6: Sub-prime Mortgages and the Finanial Crisis



(Source: BBC, 7 August 2009)

Furthermore, he identifies two elements of what we identify as systemic risk in the financial crisis - firstly, the breakdown of excessive maturity transformation in financial institutions that led to the overhang of asset-backed securities; secondly, the downward spiral effect that interplay between market malfunctioning, fair value accounting, the insufficiency of equity capital at financial institutions, and the systemic effects prudential regulation had on the overall financial system. The entire basis for Hellwig's (2008) paper, in fact, is the argument that the overall impact of the financial crisis on the world financial system is due largely to the incidence of systemic risk.

As with the above analysts, the IMF also says that systemic risk rose sharply during the financial crisis years (IMF, 2008). Hartmann (2009) goes so far as to say that the financial crisis is 'truly systemic' and also confirms the general viewpoint that triggering events lead to an increase of systemic risk in financial institutions. He pinpoints the emergence of systemic risk in relation to the crisis as happening between August 2007 and August 2008. In his conclusions, Hartmman (op. cit.) points to "'current experience' as evidence that systemic financial crises can happen and have dramatic real effects" (p. 1). Gerlach (2009), also, cites the 2007/8 crisis as a prime example of a systemic crisis. Gerlach (op. cit.) explicitly says that the financial crisis is an example of how interlinkages between banks expand the scope for financial shocks to spill over and become systemic.

The frequency of systemic banking crises worldwide further strengthens the case for suggesting systemic risk and financial crisis are strongly related to one another. The Bank of England not only assumes that the financial crisis suffered by UK banks in 2007 and 2008 was linked to systemic risk, it also assumes that a systemic crisis happens in the UK's financial sector every 20 years Haldane (2010) This is a valid point; indeed, it is safe to assume that UK recessions caused by systemic crises occur even more regularly than this. Prior to the most recent recession, post-war UK had suffered recessions in the mid-1970s, early 1980s and early 1990s. (Muriel and Sibieta, 2009). Young (2009) confirms that there has indeed been a UK recession in each decade for the past 40 years. Saporta (2009) indeed says that since the early 1970s, the probability of systemic crises appears to have been rising. This can also be applied internationally. The IMF (2008) identifies 124 systemic banking crises between 1970 and 2007 (Laeven and Valencia, 2008).

1.4.2 Study‘s approach

That systemic risk is a fixture for the financial system regulators has been made evident with the 2007/08 crisis, demonstrating how fragile the economic system is and also how costly its failure is for the taxpayer. Bailouts for too-big-to-fail financial institutions offer a temporary measure, however this may play into the hands of the institutions themselves in the long run as they may indulge in opportunistic behaviour aware of their systemically important status, thereby putting the state of the overall financial system and related systems at risk. They do, however, offer a short term solution that will be better taken advantage of by implementing more systemic endeavours in policy and regulations to prevent

This study poses key questions for the unravelling systemic risk and the spread of contagion across a network. There are many approaches already being used in the markets but we will investigate an original approach to make meaningful contribution to the conversation. The thesis' view on systemic risk differs from the rest of relevant literature as it takes the perspective that the heart of the failure rests decidedly on the systemic architecture and not the trigger event.

It is original to investigate systemic risk of EU banking system in an aggregate countries level using network theory and visualising the relationship of the players. Some of which are the part played by node centrality in networks in the spread of contagion. Using models of various networks, the multi-layered involvement of financial institutions with themselves. Our methodology is further delved into in the next chapters, where we review the various research methods, the network models and measurement criteria for the various data collection and comparative studies are done for the different techniques used so far in literature on this area of financial research making our own propositions along the way.

Chapter 2: Theoretical Framework

2.1 Network

A network consists of nodes and links that connect the nodes. A network is usually fully connected if a path exists from a particular node to any other node. In a network, effects flow across links, which may span multiple nodes. Networks provide a powerful abstraction for many processes, including the Internet and a variety of social organisations. Mathematicians refer to networks as graphs. A graph consists of edges (links) and vertices (nodes). The research done by Albert-László and Réka,1999) shows many naturally occurring networks self-organize into a hub-based network. In a hub-based network, a few nodes will have many connections while the majority of nodes will have only a few links.

2.1.1 Network and connection

From the findings of Milgram (1967), who carried out the first experiment and initiated the lost letter technique, Watts and Strogatz (1998) discovered a theory of the 'small-world'[5] networks. This theory claims that everyone is connected by an average of only six degrees of separation[6] (Watts, 2003). Near the end of his book, Watts (op. cit.) begins to investigate the dynamics of crowd behaviour and 'information cascades', offering potted histories of the Dutch tulip bubble and the dotcom boom.[7] One of the fascinating attributes, which Watts (2003) pointed out, is that the structure of the networks is probably much more important than anyone thought in influencing the dispersion of ideas or behaviours.[8] Watts's (op. cit.) final conclusion is network science suggests that our notions of cause and effect are skewed, that we're sometimes looking at the wrong actors in the play to try to understand why the drama is unfolding the way it is. In contrast to Watts (2003) and Strogatz (1998), other studies concentrate on an

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[5] The small-world networks or six degrees of separation can be summarized into two types: egalitarian and aristocratic. The egalitarian type has been explained by Watts and Strogatz (1998).

[6] This concept implies a characteristic of our social networks, that everyone in the world is separated by only six other people

[7] He infers that the success of a pseudo-viral phenomenon, such as the massive sales of the Harry Potter books, may depend not at all on the intrinsic quality of the product but on its luck in dropping into a particularly 'vulnerable' area of the network.

[8] His argument is that Harry Potter's success may have more to do with particular attributes of the social and media network it's spread across than with any inherent quality of the book.

aristocratic type of small world, (see, Albert-László and Réka, October 2009) or Granovetter (1983). They consider that a network is complex with some connectors acting as a hub to dominate the network. In aristocratic networks a few elements - hubs - have a disproportionally large number of links. Examples are: The Internet and the World Wide Web; ecosystems, food webs and the metabolic network of cells; the networks of individual airline companies; the networks of references in scientific papers and of the co-authors of those papers; networks of directors of major corporations; and the closeness of words used in English sentences.

A key characteristic of the aristocratic network is the rich get richer pattern.[9] Barabási (2002),.endeavours to describe 'six degrees of separation' through examples. Barabási (op. cit.) also looked at synthetic networks, like the networks of connections between logic gates in a very large scale integration (VLSI) microprocessor. The most interesting idea introduced by Barabási (op. cit.) is that the connectivity of these networks follows a power law distribution, where a fraction of the nodes have many connections and others have just a few connections.

2.1.2 Network and financial market and its limitation

In 1998, Watts and Strogatz (1998) published their seminal article "Collective Dynamics of 'Small-World Networks'" in the journal Nature, which had ramifications for such disparate fields as physics, biology, sociology, finance, and beyond. Network theory came to the public's attention once again with the publication in 2003 of Watts' (2003) science book.. The book is key for us to gain useful insight, it proclaimed that network theory is "nothing less than a new way to understand our connected planet." (p. 374). In the world of finance, network theory has been used through cartography methodology to map out network topology and also examine interbank payment

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[9] One of the ways a hub-based networks can be grown is through 'preferential attachment'. When a new node is added to a network, the links from the new node will have a higher likelihood of being attached to nodes that already have many links. For example, if the new node initially starts out with two links, these links will have a higher probability of being attached to nodes with many links. Preferential attachment will favour older nodes, since they will have had an opportunity to collect links. One of the examples of a naturally occurring preferential attachment network in *Linked* (Barabási April 2002) is in networks formed from journal article citations. Early journal articles on a given topic more likely to be cited. Once cited, this material is more likely to be cited again in new articles, so original articles in a field have a higher likelihood of becoming hubs in a network of references.

systems; the topology of banking networks in several countries (such as the United States, the United Kingdom, Brazil, Hungary, and the Netherlands); to identify correlations between different types of hedge funds, insider trading networks, and other topics in finance. Nonetheless, the full application of network theory to finance is still in its infancy.
In his work, Kimmo Soramäki[10] after looking at 8,000 participants in the Fedwire system, using empirical data, was amazed to find how similar the network topology of the Fedwire Funds Service interbank payment system (the primary US electronic network for real-time large-value payments operated by the Federal Reserve) is to networks in physics and sociology (SORAMAKI et al., 2006). There are some studies that attempt to describe systemic important nodes in banking, using the same algorithm that the Google search engine used to determine page rank of websites corresponding to a search keyword, in internet search results. (See (Beyeler, et al. 2007), (Galbiati and Soramäki 2011) and (Acemoglu, Ozdaglar and Tahbaz-Salehi, 2013). Beyeler, et al(2007) identified the most important nodes in the interbank payment systems not by their net worth but by the density of the linkages they have with other banks. When applied to banking, the Google algorithm indicates that a bank with a few significant linkages is more important to a network than a bank with a greater number of less dense connections, bringing more distinctiveness to the types of networks. (Rosenberg and Schuermann, 2006). Linkages in actual banking networks aren't random; clusters form based on such factors as institutional longevity, reputation, and human relations. We try to visualise the relationships of players in the system to bring more sensible tools on the table.

2.2 Network Theory and Financial Market

New findings in the financial market through network theory can raise optimism level of how this approach could help to describe embedded complexity in the financial market. However, policy makers should combine the findings from the network approach with other available information and experience before formulating any policy to ensure the robustness of the financial system. Network approach findings will so far complete part of the puzzle which is measuring/ modelling systemic risk, but it

[10] Kimmo Soramäki, an independent research consultant who performs network analysis for central banks

must be appreciated that this does not provide a complete picture. This study has so far shown that that network theory can bring a lot to current models of systemic risk. It has helped in identifying systemically important banks using not only their assets and capital but also their bilateral exposures and the input and output relationships they have with other banks. Using very common examples from daily life, it is easy to see that roads and airline routes are not evenly distributed between cities, but are concentrated heavily in big cities. Hence illustrating the concept of centrality previously expounded. The basic network topologies are illustrated in summary into the following types:

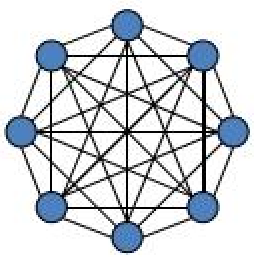

Figure 7: Complete Network

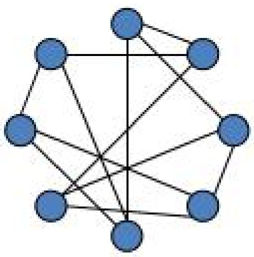

Figure 8: Random Network

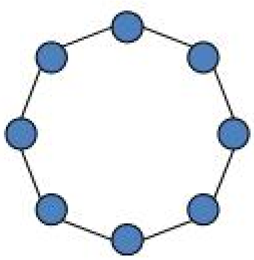

Figure 9: Ring Network

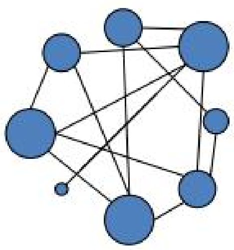

Figure 10: Scale free Network

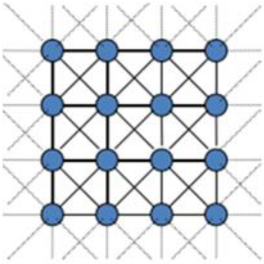

Figure 11: Lattice Network

Source (for Figures 7-11): Soramäki,(2011, p. 11).

A complete network is a network in which each of the nodes is connected to each other. (Figure 7). A random network may be described simply by a probability distribution, or by a random process which generates them (Figure 8). In a ring network, topology is set up in a circular fashion in such a way that they make a closed loop (Figure 9). A scale-free network is a network whose degree distribution follows a power law, at least asymptotically (Figure 10). Lattice network consisting of four branches and four terminals arranged in a mesh. It has two input terminals, which are nonadjacent, while the other two serve as output terminals (Figure 11).

Network theory is used in financial market network to assist describing complexity of this system

In this study we would like to highlight the role of the banking network structure in systemic risk at the country level using the already established network approach. We are fully aware of its limitations in the financial world. We understand that network problems can originate from more than one direction at a time (e.g., see (Rosenberg and Schuermann 2006) and there are to be aggregated using a unique mechanism involving copulas.

2.3 Approaches on Measuring Systemic Risk

2.3.1 Non-Network Approaches to measure systemic risk

We should not underestimate the difficulty of measuring systemic risk in a meaningful way. As a concept, it is too complex and almost abstract due to the multi-varied factors influencing it, as it is the by-product of often complex units. The emphasis here is briefly placed on measurement challenges and the associated uncertainty caused by limited data or unknown statistical models used to generate the data. A wide range of measurement methods were used in recent systemic risk research, backed by a wide scope of experts (Bisias, et al. 2012). Our study shows us that there is yet to be an agreed upon approach to systemic risk measurement. It seems that the suitability of measurements to support understanding of linkage between financial market and the macro economy is an open issue (see (Brunnermeier and Krishnamurthy, 2014). It could be an indication for the complexity and multi dimensions of systemic risk which need multiple measurements.)

Cerutti et al. (2012) in their article categorising the literature on systemic risk assessment, classed them into three broad categories, each primarily focused on banks. In the first category, the focus was on how balance sheet linkages can amplify the size of shocks and influence the direction of propagation across borders. This is exemplified by Gray and Jobst (2011) who apply what is known as contingent claims analysis. This approach features risk adjustments to sectoral balance sheets while featuring the distinct roles of debt and equity. A second category takes advantage of abundant market data and uses the information embedded in credit spreads and equity (and other asset) prices to measure systemic risk premia and the correlation of shocks across markets.[11] An example of which is the 'Tail Measurement' approach, which measures co-dependence in the tails of equity returns to financial institutions. Prominent examples of this include the work of (Adrian and Brunnermeier 2008) and (Brownlees and Engle 2011). Studies

[11] The second category in the literature has relied primarily on higher-frequency market data (e.g. equity prices, CDS spreads, and bond spreads) to extract information about how risks are correlated across markets. Studies in this category complement balance sheet-based studies since market data can capture contagion channels other than those related to direct balance sheet linkages between banks (see, for example, (Okuma, 2012) . Market data are particularly useful in the international context since comparable balance sheet data are scarce and often only available at a low frequency. Moreover, balance sheet data are costly to put together, whereas market prices are easy to obtain, at least for recent periods. Using stock-market data, (Rosenberg and Schuermann, 2006) and Camara (2004) estimate default probabilities for globally active financial institutions to derive measures of systemic risk, exploit the information embedded in large international banks' credit spreads to construct a banking stability index and estimate cross-border interbank dependence for tail events. Acemoglu, Ozdaglar and Tahbaz-Salehi (2013) examine when key global market conditions (e.g. VIX, forex swap, TED spread) move into a high volatility regime. Brunnermeier and Adrian (2009), extending the CoVAR methodology of (Avesani, et al, 2006) to 54 international banks, find that the short-term debt to assets ratio affects systemic risk, with no evidence that bank size increases systemic risks. Other market-based models are Rosenberg and Schuermann, (2006) and Zhou, et al. (2009).

such as Acharya, et al. (2010); Zhou,et al.(2009) have also proposed measures of systemic importance based on market data such as CDS spreads or equity volatility. The third category takes a more forward-looking perspective and relies on simulations to better understand how specific types of shocks may escalate into more severe systemic events.[12] All three types of analyses consider risks originating from the asset side (e.g. credit, country, and market risk) and the liability side (e.g. funding risk) of banks' balance sheets, as well as risks which arise from the interaction between the two sides (e.g. liquidity and/or currency mismatches). But the financial market history shows that linking financial market disruption to the macro economy requires more than just using "off-the-shelf" dynamic stochastic equilibrium models, say, of the type suggested by (Christiano, Eichenbaum and Evans 2005) and (Smets and Wouters, 2007).

With the exception of Elsinger et al. (2006), who propose a new method for the analysis of systemic stability of a banking system by modelling both asset correlations and interlinkages from interbank borrowing using market data. Their analysis gauges two major sources of systemic risk: correlated exposures and mutual credit relations that may cause domino effects of insolvencies.

Most simulation studies of contagion in banking networks examine the sole knock-on effects of the sudden failure of a single bank by considering an idiosyncratic shock that targets a single institution in the system. Upper and Worms (2004) estimates the scope of contagion by letting banks go bankrupt one at a time and measuring the number of banks that fail due to their exposure to the initial failed bank. (Sheldon and Maurer, 1998) and Mistrulli (2007) also study the consequences of a single idiosyncratic shock affecting individual banks in the network. Furfine (2003) measures the risk that an exogenous failure of one or a small number of institutions will cause contagion. Despite the in depth approach, these studies fail to quantify the compounded effect of correlated defaults and contagion through network externalities.

[12] The third category in the literature conducts simulations and scenario analysis, and also relies on balance sheet-based interconnections (using mostly aggregate, sometimes bank-level data). It tries to assess the path of contagion via interbank balance sheet linkages as well as the spillover effects to non-bank sectors. Many studies of this type analyse creditor countries' exposures to an initial shock in borrower countries. (Arvai et al, 2009), for example, highlight that, when taking into account common lender effects, Western European banks' exposure to Central, Eastern, and Southern European (CESE) countries is far smaller than that of CESE countries to Western European banks (except for Austria and Sweden).

In the case of first category measurement of the systemic importance of a given financial institution, some of them show each financial institution's contribution to systemic risk (see Acharya et al., 2010); however others compute a global measure of systemic risk and then allocate it to individual institutions as in Zhou et al.(2009), Liu et al. (2011) and Tarashev et al. (2010). To allow them to rank institutions in terms of the risk they pose to the system, some use a direct metric of systemic importance, the Contagion Index (Cont and Moussa, 2010), by quantifying the expected loss in capital generated by an institutions default in a macroeconomic stress scenario,

It could be argued that most studies in the first category rely on aggregate banking data, since data with information on the counterparty location (country) are generally only available in aggregate form[13] (e.g. BIS banking statistics, Coordinated Portfolio Investment Survey, CPIS, data, and balance of payments data for some countries).

Bank-level and individual loan-level data (e.g. data on cross-border syndicated loans) have also been used to study the international propagation of shocks.[14] And using bank-level cross-border syndicated loan data, De Haas and Horen (2011) s how that, during the financial crisis 2007/8, foreign banks continued to lend to countries that are geographically close and integrated in the network of domestic co-lenders, and to those countries where banks had established relationships.[15] Studies using bank-level data face limitations. For example, only a fraction of the participation share of each creditor

[13] These data are useful in cross-country (or cross-banking system) comparisons, particularly during periods of financial stress. Using aggregate BIS data, Rosenberg and Schuermann (2006) analyse how foreign banks reacted to the 1990s crises in Argentina, Brazil, and Mexico, and Rai, Kamil, (2010) study how reliance on a common lender led to problems in multiple countries during the East Asian crisis. Focusing on Latin America, (Kaminsky and Reinhart. 1998)and (Kaminski and Reinhart, 2003) find that conditions in parent countries importantly explain changes in international lending. Similarly, McGuire and Tarashev (2008) find that negative shocks to BIS reporting banks' health were associated with a slowdown in international credit to emerging markets more generally. More recently, Peek and Rosengren,(2010) document how adverse liquidity shocks in the largest banking systems in 2007-09 affected emerging countries through both cross-border and affiliates' lending; and, finally, (McCauley et al, 2010) show a long-term shift towards affiliate lending in lieu of direct cross-border lending, while highlighting that direct cross-border credit remains substantial for many borrower countries.

[14] For example, Buch (2014) and Popov and Udell(2010) fi nd that banks support their foreign affiliates in distress through internal capital markets.

[15] Other examples of studies using bank-level data are Cerrutti, McGuire et al(2011), who relied on US call reports and Japanese parent bank reports to show that Japanese banks transmitted shocks from Japan to the United States in early 1990s, and Cerutti, Claessens and McGuire (2012), who used US country exposure reports to assess whether US banks transmitted US business fluctuations to their foreign borrowers.

bank in a syndicated loan is known (typically less than half of the total syndicated loan amount).

Some approaches combine balance sheet-based and asset price-based analyses, but this is difficult in a global context. For example, Drehman and Tarashev (2011) analyse the systemic importance of interconnected banks in the absence of bilateral data, in which case the researcher needs to decide how to populate the matrix of interbank positions. They find that the conclusions reached under the common ‘maximum entropy’ assumption—i.e. that interbank positions are distributed as uniformly as possible across counterparties—can differ materially from those reached under alternative assumptions that are also consistent with the available data. The maximum entropy assumption is a common approach in studies of interbank contagion at the sovereign level, where most potential counterparty banks are included in the samples. However, as highlighted by Upper (2011), this assumption has many drawbacks in a global context since not all potential counterparties are included in the small sample of large global banks.

The IMF cross-border bank contagion module (described in more detail in (Momani, et al (2013), Tressel (2010) uses a multilateral Leontief-type input-output matrix of cross-border lender-borrower exposures based on BIS consolidated banking statistics. This matrix is then used to perform scenario analyses, which include several rounds of asset and funding shocks. Espinosa-Vega and Sole (2010) also conduct network analyses using BIS statistics and highlight the need to consider off-balance sheet exposures. Network models of the financial system offer intriguing ways to summarize data because of its focus on interconnectedness. These models open the door to some potentially important policy questions, but as previously addressed, there are some critical shortcomings in making these models fully useful for policy.

2.3.2 Network models & contagion risk in the banking sector

Haldane (2014) in his speech at the Maxwell Fry Annual Global Finance Lecture argued that the Financial Crisis 2007-8 revealed that the safety of individual banks was neither a necessary nor sufficient condition for systemic stability. Although seemingly counterintuitive, he has an interesting argument, and that lesson would have come as no surprise to anyone familiar with dynamic, integrated networks outside of the world of finance. Various models have been developed in computer science and network science among various fields like sociology. The literature, including the widely-used threshold models Granovetter (1978) where the 'threshold' proportion is the required influence that sways an actor in a network to make a decision in usual behaviour. In the percolation model Watts (2002) studies rare but large cascades over networks that are initiated by a small initial shock. By observing a sparse, random network of interacting agents whose decisions are determined by the actions of their neighbours according to a simple threshold rule. Two regimes are identified in which the network is susceptible to very large cascades which he calls 'global cascades' and can take any form such as cultural fads, collective actions or cascading failures in infrastructure and organisational networks – most significant example being the global financial crisis - that occur very rarely. A regime is the set of practices, rules and shared assumptions under which the network and actors comply.

A few works have likewise applied these ideas to various economic settings, including Durlauf (1993) and Bak, et al. (1993) in the context of economic fluctuations and the concentrations of most activity; Morris (2000) on the other hand works with networks in the specific context of contagion of different types of strategies using coordination games. Then more recently, (Gai and Kapadia, 2010) and Blume, et al.(2011) have studied the resilience of networks in the presence of cascading failures. Such failures that spread from one node to another across the network structure, creating a cascading processes at work similar to the kind of contagious failures that spread among financial institutions during a financial crisis; through nodes of a power grid or communication network during a widespread outage; or through a human population during the outbreak of an epidemic disease.

Assessing the stability of almost any network known to man whether natural, physical, social or economic relies upon a system-wide assessment. And protection mechanisms for this system need to be calibrated to system-wide characteristics Goldin and Mariathasan (2014). For the purpose of assessing contagion risk in the banking system studies based on network models have been used mainly in two categories of financial network (see Allen and Gale, 2000; Gai, Haldane and Kapadia, 2011;Caballero and Simsek, 2013; Alvarez and Barlevy, 2014;Elliott, et al., 2014). The distinctive feature of their model is the focus on an endogenous complexity such as asset price. One finding being that their implosion causes more 'banks' within the financial network to become distressed, thereby increasing each (non-distressed) bank's likelihood of being hit indirectly. The benefits of an input-output network model are also shown to capture the cascading effects, and open the door to thinking about co-movement across sectors and aggregate fluctuations not resorting to aggregate shocks. So that whether and how an idiosyncratic shock propagates across the economy via these linkages depends critically on the way the production network is arranged. (see Jovanovic,1987;, Long and Plosser(1983; Durlauf,1993; Acemoglu, et al,2013; Bigio and LaO, ,2013).

Network model studies have been used by central banks and regulators to measure contagion risk in banking systems; the pioneering works of Elsinger, et al.(2006) and Upper (2011) are solid examples of this approach. For theoretical underpinnings to the network approach some of the network literature that will be referenced in this chapter and chapters 4 and 5 are of an applied nature. (see Allen and Gale, 2000; and Freixas, Parigi and Rochet, 2000). Some network related studies focused on domestic banking systems—e.g., M. Boss, et al(2004) and Elsinger, et al.(2006) for Austria; Furfine (2003) for the United States; Martínez-Jaramillo, et al.(2010) for Mexico; Memmel and Stein(2008) and Upper and Worms(2004) for Germany; Sheldon and Maurer (1998) and Müller (2006) for Switzerland; and Wells (2004) for the United Kingdom, among others. However, there are a few studies covering a cross border application, see Chan-Lau, et al.(2009) for a cross-border application or to study contagion risk in a simulated banking system. See (Nier, et al., 2007). Majority of these studies conclude that while the probability of contagion is small, the loss resulting from contagion can be very large in some cases. See Upper, (2011), (Elsinger, et al., 2006) and (Elsinger, et al., 2006) . However there are number of studies which apply network analysis to the Bank for International Settlements (BIS) consolidated banking statistics with the same approach of this research ((McGuire and Tarashev,2008), (Rönnqvist and Sarlin, 2014), (McGuire and Tarashev, 2006) , (Hattori and Suda, 2007), (Espinosa-Vega and Solé , 2010), , Okuma, 2012) as well as to a report published by Deutsche Bank Research (Weistroffer and Möbert, 2010) or another report which was published by Fitch Rating (Murray and Rawcliffe, 2010). By contrast, Peter (2010) looks at the BIS locational banking statistics to identify important banking centres using network methods. (Castrén and Kavonius, 2009), in turn, use the Euro area flow of funds data to identify sectors and channels through which local shocks may propagate through the financial system.

Identifying systemic risks using disaggregated data; including maturity and currency mismatches, banks' asset & liabilities was a technique used by central banks and regulators. These studies' purpose was to capture systemic risks, stemming from common exposures, funding concentrations and other factors that may have a bearing on income, liquidity and capital adequacy (see, for example, Boss et al., 2006; Alessandri, et al., 2009). In our study , in order to identify sectorial interlinkages, we recompile the aggregate bilateral cross-border exposures into the interlinkage of selected countries' banks.

2.4 Role of Architecture of the Financial System

Here we will review part of a recent but growing literature that focuses on the role of the architecture of the financial system as an amplification mechanism. (Allen and Gale, 2000) (Kiyotaki and Moore, 1997) (Dale and Wolfe, 1998) , and (Freixas, et al., 2000) provided some of the first formal models of contagion over networks. Using a multi-region version of (Diamond and Dybvig, 1983)'s model, Allen and Gale (2000), for example, show that the interbank relations that emerge to pool region-specific shocks may at the same time create fragility in response to unanticipated shocks.[16] Dasgupta (2004) studies how the cross-holdings of deposits motivated by imperfectly correlated regional liquidity shocks can lead to contagious breakdowns. Shin (2008, 2009), on the other hand, constructs an accounting framework of the financial system as a network of interlinked balance sheets. He shows that securitization enables credit expansion through greater leverage of the financial system as a whole, drives down lending standards, and hence, increases fragility.

In addition to illustrating the role of the network structure on the stability of the financial system, Acemoglu, et al (2013) introduced a new notion of distance over the financial network, the harmonic distance, which captures the susceptibility of each bank to the distress at any other. They showed, in the presence of large shocks, all banks whose harmonic distances to a distressed bank is below a certain threshold default, the likelihood of contagion spreading across these susceptible links increases. They argue that various off-the-shelf measures of network centrality—such as eigenvector or Bonacich (a variation of degree) centralities—may not be the right notions for identifying systemically important financial institutions. Rather, if the interbank interactions exhibit non-linearity similar to those induced by the presence of unsecured

[16] Allen and Gale (2000) also note that compared to a four-bank ring network, a pairwise-connected (and thus overall disconnected) network can be less prone to financial contagion originating from a single shock.

debt contracts, then it is the specific bank closest to all others according to their harmonic distance measure that may be “too-interconnected-to-fail”.

More recently, Allen et al. (2012) have argued that the pattern of asset commonalities between different banks is the main determinant of the extent of information contagion and hence, the likelihood of a systemic crisis. Also with similar views is the work of Castiglionesi et al.(2012), who show that a higher degree of financial integration leads to more stable interbank interest rates in normal times, but to larger interest rate spikes during crises. For other contributions along similar lines, please see (Rochet and Tirole, 1996; Cifuentes, Ferrucci and Shin, 2005; Leitner, 2005; Nier, et al., 2007; Rotemberg 2011;, Zawadowski , 2011; Zawadowski , 2013; Battiston, et al, 2012; Gofman, 2011; Gofman ,2014; Caballero and Simsek 2013; Denbee, et al, 2013; Cohen-Cole, Patacchini and Zenou, 2013; Georg,2013) More recent and smaller literature focuses on the formation of financial networks. Examples include Babus (2013), Zawadowski (2013) and Farboodi (2014). None of the above papers, however, provide a comprehensive analysis of the relationship between the structure of the financial network and the likelihood of systemic failures due to contagion of counterparty risk. In our study we will focus on the relationship between structure and systemic risk of financial network.

The current state of uncertainty about the nature and causes of systemic risk is reflected in the potentially conflicting views on the relationship between the structure of the financial network and the extent of financial contagion, as mentioned in the preceding sections. Pioneering works by (Allen and Gale, 2000) and (Freixas, Parigi and Rochet, 2000) pre 07/08 crisis, suggested that a more interconnected architecture enhances the resilience of the system to the insolvency of any individual bank. Allen and Gale (2000), for example, argue that in a more densely interconnected financial network, the losses of a distressed bank are divided among more creditors, reducing the impact of negative shocks to individual institutions on the rest of the system.

In contrast to this view, however, others have suggested that dense interconnections may function as a destabilizing force, paving the way to systemic failures. For example, Vivier-Lirimont (2006) argues that as the number of a bank’s counterparties grows, the likelihood of a systemic collapse increases. In chapter 7 of the study role of architecture in systemic risk of financial system will be reviewed.

2.5 Visualising Financial Networks

For the purpose of preventing financial shocks or tailoring better global and local policy responses to shocks understanding the evolving nature of cross-border financial linkages is very helpful. Improved understanding will ultimately lead to identifying more and better solutions. The main question here is with all complexity of financial network how could we improve the understanding? One of the key goal of chapter 4 is to map and explain the effect of cross-border bilateral exposures and their macroeconomics consequences, the topology of network and its effect on shocks transmission. To do this we need to improve understanding of the network by visualising the financial network properties.

Iori et al. (2008) in their article visualised banking network on four groups in black, red, green and blue group. They identified a few hubs connected to a large number of peripheral banks which have only a few links. The topology of the Federal Funds Market was visualised by Bech and Atalay (2008). Unsecured sterling money market was visualised in the study by Wetherilt et al. (2008). They highlighted the insight network topology and its role on unsecured loan market in UK. In another study interbank payment flows was studied by visualising topology of interbank payment on 2007 (Soramaki et al., 2007). Marsh (2010) by using the Bank of International Settlements visualise Europe's web of debt on May 2010. He showed that banks and governments in Greece, Ireland, Italy, Spain and Portugal owe each other billions of dollars and have even larger debt to Britain, France and Germany. (Marsh 2010)

Focus of our study is to understand the evolving nature of cross-border financial linkages, mapping out the channels through which shocks are potentially transmitted, and better tailor global and local policy responses to shocks. The analytical visualised methods used in this study carries important lessons, which the research by focusing on the analytic of systemic risk and role of global financial architecture aim to internalize.

2.6 Core-periphery structure of banking network

We aim to examine the structure of financial network at country's level, so we empirically test the concept of core-periphery network at the end of chapter 4 by using the probit regressions testing whether network position can be predicted by individual network variables. The same methodology as Craig and Von (2010) used for perfect core periphery structure. We will illustrate the structure of banking network at country's level to see whether or not the topology follows hub based or scale-free network structure.

2.7 Theoretical contribution

We want to measure systemic risk of banking network using different methodologies focusing on inter-linkages between banks. In this study we will apply the concept of too big to fail (PCT test) then we will add factor of institutions' size (total assets of banks) and total exposures relative to the national marketplace. To improve the understanding of financial network then we map out and explain the effect of cross-border bilateral exposures and their macroeconomics consequences, the topology of network and its effect on shocks transmission. To do this we need to improve understanding of the network by visualising the financial network properties. To analyse the banking network in selected countries, centrality measures are used in second part of the study. We identify the most commonly used centrality measures such as Degree, Closeness and Betweenness proposed by Freeman (1978) and different variations of Eigenvector centrality. Then we apply cheiRank PageRank two-dimension model to illustrate the systemic importance role of main players in the banking network from 2005 till 2014.

The theoretical contributions to the analysis of systemic risk have mostly focused on informational contagion. We have analysed different approaches on systemic risk and a large part of the theoretical contribution focus on the effects of various parameters and network structure on the resilience of the network to contagion. Our model contagion in the network formed by EU banks exposures and find that the likelihood of the propagation of the financial distress between network players is mainly determined by the nature of their internonnectedness. Another part of theoretical contribution is for identifying sectorial interlinkages and connectedness, we recompile the aggregate bilateral cross-border exposures into the interlinkages of selected banks at countries level. Theoretically the study contribute to improve the understanding of interconnectedness and systemic risk by visualising the relationship of different players in the network. Explaining the effect of different cross-border bilateral exposures and their macroeconomic consequences as well as the network topology and its effect on shocks transmission is another angel of theoretical contribution of this study. Meanwhile we examine the structure of the financial network at country's level, testing whether network position can be predicted by individual network variables. The study provides a relevant theoretical framework that accounts for systemic risk and also by measuring it and utilizing a sample of relevant banks between 2005 and 2015. The research analyses the EU banking sector systemic risk both before and after 2007/8 financial crisis. It also accounts for the peak of the crisis. In addition this research examines the connection between systemic risk and the global financial architecture. We explain clearly a number of relevant questions that relate to the systemic risk. An important implication is that the financial crisis 2007-8 has highlighted the importance of the systemic risk and the absence of a relevant framework that can assess, monitor and regulate it. We contribute to the theoretical discussion from view point of structural characteristics that promoted systemic risks in banking sectors and we conclude they still around. The structure of banking sector has not changed much, if at all, over the period of 2007 to 2014, in a way that can tackle systemic risk. An important implication in this respect is the financial system needs to be managed as a system, what has come to be known as the macro prudential dimension of financial stability. The micro-prudential dimension, the axiom of the period prior to the crisis, was not sufficient. As a result systemic risk becomes important for it is a problem that the market cannot sort out. It follows that macro-prudential financial regulation become more important.

3. Chapter 3: Research Methodology, Data and Measurement

3.1 Methodology

The first chapter of study dealt with literature research and provided definitions, methods, models and business practices that pertain to systemic risk. This chapter details with the methodology applied in gathering and analysing the empirical and time series information. The empirical research and methodologies of each chapter is explained within it, however some research methodology guidelines are also explained in this chapter.

3.1.1 Research Questions

Generally, statistical methodology for hypotheses testing is to obtain a statistic representing the weight of evidence in favour of the experiment over another against the experiment. In this scenario, our experiment is geared towards exploring the role played by systemic risk in the global financial crisis and using our result to help create criteria that measures and subsequently predicts systemic risk in our sample financial system. Based on this, the main questions of the research are (i) What is the definition of systemic risk? (ii) How could systemic risk in the banking network be measured? (iii) What is a suitable analytical tool for assessing and monitoring systemic risk in EU banks, which will enable us to visualise the relationship between the financial network topology and systemic risk? (iv) Does the banking network follow a core-periphery structure? (v) What are the effects of microeconomic shocks on the banking structure? Does the banking structure network affect stability of the system? What is the role of aggregate fluctuations and its dependency on network structure? (vi) To what extent were EU banks exposed to systemic risk at a country level during and after the financial crisis of 2007/8? (vii) What is the impact of global financial architecture on systemic risk?

3.1.2 Research Methodology for Quantitative Approach

Regarding the measurement of systemic risk, two complementary approaches, *macro* and *micro*, can be employed. The *macro* or aggregated approach focuses on the evolution of macro indicators in order to detect possible bubbles in the economy. Some examples of this approach are Borio and Lowe (2002) and Borio and M Drehmann (2009), who propose to measure the financial unwinding of imbalances by means of price misalignments in some key indicators like inflation-adjusted equity prices or private sector leverage. The micro approach focuses on the individual institutions' financial health to determine the level of systemic risk in the economy (i.e. portfolio) by means of analyzing both market and accounting information. In this study, we focus mainly on macro level by using the aggregated data provided by individual institutions, in effect combining macro and micro level of data. Nevertheless, the macro level is also employed using aggregate variables like GDP. We realize that both approaches are complementary to each other. Although some papers have addressed the problem of systemic risk from different perspectives, (see Bühler and Prokopczuk (2010), who analyze tail dependence of stock returns by means of an Archimedean copula; and Avesani et al. (2006), who construct an indicator for sector surveillance using the default probabilities of an *nth*-to-default CDS basket of large and complex financial institutions. Few of them propose measures that allow surveillance institutions to monitor the aggregate level of systemic risk and its concentration in key financial intermediaries.

Lehar (2005) proposes extracting systemic risk measures on the basis of Merton's model (Merton, 1974). This measurement and using Monte Carlo simulations, Allenspach and Monnin (2006) employ a similar approach by estimating, through a structural model, the banks' asset-to-debt ratio. As an alternative to structural models, other authors employ CDSs to measure systemic risk. Bhansali et al. (2008) extract the idiosyncratic, sector wide and economy wide or systemic risks from US (CDX) and European (iTraxx) prices of indexed credit derivatives by means of a linearized three-jump model. Huang, et al.(2009) propose creating a synthetic Collateralized Debt Obligation (CDO) whose underlying portfolio consists of debt instruments issued by banks to measure the systemic risk of the banking system through the spread of the tranche that captures losses higher than 15%. (Segoviano and Goodhart, 2009) propose a set of banking stability measures based on distress dependence, which is estimated by the Banking System Multivariate Density (BSMD). Their procedure for estimating the multi-density function (CIMDO-copula) is able to capture both linear and non-linear distress dependences and allows changes throughout the economic cycle.[17]

Adrian and Brunnermeier(2008) propose a set of 'co-risk management' measures based on traditional management tools. They estimate the institution *i*'s Co-Value-at-Risk (*CoVaRi*) as the whole system (i.e., portfolio)'s Value-at-Risk (*VaRs*) conditioned on institution *i* being in distress (i.e., being at its unconditional *VaRi* level). On the basis of *CoVaR*, they calculate the marginal contribution of institution *i* to the overall systemic risk as the difference between *CoVaR* and the unconditional whole system's *VaR*, which we denoted as Δ*CoVaRi*. On Basel philosophy while not necessarily endorsing the adoption of systemic-based capital surcharges, IMF, in the 2010 report, (IMF. 2010) does present a methodology for the calculation of systemic-based capital surcharges to project towards a reliable buffer element in preventing illiquid scenarios; the main aim of Basel III an ongoing effort to foster greater resilience at the individual bank level in order to reduce the risk of system wide shocks. Underpinning the methodology is the notion that any surcharges should be commensurate with the large negative effects that a financial firm's distress may have on other financial firms-resulting from their systemic interconnectedness. The report goes on to present two different approaches regarding the implementation of its envisioned methodology:

A. A standardised approach, under which regulators assign systemic risk ratings to each institution and then assess a capital surcharge based on this rating.
B. A risk-budgeting approach, which borrows from the risk management literature and determines capital surcharges in relation to an institution's additional contribution to systemic risk and its probability of distress.

Table 2, reproduced from the 2010 and 2014 IMF reports, compare some methodologies to compute systemic-risk based charges.

Table 2 Systemic surcharge calculation methodologies

[17] By means of CIMDO-copula, the authors overcome the drawbacks of the characterization of distress dependence of financial returns with correlations, which has been one of the most popular approaches for measuring systemic risk.

Methodology/Proposal	Authors	Data Requirements	Pros	Cons
Proposals to design capital surcharges based on inter-bank correlations of returns	Acharya (2009)	Data on banks' returns	Based on easily accessible market data	Data may be unreliable under tail events and/or not representative of underlying fundamentals during stress periods. Charges could be procyclical. Does not take into account second-round contagion effects.
Proposals to design capital surcharges based on measures of institutions' and markets' degree of "exuberance".	Bank of England (2009)	Economic activity indicators, credit default swaps (CDS), equity prices, real estate prices	Capital surcharge displays, anticyclical behaviour	May be difficult to estimate institutions' and markets' degree of exuberance on an ongoing basis. Does not take into account second-round contagion effects.
Proposals to design capital surcharges based on co-movements of banks' risks (e.g. co-value-at-risk; Adrian and Brunnermeier, 2008).	Brunnermeier and others (2009) and Chan-Lou (forthcoming)	CDS and equity data	Based on easily accessible market data.	Data may be unreliable under tail events and/or not representative of underlying fundamentals during stress periods. Charges could be procyclical. Does not take into account second-round contagion effects.

Two alternative approaches to design capital surcharges	This report and Espinosa-Vega and Sole (forthcoming).	Data on interbank exposures and balance sheet information	Gives the regulator the choice between a refined and a practical approach. Relies on data available to financial regulators. Takes into account second-round contagion effects.	Intensive data requirements (Interbank exposure).
Tax based on over-the-counter (OTC) payables in derivative markets.	Singh (2010).	Data on payables in OTC derivatives	Based on off-balance sheet data. Includes netted exposures, measuring the potential systemic interconnectedness of these contacts more accurately.	Tax would only be based on banks' OTC derivative payables. Does not increase institutions' capital base. Does not take into account second-round contagion effects.
Supplementing capital surcharges with regulatory requirements for the	(Kashyap, Rajan, and Stein,	Balancesheet and equity	Such contingent capital	Uncertainty about the extent to which capital surcharges

issuance of hybrid debt instruments that can convert into equity during distress	2010); (French et al., 2010; and (Ötker-Robe et al., 2011)		would facilitate the recapitalization of banks during crisis times when capital is scarce	may affect the distribution of risk in the financial system
Effect higher capital on banks at a steady rate	(Aiyar, Calomiris, and Wieladek, 2014)		Indirectly mitigate externalities arising from unstable funding and market-based activities	The costs of raising capital requirements may quickly become substantial should banks respond by cutting lending therefore undo the benefits

Source: (IMF, 2010, IMF, 2014)

Much work is currently being done on potential measurement systems for systemic risk, and a definitive methodology for the measurement of systemic risk is yet to be arrived at Gerlach (2009), so we will review some of the methodologies currently being tested before proposing and explaining the methodologies we are using in this study.

3.2 Systemic risk measurement using CDS Spreads

Many of the papers already published concentrate on the 2007/8 financial crisis (Achrya et al, 2010). Hartmann, et al.(2005) measures systemic risk in the banking system by looking at institutions' CDS spreads. (Huang et al., 2009) also use data on CDS, as well as stock return correlations across financial firms, to estimate expected credit losses above a given share of the financial sector's total liabilities.(Levin, et al., 2005) measure the systemic risk of corporate banks using CDS spreads to formulate the identity below:

B§²©(M) ≡ S§²(M) _ S§²©(M)

Where S§²(M) is the CDS spread of maturity M for firm *i* at date *t*, and S§²©(M) is the corresponding spread for bond *K* issued by firm *i*.

Working on the assumption that the two spreads should be equal, they measure the degree of systemic risk against the severity of the divergence between the two spreads.3.3.2 Flaws in Credit Default Swaps (CDS) Methodology of Measurement However, measuring systemic risk according to (Credit Default Swaps) CDS spreads is a limited approach as it does not take into account other factors and analysis. Also, causes of friction between CDS spreads may not necessarily be consequential on systemic risk; they can also be firm- or bond- specific. This means that measuring the divergence of CDS spreads within a bank may lead us to assume that the bank has systemic risk, when in fact it's a completely different problem causing the divergence. Furthermore, it is difficult to operationally extract the CDS data for calculating Marginal Expected Shortfall (MES) (ASHARYA et al., 2010). The MES can indicate exposure of a financial institution to systemic risk to some degree. Another issue is that CDS may not reflect predicted losses of the financial firm to the extent some banks have more governmental guarantees as an integrated part of their capital structure, for example deposit institutions, government-sponsored enterprises and the so-called too-big-to-fail financial institutions.

3.3 Measuring systemic risk using aggregate indicators

Gerlach (2009) identifies two separate methodologies for measuring systemic risk, alternative to our chosen approach. The first approach is to use aggregate indicators of financial soundness. This has been the methodology of choice for central banks, regulatory and supervisory agencies and international institutions in the past ten years or so. Indicators that can be used for the purpose of this methodology include:

A. Interest rates and asset prices: Prices of financial assets and interest rates are continuously available with no delay and contain information about markets participants' views of a range of different risks. This information can be used to construct a number of indicators of the functioning of financial markets, including measures of liquidity premiums, risk spreads and implied volatilities.
B. Financial stocks and flows: These include measures of bank lending, net issuance of bonds and notes by firms and capital flows. The use of such indicators is motivated by the fact that localised financial tensions can become systemic and cause banks and other institutions to scale back lending, which tends to cause or aggravate macroeconomic weakness with obvious risks for a feedback loop onto the financial system.

C. Macroeconomic indicators: Since many episodes of financial crises have been triggered by severe business cycle downturns, it is natural for the authorities responsible for financial stability to monitor evidence of macroeconomic vulnerabilities.

3.3.1 Flaws in Aggregate Indicators Methodology of Measurement

This approach has two shortcomings:

a) Many indicators are reported infrequently and

b) The approach focuses on broad developments in the financial system, providing little information about the state of individual financial institutions, which is what our study is concerned with.

Also, the fact that the approach has been used by regulatory authorities for about a decade, the same authorities that failed to detect the build-up of crisis-causing risk in the system, hardly recommend the methodology as reliable.

3.4 Measuring systemic risk using interlinkages between banks

The second approach is to assess interlinkages between banks. Here Gerlach cites the IMF's (2009) list of methods for assessing interlinkages between financial firms:

A. The network approach: This approach tracks the transmission of financial stress across the banking system via linkages in the interbank market.
B. The co-risk model: This model uses market data on credit default swaps to assess how the default risk of an institution is affected by the default risk of another institution.
C. The distress dependence matrix: With this approach, analysts study a group of financial institutions and assess the probability of distress for a pair of institutions, taking into account a set of other institutions
D. The default intensity model: This captures the likelihood of default of a large fraction of financial institutions through linkages.

3.5 Measuring systemic risk using Market Values

In many studies systemic risk measurements in two broad categories were carried out:

a) The first group focused on monitoring traditional macroeconomic indicators of financial soundness and stability;

b) The second group analyzed the interlinkages between financial institutions through the analysis of the financial institutions' assets.

The first group of contributions relied on bank capital ratios and bank liabilities showing that aggregate macroeconomic indicators can provide a valid and useful instrument to predict systemic risk threat. Through the study of macroeconomic fundamentals Gonzalez-Hermosillo et al.(1997), Gorton (1988) and Gonzalez-Hermosillo (1999) proved the evidence supporting the functioning of macro analysis in estimating systemic risk. Bhansali et al.(2008) derived the 'systemic credit risk' variable from index credit derivatives and found that systemic risk during the 2007-2009 financial crisis showed a double value as compared to May 2005. De Nicolo and Lucchetta (2009) firstly, used a dynamic factor model to work out joint forecasts of indicators of systemic real risk and systemic financial risk, and secondly they elaborated stress-tests of these indicators as impulse responses to structurally identifiable shocks. The use of aggregate indicators, if on one side it looks like the most suitable instrument for systemic risk assessment, on the reverse it illustrates several limitations for the infrequent character of the data under analysis. Furthermore, by focusing on broad drivers of the financial system, this approach is bounded by the scarce information about the state of individual financial institutions, in particular about interlinkages between institutions.

The second group analyzed the interlinkages between financial institutions as well as exposures among banks that through their business can influence each other in situations of financial distress. "It was the ultra-interconnectedness of the nation's financial institutions that posed the biggest risk of all. As a result of the banks owning various slices of these new-fangled financial instruments every firm was now dependent on the others – and many didn't even know it. If one fell, it could become a series of falling dominoes" Sorkin (2009). p.15

De Bandt and Hartmann (2000) provided an interesting survey of category of studies. The contribution was given by Lehar(2005), assessing the probability that a certain number of banks within a time period go bankrupt due to the decreasing of their asset value below a well-defined liability value. This view comes from the structural model by Merton (1974) wherein a bank's default occurs when the asset banking values stand below a given threshold value. Adrian and Brunnermeier (2008) defined CoVaR as the VaR of financial institutions conditional on other institutions that experience, at the same time, financial distress. De Nicolo and Lucchetta.(2009)investigated the transmission channels and contagion effects of certain shocks between the macro economy, financial markets and intermediaries. Huang, et al.(2009) used as a proxy of systemic risk the price of insuring a dozen major US banks against financial turmoil by using both ex-ante bank default probabilities and forecasted asset-returns correlations.

Increased cross-border financial linkages promote risk diversification at the individual country level, reducing exposure to localized shocks. However, increased interconnectedness, by facilitating transmission of shocks, also generates a network externality that makes the global financial network more prone to systemic risk. Moreover, as the extent and complexity of cross-border financial linkages grow, investor information about specific exposures becomes less certain, amplifying systemic risks from panic responses to shocks. For this purpose, the analysis of interlinkages between financial institutions is of key importance, both from a domestic and international point of view. With regard to this, the IMF (2009) surveyed four different methods to assess interlinkages between financial institutions:

-The network approach: here the interbank market spreads the transmission of financial stress through the banking system. (Allen and Babus, 2007) stated that network analysis is the best approach to lead an in-depth analysis of systemic risk, as it allows the regulator to analyse not only the fulcrum of the problem, but also the spillover effects from direct financial linkages through the construction of a matrix of inter-institution exposures that includes gross exposures among financial institutions (both national and international).

-The *co-risk model* (or co-movement risk model): in this specification, the probability of default of one institution is directly linked to the default risk of another institution. As underlined in Brunnermeier and Adrian(2009) "It may be that the best way to assess the implications of endogenous co-risk measures that measure the increase in overall risk after conditioning on the fact that one bank is in trouble" *(p. 5).* Empirical studies during the past ten years, such as Vries, Hartmann and Straetmans (2001), Longin and Solnik (2001) and Mathieson andYao(2004) found a clear evidence that co-movement between financial variables is stronger during troubled times than during normal times.

-The distress dependence matrix studies the probability of default of a pair of banks, by taking into account a panel of financial banks. Through this method, it is possible to assess the probability of a financial institution experiencing distress conditional on another institution that shows clear signs of financial troubles (Segoviano and Goodhart. 2009 p.16-18) offered a brilliant contribution to this technique.

-The *default intensity model* is able to capture the probability of default of a large part of financial institutions through linkages between some institutions. These kinds of models are worked out in terms of default rate jumps that occur at failure events, reflecting the increased likelihood of further events due to spillover effects. In this regard, Giesecke and Bacho (2009) captured the clustering of the economy-wide default events as represented by the fitted intensity.

Using standard risk management techniques, Lehar (2005) estimates the current value as well as the volatility of the regulator’s liability. These numbers can be used to estimate the funds that the lender of last resort has to be ready to inject into the banking system or to derive a value-at-risk for the deposit insurance agency, which defines the optimal size of the deposit insurance fund. Using standard value-at-risk tools, the contribution of an individual bank or of a group of banks to the volatility of a deposit insurer’s liability can be derived using $\pm^2$.

As Lehar (2005) shows in his work, systemic risk based on market values can be estimated using the following likelihood function, where E represents a time series of equity prices, and *m* represents two years (*m* = 24 months).

$$L(\mathrm{E}, «, \pm) \equiv -\frac{m-1}{2}\ln(2®) - \frac{m-1}{2}\ln \pm^{2} - \sum_{t=2}^{m} \ln(N(\hat{d}t)) - \frac{1}{2\pm^{2}}\sum_{t=2}^{m}\left[\ln\left(\frac{\hat{V}t(\pm)}{\hat{V}t-1(\pm)}\right) - «\right]^{2}$$

Segoviano and Goodhart.(2009) also treat the financial sector as a portfolio of individual financial firms, looking at individual institutions’ contribution to the potential distress of the system by using the CDS of these firms within a multivariate setting.

This is similar to the approach identified by the IMF as the ‘co-risk model’, also mentioned above. Gray, et al.(2007) use a similar contingent claims analysis approach, as a means to providing an overall framework for measuring systemic risk across different sectors and countries. Despite the fact that a major focus of the literature on systemic risk is on quantitative measures, there are also some contributions that take into consideration qualitative measuring instruments (Nelson and Perli. 2005).

3.5.1 Flaws in Market Values Methodology of Measurement

The data Lehar (2005) uses is only taken from the financial markets, making his findings limited and biased. Additionally, it is hard to verify the results empirically by means of a statistical test. In theory standard tests could be applied for market models, but there are two points on which we can challenge this setting.

a) Considering the number of years needed for the data, the actual amount of data eventually yielded from the collation process is not proportionately enough, in terms of statistics, to garner reliable results.

b) In the UK, there is no data available on actual bank failures and interventions by regulators such as the FSA (the now defunct regulator) and Bank of England or FCA at the time being. As we are measuring the systemic risk in EU banks including the UK, this methodology of measuring systemic risk proves to be of no use to us.
Although this form of measurement is useful for measuring systemic risk in the aggregate banking system as a whole rather than the interlinkage amongst the banks network. Similarly, the use of combined data gives a skewed result when the individual components are not standardised to take into account their unique features. Take for instance the analysis carried out for the Swiss banking sector for the period 1987-1995 by Sheldon and Maurer(1998). Historical aggregate data for the groups of banks rather than for individual banks is used to construct a model and within each group, borrowings are distributed evenly. The authors consider several scenarios and find that in the most realistic scenario using collected aggregate data there is no domino effect. However, within a theoretical framework proposed in other methodologies, the results confirm that indeed it is a heterogeneous banking system, and as such the interbank market has the potential to create contagion, which was exactly what happened during the financial crisis 07/08.

3.6 Measuring systemic risk using Systemic Expected Shortfall (SES)

Acharya et al. (2010) propose a systemic expected shortfall (SES) as a systemic risk measure. SES is a bank's propensity to be undercapitalised when the system as a whole is undercapitalised. SES increases with the institution's leverage (i.e. short term lending against long term lending). It is also increased with anticipated loss in the tail of the system's loss distribution. Although modern banks create many externalities as they take more and more risks, they internalise these risks if they are taxed based on their SES.

Acharya et al. (2010) show how, using this measure, a bank's contribution to systemic risk can be measured and priced. Using a similar sample time period to us - 2007-2009 - they aim to demonstrate empirically the ability of SES to measure systemic risk in banks during the financial crisis in particular using (i) the outcome of regulators' stress tests (ii) the fall in equity valuations in the banks during the crisis and (iii) the widening of their credit default swap spreads.

By focusing their empirical analysis on the cross-sectional systemic risk, Systemic Expected Shortfall (SES), Acharya et al. (2010) use the following cross-sectional variation in systemic risk SES. To control for each bank's size, they scale by initial equity $\mu \frac{§}{-}$, :

$$\frac{\int SES§}{\mu \frac{§}{-}} \equiv \frac{za§}{\mu \frac{§}{-}} - \int \mathrm{E}\left[\frac{\mu \frac{§}{1}}{\mu \frac{§}{-}}\right] - 1 \middle| W1 \leq zA$$

The first part, $za§ \big/ \mu \frac{§}{-} - 1$, measures whether the leverage, represented by $ai \big/ \mu \frac{i}{o}$ is initially already "too high". Specifically, seeing as systemic financial crises tend to happen when aggregate bank capital slips to below *z* times assets, (Acharya, et al., 2010) argue that *z* times leverage should be less than the sum of 1. Therefore, a positive value of $\int za§ \big/ \mu \frac{§}{-} - 1$ means that the bank is already under-capitalised at time *O*. Thus, argues Acharya, the bank is suffering from SES shortfall. The extent to which the positive value deviates from 1 is the degree to which there is such SES shortfall. The writers of the paper claim that systemic risk can be measured by measuring the extent of this shortfall.

3.6.1 Flaws in SES Methodology of Measurement

This methodology of measurement, however, refers to a bank's contribution to overall systemic risk in the financial system, not to how much systemic risk is present in the individual banks themselves. It also ignores the significance of prices of out-of-the-money equity options and insurance against losses of individual firms when the system as a whole is in stress.

3.7 Measuring systemic risk using 'Too Big to Fail/Too Interconnected to Fail'

Another popular methodology is the 'Too Big to Fail' test (PCI). This assesses the risk of required government intervention. Government intervention is a well-known symptom of systemic crises; it is the State's attempt at stopping the pattern of systemic risk spilling over and spreading from bank to bank by bailing out the bank(s) that is at the root, or the peak, of the trouble and are 'too big to fail', least it poisons the waters of smaller institutions. According to PCI, the 'Too Big to Fail' factor can be measured in terms of an institution's size relative to the national and international marketplace, market share concentration (using the Herfindahl-Hirschman Index[18] for example), and competitive barriers to entry or how easily a product can be substituted.

Another test based on the likelihood of governmental intervention is the 'Too Interconnected to Fail' test (PCI). TICTF is a measure of the likelihood and amount of medium-term net negative impact to the larger economy of an institution's failure to be able to conduct its ongoing business. The impact is measured not just on the institution's products and activities, but also the economic multiplier of all other commercial activities dependent specifically on that institution. It is also dependent on how correlated an institution's business is with other systemic risks. PCI cites insurer AIG[19]

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[18] The Herfindahl-Hirschman Index, or HHI, is a measure of the size of firms in relation to the industry and an indicator of the amount of competition among them. It is defined as the sum of the squares of the market shares of the 50 largest firms (or summed over all the firms if there are fewer than 50) within the industry, where the market shares are expressed as fractions. The result is proportional to the average market share, weighted by market share. As such, it can range from 0 to 1.0, moving from a huge number of very small firms to a single monopolistic producer. Increases in the Herfindahl index generally indicate a decrease in competition and an increase in market power, whereas decreases indicate the opposite.

[19] For more on AIG during the crisis, see The New York Times article 'Behind Insurer's Crisis, Blind Eye to a Web of Risk' by Gretchen Morgenson, published 27th September 2008 and available at http://www.nytimes.com/2008/09/28/business/28melt.html?_r=1

as an example of ‘Too Interconnected to Fail’ rather than ‘Too Big to Fail’ explaining the unusual degree of federal assistance the firm received in the light of the crisis. Cont (2009) use the TICTF concept to develop a methodology based on explicit modelling of counterparty relations between financial institutions. Within this framework, Cont (op.cit) propose a measure of systemic risk that puts emphasis on ‘Too Interconnected to Fail’ over and above ‘Too Big to Fail’.

3.7.1 Flaws in the Too Big to Fail/Too Interconnected to Fail Methodology of Measurement

The real-world problem with the ‘Too Big to Fail’ and ‘Too Interconnected to Fail’ tests is that continual use and reference to them, even in theoretical study, propagate the idea that governments across the world are obliged to bail out certain institutions that match certain formulas. According to Thompson (2009) expectancy of a government bail-out creates, “the mother of all moral hazards-implicit rescue guarantees as far as the eye can see?” (p. 2).

3.8 Measuring systemic risk using High Leverage and Security Mismatch

As discussed in the preceding chapters, two causes of systemic risk are high leverage and security mismatch; therefore, some analysts believe they are justified in using these, and similar factors, as a gauge of systemic risk. One Harvard Business School senior lecturer, for instance, told a US Senate committee in March 2009 that regulators should gauge systemic risk by using five factors historically associated with financial crises Thompson (2009) :

1. Inflated prices of real estate
2. Institutions with high levels of leverage
3. New products falling into regulatory gaps
4. Rapid growth in an asset class or intermediary
5. Mismatches of assets and liabilities

3.8.1 Flaws in the High Leverage and Maturity Mismatch Methodology of Measurement

The problem with such a methodology, however, is that it is relatively subjective. In regards to factor number three, for instance, how does one empirically measure to what extent a new product is not covered by existing regulation? One analyst may believe none of the current regulatory rules apply to a new product; another may argue that some of them do. Although if all factors are taken as symptomatic, without exception the proposition holds stronger.

3.9 Are Credit Default Swaps (CDS) spreads a good proxy of bank risk

During the last few years, a number of studies refer to CDS spread as a good proxy for reflecting banking risk (see, for example, Chiaramonte and Casu, 2010). Chiaramonte and Casu (op. cit.) refering in their study to the empirical analysis, which indicates that bank CDS spreads, both in the pre-crisis period, but especially in the crisis period (acute and less acute), reflect the risk captured by bank balance sheet ratios.

3.10 Selected measurement methodology: quantitative measurement

Rodríguez-Moreno et al. (2012) compute six different sets of systemic risk measures for a sample of the 20 biggest European and 13 biggest US banks from January 2004 to November 2009. The six measures are based on (i) Principal components of the bank's Credit Default Swaps (CDSs), (ii) Interbank interest rate spreads, (iii) Structural credit risk models, (iv) Collateralized Debt Obligations (CDOs) indexes and their tranches, (v) Multivariate densities computed from CDS spreads and (vi) Co-Risk measures. They then rank the measures using three different criteria: (i) Granger Causality tests, (ii) Gonzalo and Granger metric and (iii) their correlation with an index of systemic events. The conclusion was for the European and US markets, the best indicators are the first Principal Component of the single-name CDSs and the LIBOR-OIS or LIBOR-Tbill spreads, respectively, whereas the least reliable indicators are the Co-Risk measures.

3.10.1 Tail Measures

One approach measures co-dependence in the tails of equity returns to financial institutions. Some form of co-dependence is needed to distinguish the impact of the disturbances to the entire financial sector from firm-specific disturbances. Prominent examples of this include the work of Adrian and Brunnermeier (2008) and Brownlees and Engle(2011). Measuring tail dependence is particularly challenging because of limited historical data. To obtain estimates requires implicit extrapolations from the historical time series of returns because of the very limited number of extreme values of the magnitude of a financial crisis. While co-dependence helps to identify large aggregate shocks, all such shocks are in effect treated as a conglomerate when extracting information from historical evidence. The resulting measurements are interesting, but they put aside some critical questions that are needed to understand better policy advice. For example, while equity returns are used to identify an amalgam of aggregate shocks that could induce crises, how does the mechanism by which the disturbance is transmitted to the macro economy differ depending on the source of the disturbance? Not all financial market crises are macroeconomic crises.

It is wrong to say that this tail-based research is devoid of theory, and in fact Acharya et al. (2010) suggest how to use tail-risk measures as inputs into calculations about the solvency of the financial system. Their paper includes an explicit welfare calculation, and their use of measurements of tail dependence is driven in part by a particular policy perspective. Their theoretical supporting analysis is essentially static in nature, however. The macroeconomic consequences of crises events and how they unfold over time is largely put to the side. Instead, the focus is on providing a measure of the public cost of providing capital in order to exceed a specific threshold. This research does result in model-based measurements of what is called marginal expected shortfall and systemic risk. These measurements are updated regularly on the V-Lab web page at New York University. The use of tail-risk measures by Acharya et al. (2010) is an interesting illustration of how to model systemic risk and may well serve as a valuable platform for a more ambitious approach. Although, the focus on equity calculations limits the financial institutions that can be analysed.

3.10.2 Contingent claims analysis

In related research, Gray and Jobst (2011) apply what is known as contingent claims analysis. This approach features risk adjustments to sectoral balance sheets while featuring the distinct roles of debt and equity. It builds on the use of option pricing theory for firm financing where there is an underlying stochastic process for the value of the firm assets. Equity is a call option on these assets and debt is the corresponding put option. Gray and Jobst (2011) discuss examples of this approach extended to sectors of the economy including the government. In their applications, they measure sectoral balance sheets with a particular interest in financial crises. This approach neatly sidesteps statistical challenges by using 'market expectations' and risk-adjusted probabilities in conjunction with equity-based measures of uncertainty and simplified models of debt obligations (Brunnermeier and Krishnamurthy, 2014). Extending contingent claims analysis from the valuation of firms to systems of firms and governments is fruitful. Note however, as our aim is to make welfare assessments and direct linkages to the macroeconomy, then the statistical modelling and measurement challenges that are skirted will quickly resurface.

Market expectations and risk-neutral probability assessments offer the advantage of not needing to distinguish actual probabilities from the marginal utilities of investors in financial markets, but this advantage can only be pushed so far. A more fundamental understanding of the market-based ‘appetite for risk’ and a characterization of the macroeconomic implications of the shocks that command large risk prices require further modelling and a more prominent examination of historical evidence. Such an understanding is central when our ambition is to engage in the analysis of counterfactuals and hypothetical changes in policies.

3.11 Comparison of our measurement methodology and our way of measurement

We will now compare side-by-side our way of measurement (beta measurement) with the other measurement methodologies we have mentioned above. Table 3 shows the different features, advantages and disadvantages of each method, thus summarising the main postulations of the several methodologies.

Table 3 Measurement Methodology Comparison

Measurement method	**Main features**	**Advantages**	**Disadvantages**
1) CDS Spreads	Works on the assumption that two spreads should be equal. Measures the degree of systemic risk against the severity of the divergence between the two spreads.	Allows you to look at the credit losses of each institution, giving you an idea of the given share of the financial sector’s total liabilities.	It is a limited approach as it doesn’t take into account other factors and analysis. Assumes that friction between spreads can only be due to systemic risk. Difficult to operationalise the data for calculating MES.

2) Aggregate indicators	Central banks, regulatory & supervisory agencies and international institutions tend to use this way of measurement. Indicators used include interest rates, asset prices, financial stocks/flows, and macroeconomic indicators.	Some of these indicators are available with no delay and contain information about market participants' views of a range of different risks.	Other indicators are, however, reported infrequently. The approach provides little information about the state of individual banks. It's a method that obviously didn't help authorities detect the build up of crisis-proportion risk in the system.
3) Interlinkages between banks	Within this method are several sub-approaches, including the network approach, the co-risk model, the distress dependence matrix, and the default intensity model.	This method captures the likelihood of a default of a large fraction of financial institutions through linkages. It also makes clear the probability of distress in each firm.	A large amount of data is required and much of that data is only accessible to policy makers.
4) Market Values	This measures systemic risk based on the dynamics and correlations	The method is good for exploring the role of systemic risk in a	This method is not very good for measuring the individual risk of each individual bank, as opposed to the system

	between bank asset portfolios. This method is used to measure the banking system as a whole, rather than individual banks. The individual liabilities that the regulator has to each bank are modelled as contingent claims on the bank's assets.	banking crisis, as it measures the systemic risk of the whole banking system.	as a whole. The data is also limited as it is only from financial markets. Also, it is hard to verify the results empirically by means of a statistical test.
5) Systemic Expected Shortfall	This method can be used to measure and price a bank's individual contribution to systemic risk. The outcome of regulators' stress tests and the fall in equity valuations in the banks during the crisis and the widening of credit default swap spreads are all used in this method.	This method is good at presenting a cross-sectional perspective on systemic risk.	This methodology of measurement is flawed because it refers to a bank's contribution to overall systemic risk in the financial system, not to how much systemic risk is present in the individual banks themselves. It also ignores the significance of prices of out-of-the-money equity options and insurances against losses of individual firms when the system as a whole is in stress.

6) Too Big to Fail/Too Interconnected to Fail	This method measures systemic risk through assessment of the risk of required government intervention. 'Too Big to Fail' is measured in terms of an institution's size relative to the national and international marketplace and other factors. 'Too Interconnected to Fail' measures the likelihood and amount of medium-term net negative impact to the larger economy of an institution's failure to be able to conduct its ongoing business.	This methodology is popular because it takes into account not just the bank's products and activities, but also the economic multiplier of all other commercial activities dependent specifically on that bank.	The real-world problem with the 'Too Big to Fail' and 'Too Interconnected to Fail' tests is that continual use and reference to them, even in theoretical study, propagate the idea that governments across the world are obliged to bail out certain institutions that match certain formulas.
7) High Leverage and Security Mismatch	High leverage and security mismatch	This form of measurement	This form of measurement is very

	are each used as a gauge of systemic risk within each bank.	takes into account five evenly balanced factors, namely inflated prices of real estate, institutions with high levels of leverage, new products falling into regulatory gaps, rapid growth in an asset class or intermediary, mismatches of assets and liabilities.	subjective so it is very hard to get any factual information from it. For example, it is difficult to empirically measure to what extent a new product is not covered by existing regulation.
8) Our methodology: combination of micro & macro factors in light of network models	The systemic risks of banks are measured using aggregated banks data on a quarterly basis. Selected countries banks' exposures were analysed in light of the countries' banking sector size (mainly from European central bank, and Federal	This method captures the likelihood of a default of a large fraction of financial institutions through linkages at country level. It is a comprehensive approach as it uses micro and	Large amount of data is required and time consuming.

	Reserve Economic data) total exposure and the country's GDP quarterly basis data. The output reviewed with introducing an index combination of banking assets and GDP of the country using Herfindahl index and author's calculation. We use the most commonly used centrality measures such as Degree, Closeness and Betweenness proposed by (Freeman,1978) and different variations of Eigenvector centrality. Then we apply cheiRank, PageRank, two-dimension, model to illustrate the systemic	macro level of data. It also pays decent attention to the structure of banking system which seems to be a significant advantage.	

	importance of the role of main players in the banking network from 2005 till 2014.		

Source: **author's compilation**

Upon detailed analysis of the seven methodologies currently in literature for measuring systemic risk we were able to build a more specific method that bypassed their shortcomings as outlined above in Table 3. For example, despite the most expansive dataset being available for analysis, there are still other restrictions such as significant confidentiality issues and unavailable/unrecorded relevant data for individual institutions like non-public financial firms or non-bank financial companies such as pension funds. Hence, the methodologies being applied must be mindful of this. The nature of Credit Default Swaps contracts, counterparties are exposed to a unique risk in the case of multilateral defaults as experienced during a systemic episode. The OTC market for CDS swaps is highly active as large financial institutions and banks are constantly insuring their credit accounts and payments due against defaults. However, when the insurer is however at risk of defaulting, the value of the insurance (CDS spread) is significantly lowered. So how does one predict the systemic risk measures also of the insurers? The CDS Marginal Expected Shortfall is utilised and the criteria for it is readily accessible from stock market information. Aggregate Market Indicators are an easy tool to apply as they affect the entire markets. Financial institutions' market share, the state of the economy, and equity prices are easily affected by these factors. When a macroeconomic event occurs its effects are always seen in these key indicators either as a by-product or an orchestrated supervisory or regulatory event.

As the financial ecosystem has grown, the interrelation between its composite parts has also grown. This interlinkage can be seen in the speed and depth of the failures experienced during the crisis. This contagion effect (to be delved into later) is measureable by several modelling techniques that attempt to show the multilateral dimensions of a systemic event on various kinds of networks. The success of the models is determined by the thorough assessment of co-dependence data between financial institutions within the financial system (which are modelled as nodes on the network). As already mentioned, Credit Default Swaps (CDS) spread data encompassing both multi-level transactional and institutional information, for the comprehensive analysis of potential systematic risk is not available for the global level at which it gives researchers the most penetrative insight and in depth perspective on the market.[20] Hence, one needs to rely on publicly available information from sources like Bloomberg or BIS, and the accuracy of result becomes questionable when implemented. On the other hand, the IMF (2009) recommends several approaches in the methodology measuring interlinkages between banks. However, as was shown, data access constitutes a major hindrance, yet again and the numerous approaches discussed in this methodology, such as co-risk that inspects the joint relationship between two elements to see how one affects the other i.e. how can bank A affect bank *B* and vice versa, when a shock is transmitted either/both way(s)? This consideration is a better placed measurement of systemic risk, which is a network-wide interruption and affects multiple rather than individual institutions. Meanwhile, other measures such as systemic expected short fall or 'Too-big-to-fail/Too-interconnected-to-fail' methodologies require quantitative tests and valuations that may not accurately model the relationship between the individual parts because it takes a holistic approach all together. Such that even if a fuller view of the network is given, useful economic implications may be ignored to the detriment of the researcher. The confidence the author places in the proprietary methodology being implemented for this research is based on the multi-faceted approach in place. As we will come to find, there are subtle indicators that have system-wide effects on the network. By diversifying measures to cover micro and macro factors, as well as structural and relational input - as will be discussed further – this tremendously reduces susceptibility to traditional pitfalls. However, the sheer volume of data required makes this method quite time consuming.

[20] European Systemic Risk Board, Assessing Contagion Risk from the CDS Market (p. 5). Available at: https://www.esrb.europa.eu/pub/pdf/occasional/20130917_occasional_paper_4.pdf?ff625a08c2bd438f8e68bfa4ed4db09b

3.12 The research methodology

Furthermore, considering the lack of consensus of what construes systemic risk, (and the difficulty in detecting an independent and clear measure suitable for any scenario and market, there are a distinct number of reliable quantitative indicators utilised to measure the first signs of financial distress). In this aspect, we propose a dual classification to study the principal measurement tools of systemic risk. We opted for a different choice from macro or micro approaches, as we consider that the contagion among banks and the subsequent spillover effects coming from the interlinkage between, in light of their macro and micro factors on their environments. To this end, the interlinkage between banks at country level should be considered using different types of data in both macro and micro including different cross-border banks' exposures, GDP, banks' balance sheet data, CDSs, LIBOR-OIS, and LIBOR –Tbill spreads.

Echoing Haldane's (2014) sentiments that 20th global finance was more patchwork than network, yet that the past thirty years have seen that picture change spectacularly. Therefore, this well-connected network, a tightly-woven and tangled web, is a genuine system (Haldane, op. cit.). Such that to study this well-connected network, a network approach to problem-solving, which will be explained in detail, might be more relevant to the nature of today's banking system.

3.12.1 Network models

Network models of the financial system offer intriguing ways to summarize data because of its focus on interconnectedness. These models open the door to some potentially important policy questions, but there are some critical shortcomings in making these models fully useful for policy. A financial firm in a network may be highly connected, interacting with many firms. Perhaps these links are such that the firm is too interconnected to fail. A critical input into a policy response is how quickly the networks structure will evolve when such a firm fails. As is well recognized, in a dynamic setting these communication links will be endogenous, but this endogeneity makes modelling in a tractable way much more difficult and refocuses some of the measurements needed to address policy concerns.

Linking financial market disruption to the macro-economy requires more than just using 'off-the-shelf' dynamic stochastic equilibrium models, say, of the type suggested by (Christiano, Eichenbaum and Evans 2005) and Smets and Wouters(2007). By design, models of this type are well suited for econometric estimation and they measure the consequences of multiple shocks and model explicitly the transition mechanisms for those shocks. Identification in these multi-shock models is tenuous. More importantly they are 'small-shock' models. In order to handle a substantial number of state variables, they appeal to small noise approximations for analytical tractability. Since the financial crisis, there has been a rush to integrate financial market restrictions into these models. Crises are modelled as times when ad hoc financial constraints bind. To use local methods of analysis, separate approximations are made around crisis periods. See (Gertler and Kiyotaki, 2010) for a recent development and discussion of this literature.

Furthermore, there is promising research developing, which applies computational methods that allow for a more global approach to analysing non-linear dynamic economic models. More application and experience with such methods should open the door to a better understanding of stochastic models with linkages between financial markets and the macro-economy. Enriching dynamic stochastic equilibrium is a promising research agenda, but this literature has only scratched the surface on how to extend these models to improve our understanding of the macroeconomic consequence to upheaval in financial markets. It remains an open research question as to how best (i) to model financial constraints, both in terms of theoretical grounding and empirical importance; (ii) to characterize the macroeconomic consequences of crisis level shocks that are very large but infrequent 'black swan events'; and (iii) to model the origins of these shocks. Identifying systemic risks using disaggregated data including maturity and currency mismatches, banks' asset and liabilities were used by central banks and regulators. These studies' purposes were to capture systemic risks, stemming from common exposures, funding concentrations and other factors that may have a bearing on income, liquidity and capital adequacy. (For example see (Boss, et al. 2006), (Alessandri, et al, 2009)). In this study for identifying sectorial interlinkages, we recompile the aggregate bilateral cross-border exposures into the interlinkages of selected countries' banks. We will explain in more detail the research methodologies in Chapters 4, 5 and 6.

3.12.2 Visualising financial networks literature

For the purpose of preventing financial shocks or tailoring better global and local policy responses to shocks, understanding the evolving nature of cross-border financial linkages is very helpful. Improved understanding will ultimately lead to identifying more and better suited solutions. The main question here is that with all the complexities of the financial network, how could we improve our understanding? One of the key goals of this chapter is to map and explain the effect of cross-border bilateral exposures and their macroeconomic consequences, as well as the network topology and its effect on shocks transmission. To do this we need to improve understanding of the network by visualising the specific financial network properties. Iori et al. (2008) in their article visualised the banking network in four groups namely: black, red, green and blue groups. They identified a few hubs connected to a large number of peripheral banks which have only a few links. The topology of the Federal Funds Market was visualised by Bech and Atalay (2008). Unsecured sterling money market was visualised in a study by Wetherilt, Zimmerman, and Soramäki in 2008, (Wetherilt, et al., 2008). They highlighted the insight network topology and its role in the unsecured loan market in the UK. In another study interbank payment flow was studied by visualising topology of interbank payments in 2007 (Soramaki et al., 2007). Marsh (2010) by using the Bank of International Settlements visualised Europe's web of debt in May 2010. He showed that banks and governments in Greece, Ireland, Italy, Spain and Portugal owe each other billions of dollars and have even larger debts to Britain, France and Germany.

The primary focus of the chapter three is to understand the evolving nature of cross-border financial linkages, mapping out the channels through which shocks are potentially transmitted, and better tailor global and local policy responses to shocks. The analytical visualised methods used in this chapter carry important lessons, which this chapter by focusing on the analytics of systemic risk and the role of global financial architecture aims to internalize.

3.12.3 An empirical study of examining the structure of banking networks and mapping out the systemic risk

We measure systemic risk of the banking network using different methodologies focusing on interlinkages between banks. We will apply the concept of 'Too-big-to-fail' (PCI test), we add factor of institutions' size (total assets of banks) and total exposures relative to the national marketplace. To improve the understanding of the financial network, we map out and explain the effect of cross-border bilateral exposures and their macroeconomic consequences, the topology of the network and its effect on shocks transmission. We identify the most commonly used centrality measures such as Degree, Closeness and Betweenness proposed by Freeman (1978) and different variations of Eigenvector centrality. Then we apply cheiRank-PageRank two-dimension model to illustrate the systemic importance of the main players in the banking network from 2005 till 2014.

Meanwhile as we aim to examine the structure of the financial network at country's level, we empirically test the concept of core-periphery network at the end of the chapter by using the probit regressions, testing whether network position can be predicted by individual network variables. The same methodology as Craig and Peter (2010) used for perfect core periphery structure. We will illustrate the structure of the banking network at country's level to see whether or not the topology follows a hub-based or scale-free network structure.

3.13 Challenges in identifying and measuring systemic risk

According to Brunnermeier et al., (2010, p. 2) the global regulatory response to the crisis has followed Bernanke's dictum, creating various agencies and committees that are charged with monitoring and controlling these risks. In the United States, a substantial portion of the Dodd-Frank Wall Street Reform and Consumer Protection Act details how systemic risk should be regulated. Fundamental to regulate systemic risk, identifying and measuring it is the preliminary step, although fulfilling this object will be extremely challenging. Currently, we lack not only an operational definition of systemic risk, but also suitable measuring methods of this particular risk as well as the data needed to measure it.. Without the potential for measurement, the term 'systemic risk' is mere jargon that unwittingly supports the continued use of discretionary regulatory policy applied to financial institutions and in effect lead to ad-hoc policies that are inconsistent and fraught with unintended consequences. Measuring systemic risk is the trend with many groups resulting in particular from the ambition set out in the Dodd-Frank Act , the Board of Governors of the Federal Reserve System and some of the constituent regional banks have assembled research groups charged with producing measurements of systemic risk. Such measurements are also part of the job of the newly created office of Financial Research housed in the Treasury Department.

Similar research groups have been assembled in Europe. While the need for legislative responses put pressure on research departments to produce quick answers, many believe that it is also critical to take a longer-term perspective so that we can do more than just respond to the last crisis. By now, a multitude of proposed measures exist and many of these are summarized in Bisias, et al., (2012), where thirty-one ways to measure systemic risk are identified. While the authors describe this catalogue as an 'embarrassment of riches', we can review some of these measures without providing a full-blown critique.

The measurements by Burns and Mitchell (1946) generated a lot of attention and renewed interest in quantifying business cycles. They served to motivate development of both formal economic and statistical models. An important role for economic modelling is to provide an interpretable structure for using available data to explore the consequences of alternative policies in a meaningful way. When Koopmans (1947) did a review of the Burns and Mitchell (1946) book he came up with the famous title Measurement without Theory. The review sums up thus: "The book is unbendingly empiricist in outlook... But the decision not to use theories of man's economic behavior, even hypothetically, limits the value to economic science and to the maker of policies, of the results obtained or obtainable by the methods developed" (p. 186). To overcome with the challenges obstructing our means of systemic risk measurement we should answer these simple questions first, how do we distinguish systemic from systematic risk? How do we conceptualise and quantify the uncertainty associated with systemic risk measurement?

3.14 Data of Measuring Systemic Risk

There are different data categories in the research:

A. In the first step we gather the data based on the conclusions of Rodríguez-Moreno and Ignacio Peña (2011) research, which are for the European and US markets. The best indicators are the first Principal Component of the single-name CDSs and the LIBOR-OIS or LIBOR-Tbill spreads, respectively. We collect the CDS spreads, LIBOR-OIS and LIBOR-Tbill before and after the financial recession 2007/8 to study the behavior of these indicators. This category of data is used to show the relationship between the financial crisis of

2007/8 and systemic risk. We use the CDS spread for the banking sector during 2006 till 2012 (before the financial crisis and thereafter) to see the behaviour of CDSs. Also LIBOR-OIS and LIBOR-Tbills data during 2002 till 2012; and we compare Eurozone CDS spreads with US CDSs from 2006 till 2012. The TED Spread of the Euro Area, the UK and US are also being compared for 2007-2010. The main flaws of this method is firstly the result is based on the assumption that the market prices the risk and return accurately; secondly it is unable to show the linkage between components of the financial market, as a result, we employ a more detailed method to measure systemic risk in the second step.

B. We measure systemic risk taking into account the interlinkages between banks**,** **(**Gerlach approach) while using IMF's (2009) default intensity model to assess this interlinkage. Then applying the concept of 'Too-big-to-fail' (PCI test) we factor in the institutions' sizes (total assets of banks) & the total exposures relative to the national marketplace. (Using the combined index of institutions' sizes, national Gross Domestic Product and Herfindahl index).

C. Whether network position can be predicted by individual network variables or by the banking network structure whether it follows core periphery structure is tested using probit regressions. To test the hypothesis we track the evolution of the network on a quarterly basis consolidated bilateral exposures ultimate risk (from the Bank of International Settlements consolidated banking statistics; (BIS consolidated data 2005)[21] from 2005 Q1 through 2015 Q3 for 43 periods. For our procedure we first estimate the Core Periphery model, finding the of core countries for every period. In our dataset, the core varies between 13 and 21 countries. Using the binary variables by Craig Von Peter Core Index, core membership takes the value 1 for banks that were determined to be in the core,

[21]These statistics measure banks' country risk exposures. They capture the worldwide consolidated claims of internationally active banks headquartered in BIS reporting countries. The consolidated statistics include the claims of banks' foreign affiliates but exclude intragroup positions, similarly to the consolidation approach followed by banking supervisors. They detail the transfer of credit risk from the immediate counterparty to the country of ultimate risk (where the guarantor of a claim resides). Available at http://www.bis.org/statistics/consstats.htm?m=6%7C31%7C70

and 0 for the remaining banks. (It is regressed on a constant and the regressors shown in the rows, which rely only on consolidated bank data; except for some variables, which require the network data). Each regression comprises 8872 observations.

D. Our analysis of systemic risk is based on EU selected countries' banks' data. We select 16 EU countries then we get the EU banks' exposure to the rest of the world from 2005 till end of June 2014 on a quarterly basis. We implement the empirical study through the quarterly data of consolidated exposures from the Bank for International Settlements (BIS) and debt/GDP ratios among EU countries. To explore an analytical tool, the EU banks exposures were analysed in light of the total banks' assets, total exposure and the country's GDP. Finally, the output was reviewed using an index combination of banking assets, GDP of the country and Herfindahl index. This analytical tool has a twofold application of providing the regulators and practitioners with the status of interconnectivity and pointing out the degree of the default risk. Moreover, it sheds light on quantifying the systemic risk of financial institutions on a global scale. To answer the question on EU banks' interconnectedness, we use the quarterly report of consolidated foreign claims from the BIS. The foreign claims are classed by the nationality of reporting banks and are the ultimate risk basis covering the selected EU countries from 2005 Q1 to 2014 Q1. The following three samples have been selected:

   A. Main sample including EU banks, American banks, Canadian, Australian, Chilean, Indian, Japanese, South Korean and Turkish banks
   B. EU banks and American banks
   C. EU banks

The required data has been collected from different resources. First, the Bank of International Settlements consolidated banking statistics (BIS consolidated data

2005)[22] has been used for data on consolidated foreign claims, which are the ultimate risk basis for banking system exposures for each sample to the rest of the world since 2005 till end of March 2014 in a using quarterly records. We implement the empirical study through the quarterly data of consolidated exposures from the Bank for International Settlements and GDP among selected countries (from OECD statistics, OECD.Stat includes data and metadata for OECD countries and selected non-member economies.) (OECD Data, 2005).[23] For our methodology, the selected countries banks' exposures were analysed in light of the countries' banking sector size (computed mainly from European Central Bank, (The ECB Statistical Data Warehouse) ECB Statistics Data Services gives access to the euro area statistics, including in some cases national breakdowns.[24] (ECB Data 2004) and Federal Reserve Economic data[25], (Federal Reserve Economic Data) total exposure and the country's GDP also using quarterly records. Finally, the output is reviewed with an index combination of banking assets and GDP of the country, using Herfindahl index and author's own calculations. (for more details see Appendix 3)

For the first step the main inputs of the measures are single-name CDS spreads, liabilities and equity prices. The CDS spreads and equity prices are reported on a daily basis (end of day) while the liabilities are reported on annual terms. These variables are obtained either from Reuters or DataStream depending on the data availability of both data sources. Additionally, other variables are required. For instance, the 3-month and 10-year LIBOR, swap rates and treasury yields are needed. We employ interest rates from the two economic areas: US and the Eurozone. These variables are obtained from Reuters. The sample spans from January 1, 2004 to November 4, 2009. This sample period allows us to study the behavior of the systemic risk measures for both pre-crisis and crisis periods because August 2007 is commonly considered as the beginning of the sub-prime crisis.

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[22]These statistics measure banks' country risk exposures. They capture the worldwide consolidated claims of internationally active banks headquartered in BIS reporting countries. The consolidated statistics include the claims of banks' foreign affiliates but exclude intragroup positions, similarly to the consolidation approach followed by banking supervisors. They detail the transfer of credit risk from the immediate counterparty to the country of ultimate risk (where the guarantor of a claim resides). Available at http://www.bis.org/statistics/consstats.htm?m=6%7C31%7C70

[23] Available at: http://stats.oecd.org/

[24] Available at: https://www.ecb.europa.eu/stats/services/html/index.en.html

[25] Federal Reserve Economic Data (FRED) is a database maintained by the Research division of the Federal Reserve Bank of St. Louis that has more than 381,000 economic time series from 81 sources. Available at: https://research.stlouisfed.org/fred2

13.14.1 Measurement of Single-Name CDS and the LIBOR-OIS or LIBOR-Tbill

In this sub-section, we briefly summarize the systemic risk measures which are proposed above, based on market information and report our estimation for these measures using our data set. We classify those measures into two different groups: (i) based on a Principal Component Analysis (PCA) of CDS spreads; (ii) based on interbank interest rates.

a) PCA of CDS spreads

CDSs are credit derivatives that provide insurance against the risk of default of a certain company (‘name’), and hence, their spreads measure the risk that is faced by bondholders of the reference entity. The first measure that we implement consists of performing a Principal Component Analysis (PCA) on a pool of the CDS spreads. Longstaff and Rajan (2008) analyse the CDS spreads of the constituents of the CDX (CDS index). They find that there is a dominant factor that mainly drives the spreads across all industries, which is consistent with the existence of an economy-wide or systemic risk component. Rodríguez-Moreno, et al(2012) find that 93% of the banks’ CDSs variance is explained by the first Principal Component Factor (PCF) in the European banks portfolio, in agreement with Longstaff and Rajan (2008).

b) LIBOR Spreads

The second group of systemic risk measures involves the use of LIBOR[26] as the reference interest rate relative to either the Overnight Interest Swap (OIS) or Treasury bills (TBills), usually known in literature as LIBOR spreads.[27] The first measure is defined as the difference between the 3-month LIBOR rate and the 3-month Overnight Interest Swap (OIS). The second measure is defined as the difference between the 3-month LIBOR rate and 3-month Treasury bill rate (this measure is also known as the TED spread). These measures are employed by Brunnermeier and Adrian (2009) to

[26] We use the LIBOR for the main currencies under study (i.e., USD LIBOR and EURIBOR, obtained from Reuters).

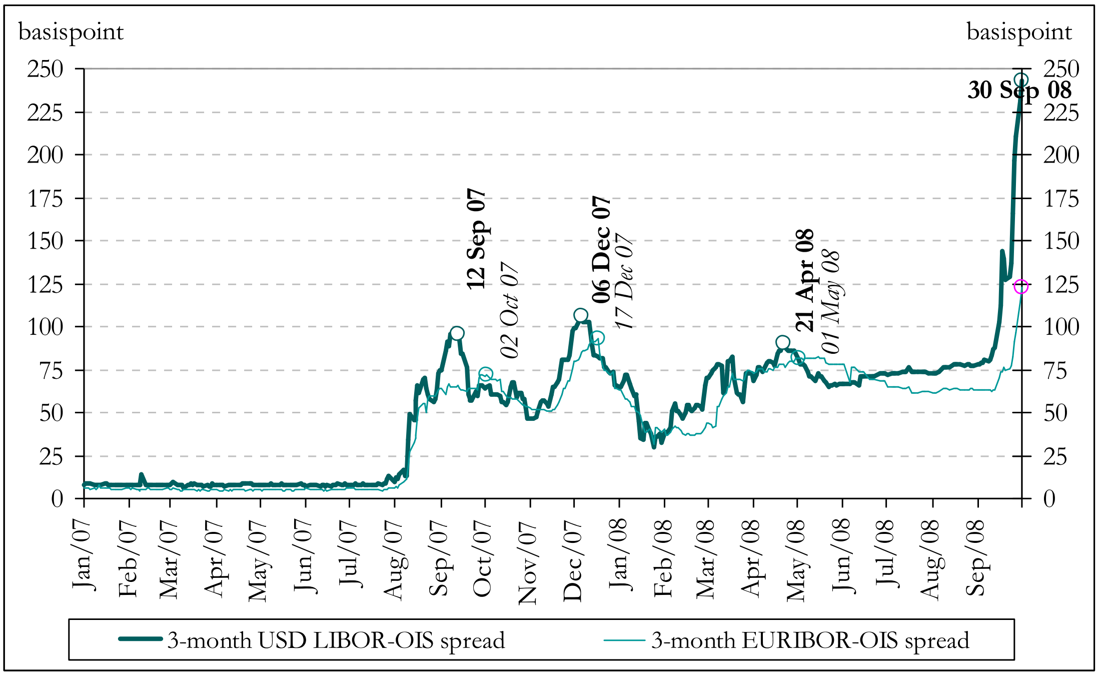
[27] These measures do not directly refer to the individual financial institution’s financial health, but give information about the overall situation of the banking industry.

describe the event logbook of the current crisis; equivalently adopted by the IMF on the Global Financial Stability Report (2009), among others. These two proxies of systemic risk are similar, but important conceptual differences appear between them. The LIBOR rate represents the unsecured interest rate at which banks lend money to each other under certain creditworthiness criteria. Typically, the banks' credit rating must be at least AA. LIBOR is not totally free of credit risk because it reflects liquidity risk and the bank's default risk over the following months. On the other hand, OIS is equivalent to the average of the overnight interest rates expected until maturity. It is almost riskless and hence it is not subject to pressures associated with those risks. Therefore, LIBOR minus OIS, or LIBOR-OIS (LO henceforth), reflects liquidity and default risk over the following months.

In tranquil periods, this measure should be very low because AA rated institutions should not have significant liquidity or default risk. However, in periods of turmoil, this spread should widen so as to capture these risks. LIBOR minus Treasury bill or LIBOR-Tbill (LT henceforth) is the second systemic risk measure considered in this section. Treasury bill rates are the rates that an investor earns on Treasury bills. In times of crisis, most lenders only accept Treasuries as collateral, pushing down Treasury rates. Hence, LT captures not only liquidity and default risk but also the additional fact that, during periods of turmoil, investors lend against Treasury bills (the best form of collateral), measuring the "flight to quality" effect. In tranquil periods, LT should be very low, while in periods of turmoil, this spread should be larger. Additionally, we computed what we name the "Natives Are Restless Factor" (NARF),[28] namely, the difference between the LT and LO spreads (or, equivalently, the OIS-Tbill difference). In normal times, the NARF should be close to zero. However, when investors feel growing disquiet because of an unexpected increase in market uncertainty, they are more willing to pay an extra amount to buy the supposedly safer government securities (lowering their yields) and then the NARF increases.

[28] This phrase was famously used in 'The Island of Lost Souls', a 1933 film based on the H.G. Wells novel 'The Island of Doctor Moreau'.

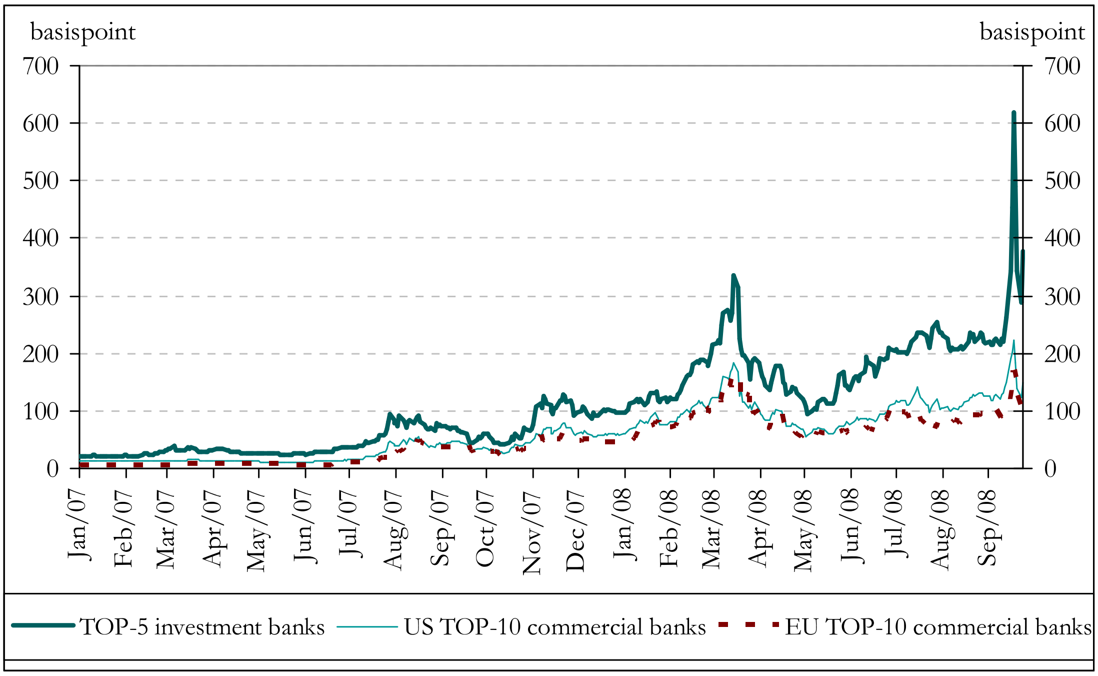
Figure 12: 3-Month USD LIBOR-OIS spread vs 3-month EUR LIBOR-OIS



Source: Author's own figure

During the crisis there's a sharp rise in the 3-month spread for the EURIBOR and USD LIBOR OS spreads. Very much an indicator of the money markets especially banks' perception of the creditworthiness of their peers and other financial institutions. These peaks are correspondent to the crisis and recession, with the highest liquidity and default risk, note particularly the EURIBOR- OIS spread, which when compared to the USD reveals that banks' confidence lost in the US is more than lost in the European market. Understandably also, as the largest losses and defaults originated or were experienced in the US markets.

Figure 13: US Top 10 Commercial Banks & EU top 10 commercial Banks

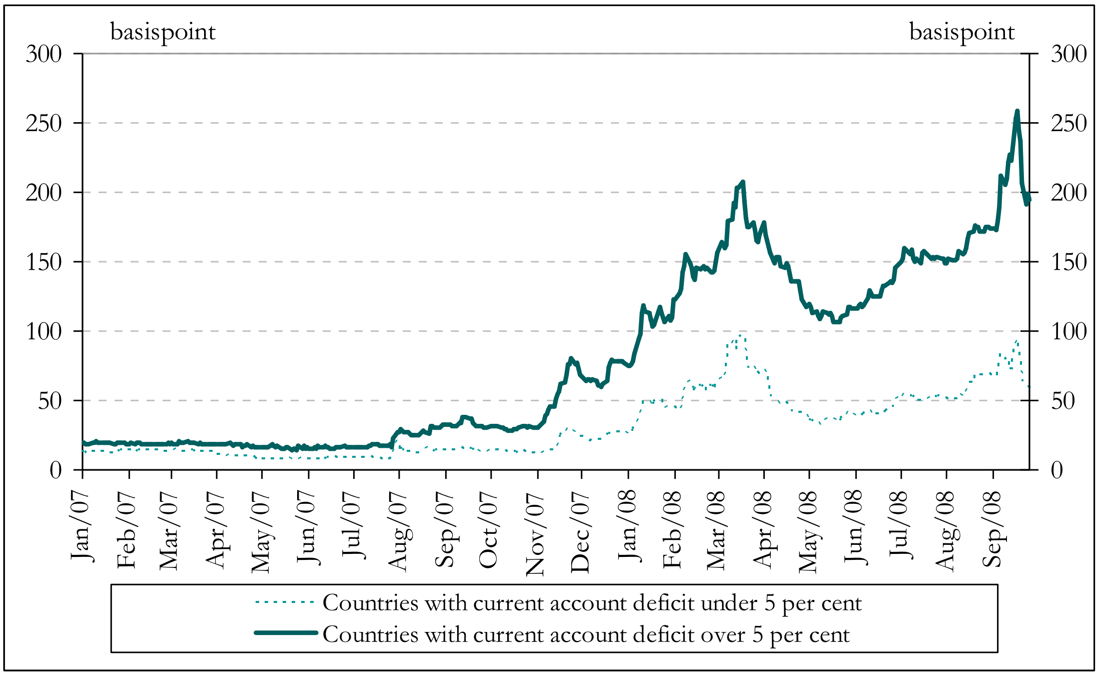


Source: Author's own figure

Figure 13 shows changes in banks loan interest rates and we see the highest value recorded was over 600bps in the top global investment banks during the crisis and the ensuing recession after, with falls in global stock markets as well as the unprecedented losses reported. FTSE's steepest decline in 7 years was recorded as well as continuing falling house prices. As suspected, EU and US top commercial banks lag behind the global investment bank curve and then they experience similar patterns.

We will now discuss how we will access and collate the necessary data for our research methodologies, how we will use it to assess the level of systemic risk in UK banks, and how we will display the results.

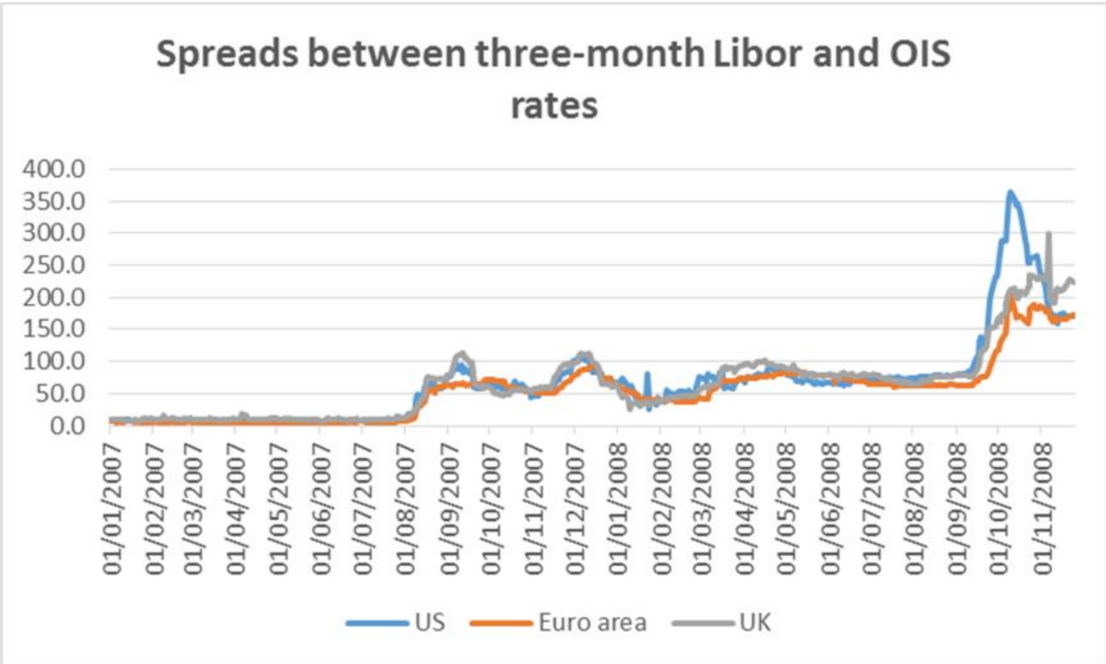
Figure 14 Countries with Current account deficit under 5% and Over 5%



Source: Author's own figure

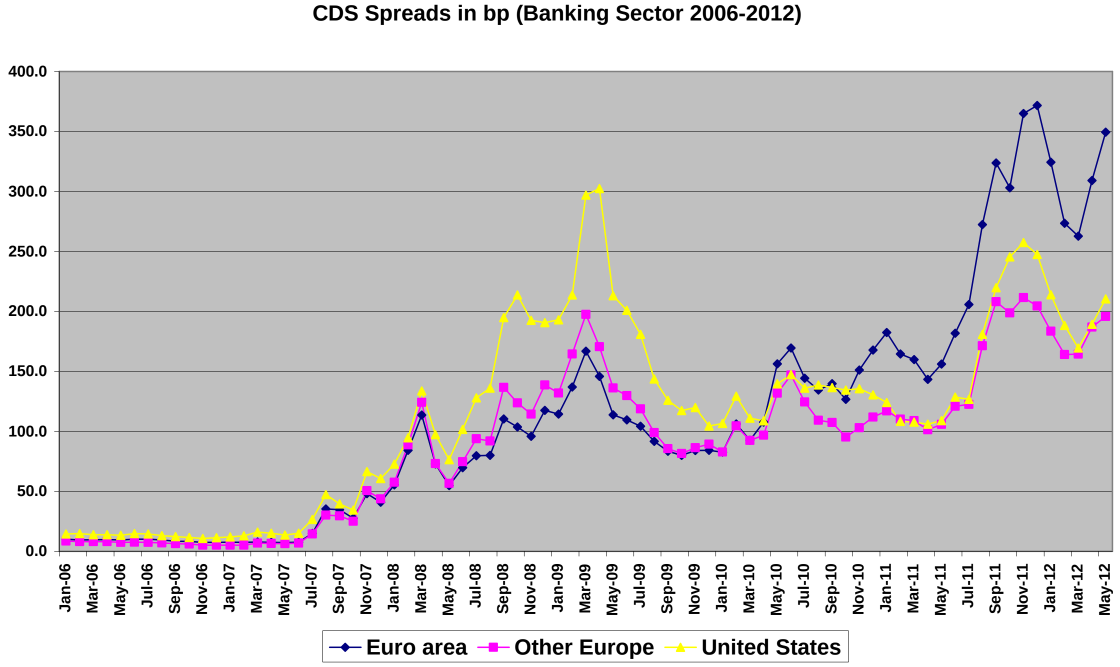
Shown here in Figure 14, it is evident that countries with current account deficits over 5% have less liquidity. The changes in interest rates reflect a lack of liquidity hence the higher percentage disparities. The shape of the graph is relatively unchanged between the two groups however the lack of access to liquidity makes all the difference.

Figure 15 Spreads between 3-Month LIBOR and OIS rates



The 3-month LIBOR in Figure 13 is a show of measuring default risk for banks. The cost (spread) during the 2008 recession culminating at 350bps, with the US and Europe leading the way for highest increases.

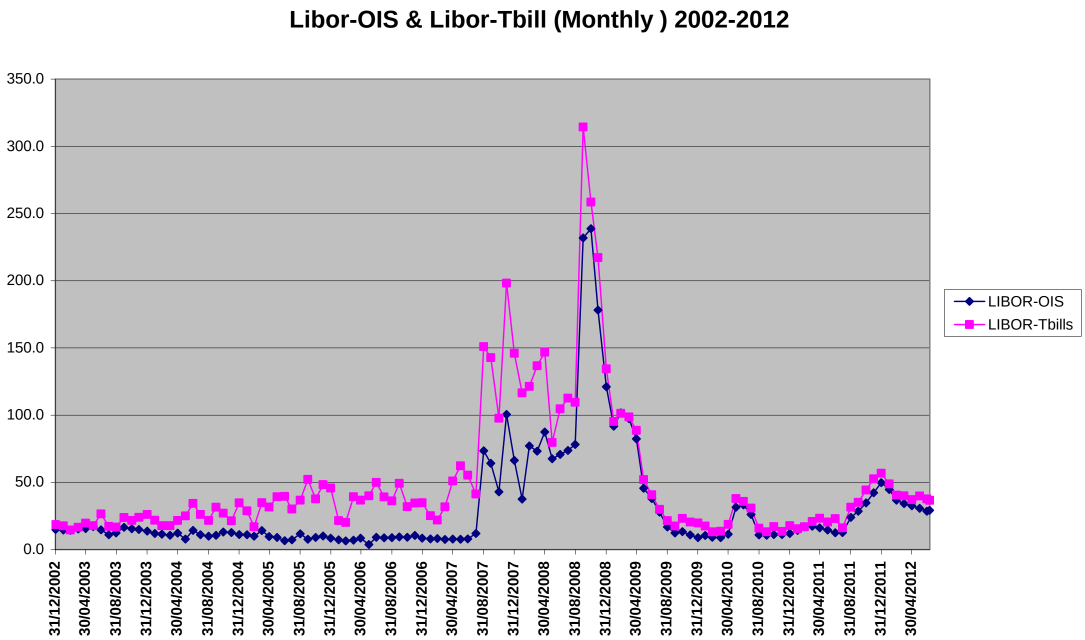
Figure 16 CDS Spread (Banking Sector 2006-2012)



Source: Author's own figure

CDS spreads in the banking sector over a much longer period of 2006 – 2012 gives the volatility induced by the crises from July 2007 and the evidence becomes obvious as escalations again in 2008 Q4. Whereas the US reaches the highest number in 2008/2009, the Euro area dealing with near-sovereign defaults steals that position in 2012.

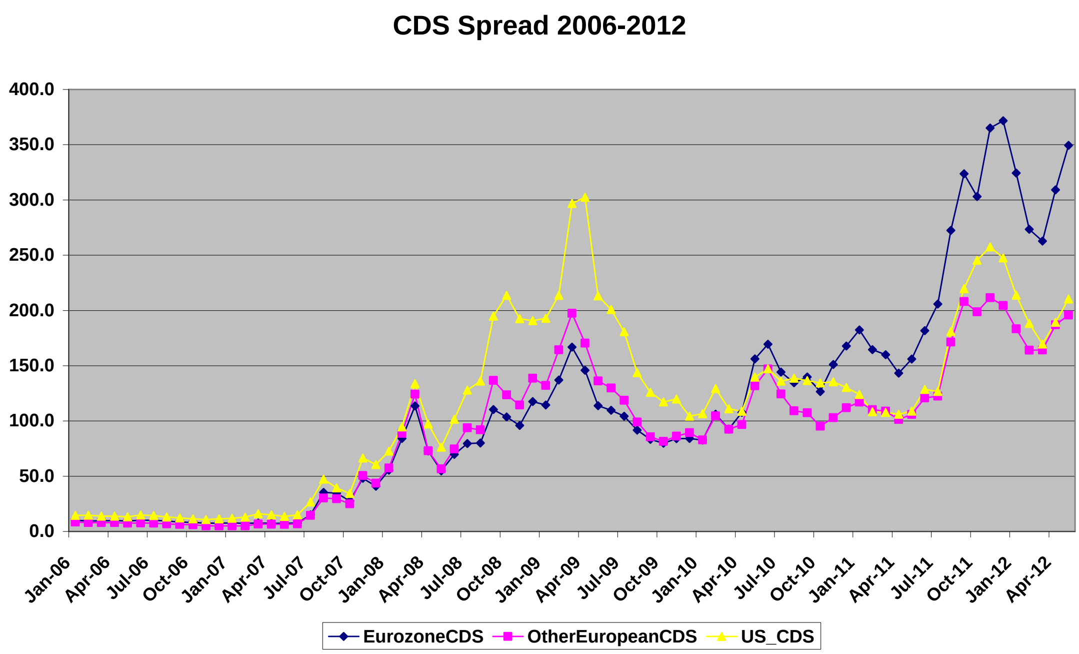
Figure 17 LIBOR-OIS & LIBOR-Tbill 2002-2012



Source: Author's own figure

T-bills have the benefit of being almost risk-free due to their US Government backing. However, in the heat of the crisis their worth was highly affected. So a LIBOR spread with OIS vs a T-Bill spread also reflects the market confidence in the US Government. Again the trend shows it's lowest at the peak of the crisis (2007 Q4) and the recession (2008 Q4). Then it again benchmarks the OIS spread after 2010.

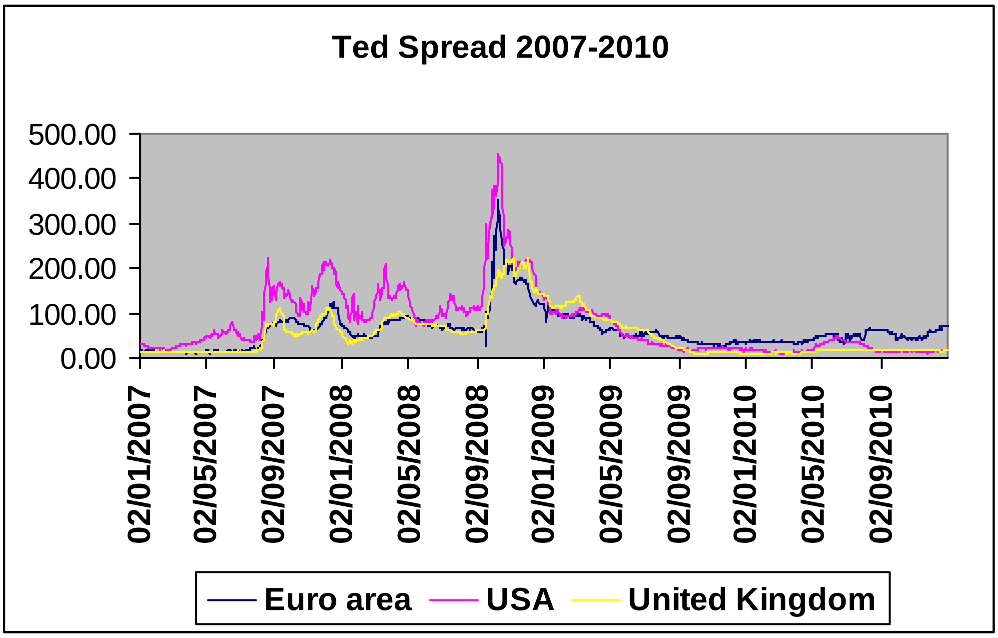
Figure 18 CDS Spread 2006-2012



Source: Author's own figure

CDS spread gives a representation of how expensive loans are to insure between Finance Institutions. The graph shows the values attained were at the highest during the bank uncertainties and in the throes of the most tumults. US Banks were especially affected at the peak of the recession. Values have not been shown to regain pre-crises levels.

Figure 19 TED Spread 2007-2010



Source: Author's own figure

Figure 19 TED Spread shows the T-Bills lose value at the peak of the recession with the US recording highest TED spreads bps at over 450bps. This broke the previous Black Monday records of the 1987 crash. The UK and Euro area experience similar but at the end of 2010, pre-crisis values are regained.

4. Chapter4: Systemic Risk in European Banks- Analytical Insights from the Network Approach

4.1 Introduction

The recent crisis has vividly illustrated the costs and benefits of increased interconnectedness. Suffice to say, linkages, and interconnectedness will be used interchangeably in this chapter exposing lacunae in the global financial architecture. As a result, effective financial system surveillance requires the monitoring of direct and indirect financial linkages, whose disruption could have important implications for the stability of the entire financial system. Proactively tracking potential systemic linkages is very crucial for regulators and policy makers worldwide. Tracking potential systemic linkages and interconnectedness highlighted the role of network analysis. There are some studies that aid this challenge (See (Allen and Babus, 2007)). Allen and Babus' (2007) study allows regulators and policy makers to assess externalities to the rest of the financial system, by tracking the rounds of spillovers likely to arise from direct financial linkages. With interconnected financial markets around the world, the analysis of 'networks' in the financial system would help deepen understanding of systemic risk and is key to preventing future financial crises.

4.2 Why Cross-Country Exposures is the Focus of this Study

The financial crisis 2007/8 has demonstrated that significant risks to national banking sectors can stem not only from domestic asset and credit markets but also from cross-border exposures due to interconnectedness. Among our pool, German banks are a good case in this regard. Prior to the financial crisis 2007/8, country risk indicators in Germany at the national level typically issued no alerts. However, a significant portion of German banks' claim was on American borrowers (on the balance sheet or the main part off balance sheet), which exposed the German Banks, making them highly vulnerable to the international credit shocks. Likewise, Belgium, the Netherlands and Switzerland were adversely affected through their banks' US exposures. This is why our main focus of attention is on cross country exposure in this study.

4.3 Network Measurements

This study intends to measure systemic risk using interlinkages between banks, -we implement Gerlach's approach Gerlach (2009) using the network approach model of IMF's (Chan-Lau et al., 2009) as our method for assessing interlinkage. Then applying the concept of 'Too-big-to-fail' (PCT test) we add a factor of the institutions' sizes (total assets of banks) and the total exposures relative to the national marketplace.

Using the combined index of institutions' sizes, Gross Domestic Product and Herfindahl index, we introduce four ratios to capture the importance of bilateral lending activities for the banking sector and the economy overall. Network variables are defined as follows:

Equation 1:

$$\text{Bilateral Exposures to GDP} = \frac{Exposure\ of\ banking\ sector\ of\ country\ i\ vs\ \ country\ j}{GDP\ of\ country\ i}$$

To calculate the bilateral exposures to GDP we divide the total exposures of the banking sector of a country *i* by the GDP of the country *i* in that year.

Equation 2:

$$\text{Bilateral Exposures to total banks assets} = \frac{Exposure\ of\ banking\ sector\ of\ country\ i\ vs\ \ country\ j}{total\ banks\ assets\ of\ country\ i}$$

To calculate the bilateral exposures to total assets, we divide the total exposures of the banking sector of a country *i* by the total assets of the banking network of the country *i* in that year.

Equation 3:

$$\text{Bilateral Exposures to total Exposures} = \frac{Exposure\ of\ banking\ sector\ of\ country\ i\ vs\ \ country\ j}{Total\ exposure\ of\ network}$$

To calculate the bilateral exposures relative to total exposure of the network we divide the total exposures of the banking sector of a country *i* by the total exposures of the whole banking network in that year.

Equation 4:

$$\text{Bilateral Exposures to Concentration Index} = \frac{\textit{Exposure of banking sector of country i vs country j}}{\textit{Concentration Index of country i}}$$

To calculate the bilateral exposures relative to concentration index we divide the total exposures of the banking sector of a country *i* by the total assets of the banks in country *i* plus the given Herfindhal index of the country *i* times by the GDP of the country *i* in that year.

4.3.1 Centrality Measures

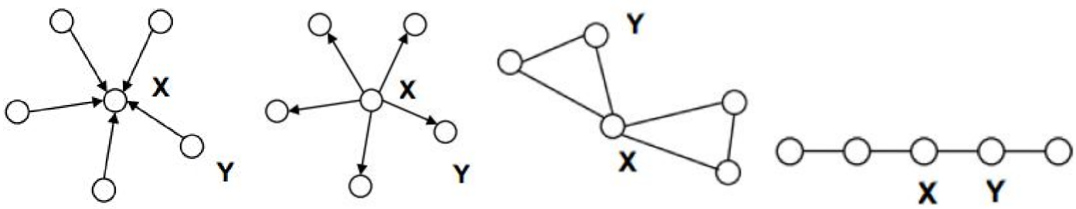
To analyse the banking network in selected countries, centrality measures have been used in the second part of the study. The most commonly used centrality measures are Degree, Closeness and Betweenness proposed by Freeman(1978) and different variations of Eigenvector centrality which was pioneered by Katz (1953), Bonacich (1972) and Bonacich (1987). Degree centrality (or simply Degree) counts the number of neighbours of each node. It is a local measure that only takes the immediate neighbourhood of the node into account. It can count neighbours with incoming links, outgoing links or either, and can be weighted by link properties; for example, the weighted out-degree is referred to as out-strength. While the insight underlying Closeness centrality is that nodes that have shorter geodesic paths to other nodes are more central. This closeness is important, as it will play a role on the eventual spread of shocks across the network. The ability to calculate this ratio of centrality is explored: it is generally calculated as the average length of geodesic paths from a node to each other node in the network. Betweenness centrality defines nodes through which a high share of geodesic paths pass as central. What is known today as Eigenvector centrality encapsulates the idea that the centrality of a node depends directly on the centrality of the nodes that link to it (or that it links to). Eigenvector centrality measures assume parallel duplication along walks. A famous commercialization of Eigenvector centrality is Google's PageRank algorithm (Page et al., 1999), which adds a random jump probability for ’dangling’ nodes and thus allows the measure to be calculated for all types of networks. PageRank and Eigenvector centrality can be thought of as the proportion of time spent visiting each node in an infinite random walk through the network. For calculating Eigenvector centrality, the network must be strongly connected (i.e. the underlying transition matrix must be non-singular).

To sum up all different centrality measures, degree is the number of links in the network, distance to other nodes via shortest paths is closeness, betweenness is defined as number of shortest paths going through the node, eigenvector says nodes that are linked by/to other important nodes are more central (parallel duplication via walks). Why are centrality measures important in a network? The centrality of nodes, or the identification of which nodes are more “central” than others, has been a key issue in network analysis ((Freeman, 1978; Bonacich,1987; Borgatti, 2005). According to Freeman (1978), central nodes were identified as those in the focal point or “in the thick of things” (pp. 215-239). To describe the issue, he used a network consisting of 5 nodes. The middle node has three advantages over the other nodes: it has more ties, it can reach all the others more quickly, and it controls the flow between the others. This level of influence on other nodes and as a result the entire network will prove to be important. Based on these three features, Freeman (1978) introduced three different measures of node centrality previously seen: degree, closeness, and betweenness. Degree can also be identified as the number of nodes that a focal node is connected to, and measures the involvement of the node in the network. The failure in considering the global structure of the network is the main limitation of this measurement. For example, a node might be well connected using other factors, but not be in a position to reach others quickly to access information or resources Borgatti (2005), Brass (1984).

For this purpose, closeness centrality was defined as shortest distance to all other nodes from a focal node. Although this measure couldn’t be easily applied to a network with disconnected components, it has the benefit of capturing the most information in a connected network. Betweenness evaluates the degree to which a node lies on the shortest path between two other nodes, and is able to funnel the flow in the network. In this way the node can assert control over the flow. The limitation of this measure is the fact that a large proportion of nodes in a network do not lie on a shortest path between any two other nodes, and thus receive the same score of ‘zero’. In the case of weighted networks Barrat et al., 2004) generalised degree by taking the sum of weights instead of the number of ties, however to generalise closeness to weighted network Newman (2001) apply Dijkstra (1959) algorithm; and to generalise betweenness Brandes (2001) apply Dijkstra (1959) algorithm to weighted network. The focal point of this generalisations lies with tie weights, and the original feature of the measures (number of ties) was ignored so the second set of generalisation incorporates both the number of ties and the weights by using a tuning parameter (Opsahl et al., 2010).

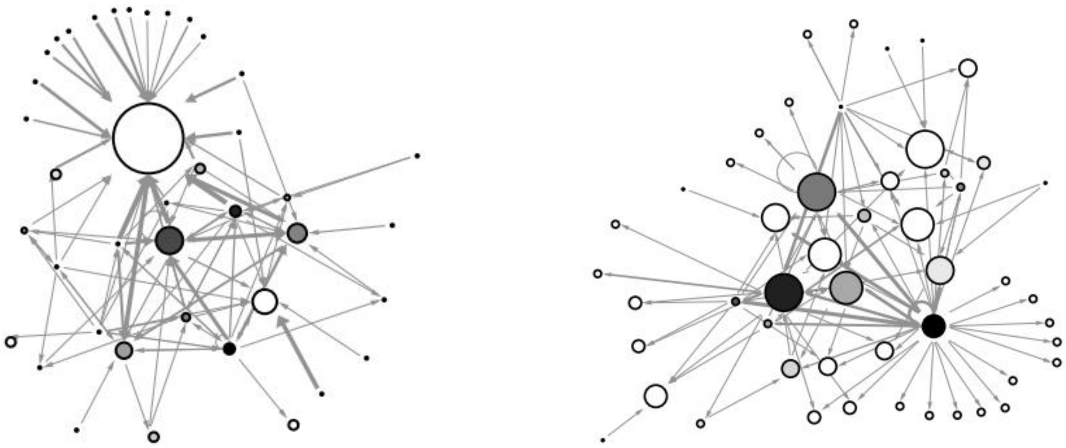
The following figures are illustrations of a few centrality measures. In each of the following networks, X has higher centrality than Y according to a particular measure.

Figure 20 Examples of



I Indegree Outdegree Betweenness Closeness

Figure 21 Degree Centralization Examples:



High centralised: one node trading with many others **Low centralised: more evenly distributed**

Source: Network centrality Slides are modified from Lada Adamic (2015)

Node level centrality measure: a node's average shortest path is the average length of the shortest path from that node to each other node reachable from it. Finding out the central node in the network could help to protect the network from breaking.

Betweenness Centrality: A node's betweenness centrality is the number of directed shortest paths between all other pairs of nodes that pass through the given node. In other words, it is the number of shortest paths going through the nodes. With the exception of betweenness centrality, all of the node-level centrality measures have an optional weight property; any numeric arc property can be used as a weight. In a link, a link's betweenness centrality is the number of directed shortest paths (besides the link itself) that pass through the given link.

Equation 5: Betweenness Centrality

$$C_b\ i\ =\ \sum_{j\neq k} g_{jk}(i)/g_{jk}$$ (Freeman, Borgatti and White 1991)

If g_{jk} is the number of geodesics linking points j to k in a graph, and $g_{jk}\ i$ is the number of such paths that contain point i. Usually normalised by:

$$\acute{C}_B\ i\ =\ (C_B\ i\ /\ (n-\ 1)(n-\ 2)/2$$

Where bracket is the number of pairs of vertices excluding the vertex itself, and in equation, 5 where $g_{jk} =$ the number of geodesics connecting jk, and $g_{jk}\ i\ =$ the number of geodesics that actor *i* is on.

Closeness Centrality: What if it is not important to have many direct links or be "between" others? If we still want to have a node in the "middle" of things not too far from the centre, the closeness is important. The closeness measure is based on the length of the average shortest path between a vertex and all vertices in the graph. Such that closeness is the distance from/to other nodes via the shortest paths which could be calculated as:

$$C_c(\mathrm{i}) = \sum_{j=1}^{N} d(i,j)\ ^{-1}.$$

Normalised closeness centrality is calculated as, $\acute{C}_c\ i\ =\ (C_c\ i\ )/(N-\ 1)$. So closeness is the length of shortest path to all others.

CheiRank vs PageRank: A node's PageRank is the expected amount of time spent visiting that node in a random walk over the network. The parameter *alpha (α)* adds a small probability of moving between any two pairs of nodes, which allows the metric to be calculated even for networks that are not strongly connected. When alpha is equal to zero, PageRank is equal to the standard eigenvector centrality. A node's CheiRank is calculated by first transposing the network (that is, reversing the direction of all directed links) and then calculating its PageRank. While the PageRank ranks the network nodes in average proportionally to a number of ingoing links, the CheiRank ranks nodes in average proportionally to a number of outgoing links. The physical meaning of PageRank vector components is tied to the original purpose for which the Google search engine builders implemented it. That is they give the probability of finding a random website surfer on a given node (or website) when the surfer follows the given directions of network links. In a similar way the CheiRank vector components give the probability to find a random website surfer on a given node (or website) when a surfer follows the inverted directions of network links. Since each node belongs both to CheiRank and PageRank vectors the ranking of information flow on a directed network becomes two-dimensional (for more details see Ermann, Chepelianskii and Shepelyansky, 2012).

Eigenvector centrality: Degree centrality depends on having many connections, but what if these connections are isolated? A central node should be one connected to more influential nodes. Connection to a more important node is more important. A node's eccentricity is the longest *path* from that node to any other node in the network. A path is any route between two nodes where no node is visited more than once.

Maximum Clique: As previously mentioned, a network can interchangeably be referred to as a graph. A graph may contain many complete subgraphs ('cliques'), i.e. sets of nodes where each pair of nodes is connected. So a clique of graph G is a complete subgraph of G, the largest possible size is referred to as 'Maximum Clique', the maximum clique is one way of finding the 'core'. The maximum clique cannot be extended by including one more adjacent vertex, so it is not a subset of a larger clique (for more details see Wasserman and Faust, 1994).

Newman Modularity: Modularity is a measure of the structure of a network. The networks with high modularity have dense connections between nodes within modules but sparse connections between nodes in different modules. In methods for detecting modules (also called groups, clusters or communities), networks with high modularity have dense connections between the nodes within modules but sparse connections between nodes in different modules (see Newmann, 2006).

4.3.2 Core-Periphery network structure

Recent empirical evidence suggests that financial networks exhibit a core periphery network structure. This chapter aims to examine the structure of financial networks at national level in selected countries using network formation theory for illustrating the structure of this network. Then we explained the role of core periphery network structure in the stability or fragility of the system. We will focus on the core periphery network as it is not only relatively simple and intuitively appealing but also it is a fair representation of the complex empirical structures.

Perhaps one of the most important questions to ask is if there exist any relationships between fragility or robustness of the system and its structure? In biology, Smilkov, Hidalgo and Kocarev (2014) argue that for the SIS model (corresponding to the Susceptible-Infected-Susceptible 'damage' status of the network) differential susceptibility can make networks more vulnerable to the spread of diseases when the correlation between a node's degree and susceptibility are positive, and less vulnerable when this correlation is negative.

4.4 Outcome of the Network Analysis

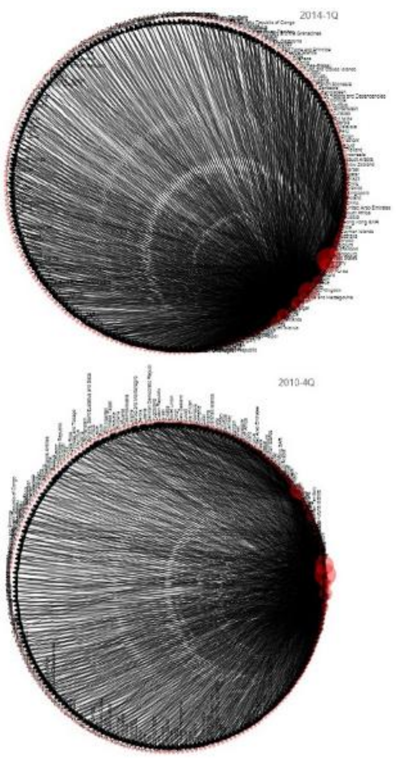
4.4.1 Putting the data into perspective

The network perspective is readily introduced by looking at bilateral lending relationships between the countries in selected samples. In this part we look at three data samples:

A. Main sample including EU banks, American banks, Canadian, Australian, Chilean, Indian, Japanese, South Korean and Turkish banks
B. EU banks and American banks
C. EU banks

The above banks exposures to 219 countries with total, 145,990 exposures were considered. There are a number of possible ways to explore the data, of which we will highlight the most relevant for monitoring banking sector risk. One of the most basic approaches is to look at absolute numbers of exposures. The following figures mapped out and compared the bilateral exposure of the banking system in the selected countries on a quarterly basis since 2005. Let's start by mapping out the sample A countries. The illustration clearly indicates that the banking network follows a core-periphery structure. They consist of a dense cohesive core and a sparse, loosely connected periphery. This meso-scale feature network known as core-periphery structure, which entails identifying densely-connected core nodes and sparsely-connected periphery nodes. A scale-free structure of the network could be seen not only in 2014 but also before, starting in 2005 we examined all quarters and all quarters having the same structure. (Figures 22 and 23).

A:



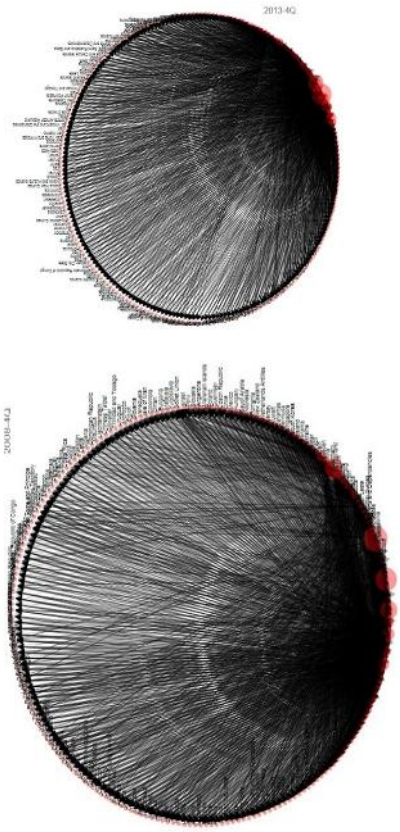
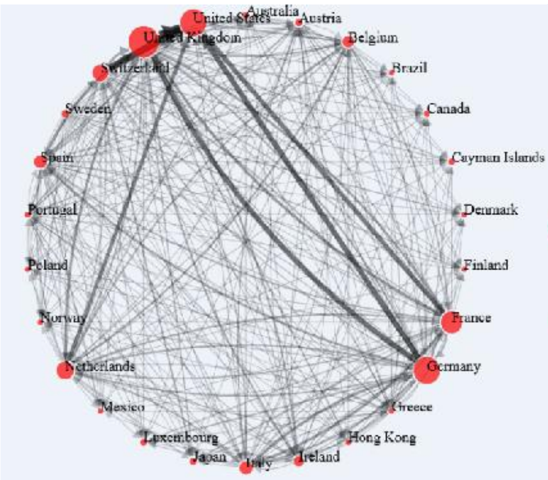


Figure 22 Network Structure 2014-Q1 2010-Q4 **Figure 23 2013-Q4 2008-Q**4

Source: Author's own figure

A: Selected EU countries



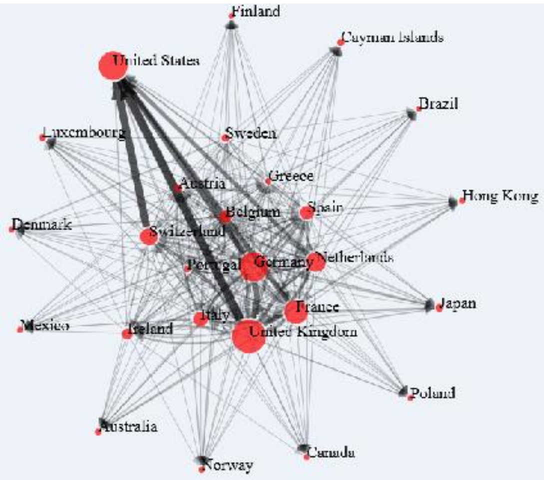


Figure 24: Bilateral Exposure 2007-Q3
Source: Author's own figure

Figure 25: Bilateral Exposure 2007-Q3

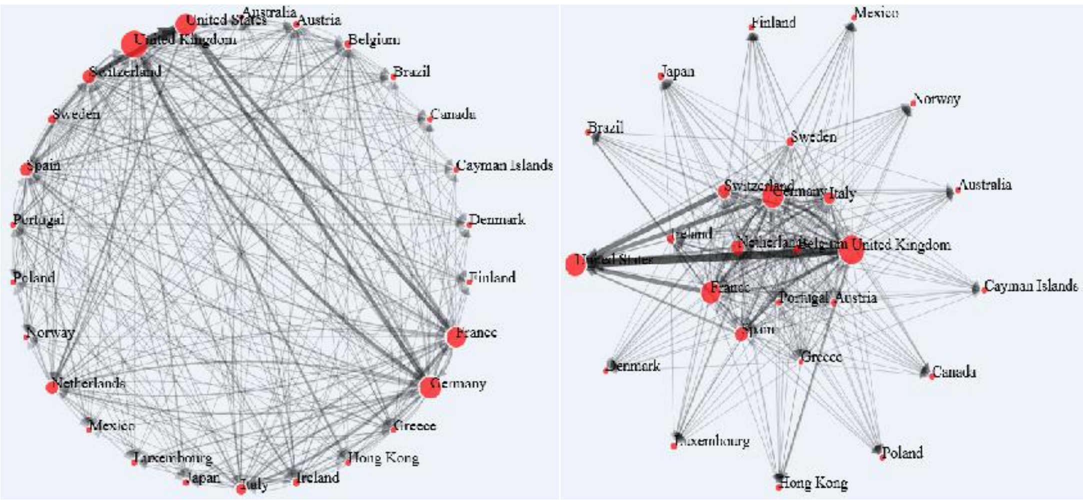


Figure 26: Bilateral Exposure 2011-Q3
Source: Author's own figure

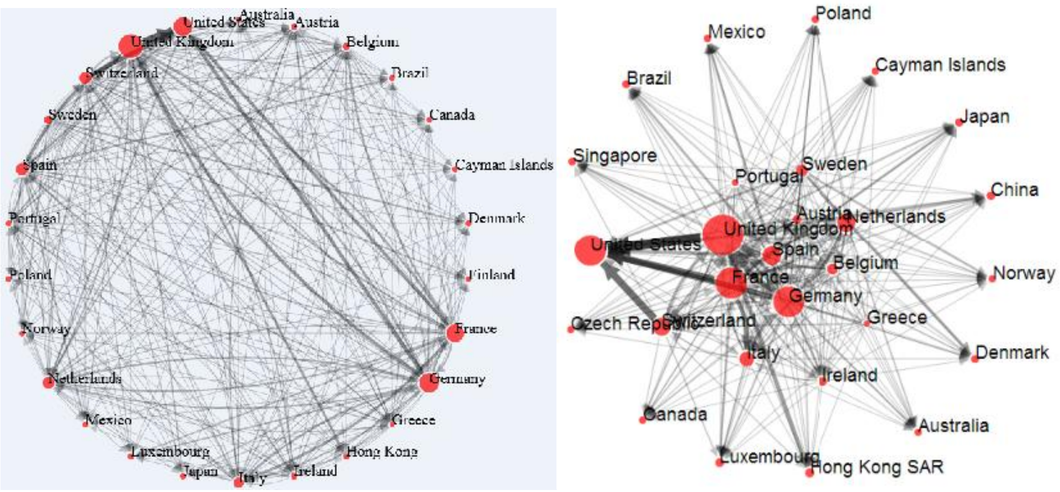


Figure 27: Bilateral Exposure 2014-Q1

Source: Author's own figure

B: Selected EU Countries & United States

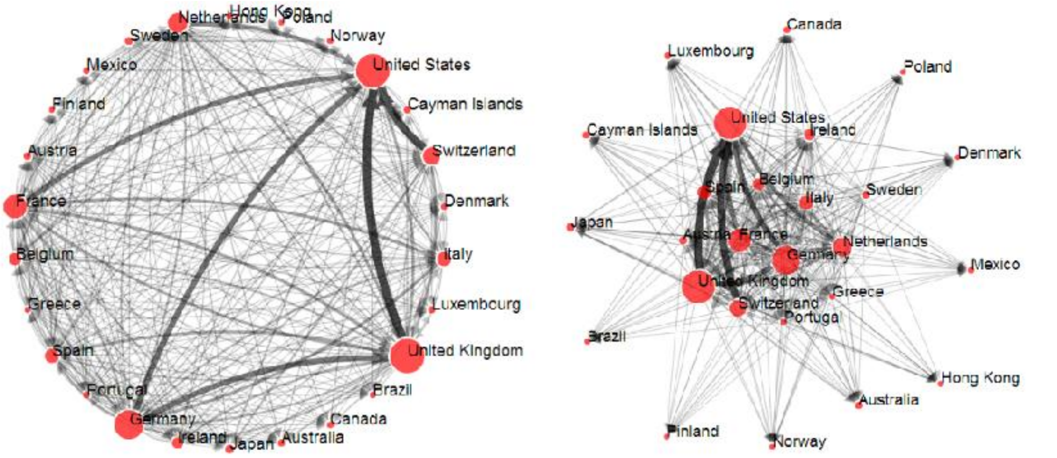


Figure 28: Bilateral Exposures 2007-3Q
Source: Author's own figure

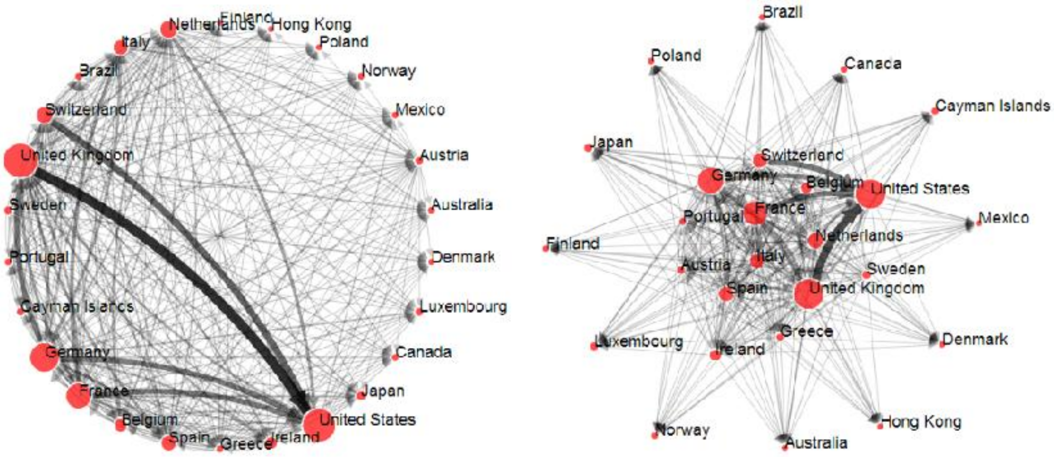


Figure 29: Bilateral Exposure 2008-Q3 Source: Author's own figure

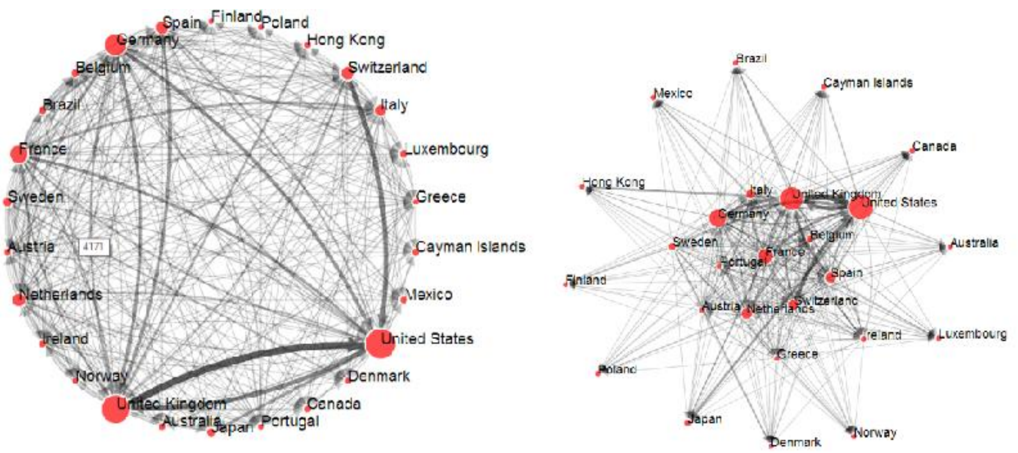


Figure 30: Bilateral Exposure 2012-Q3
Source: Author's own figure

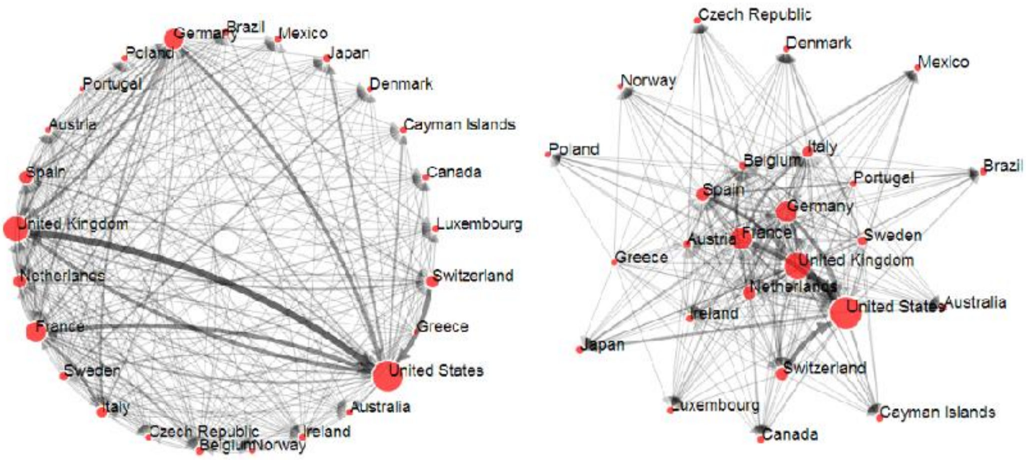
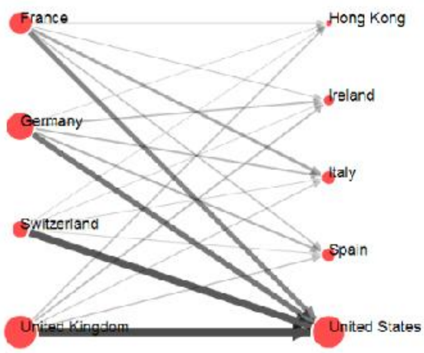


Figure 31: Bilateral Exposure 2014-Q1
Source: Author's own figure



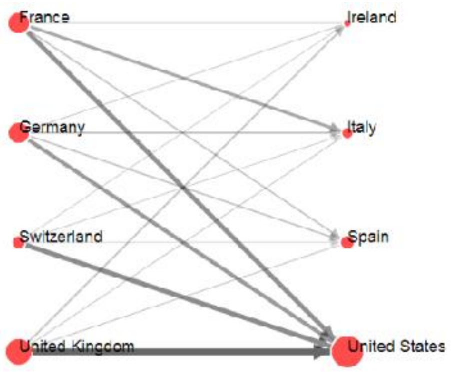


Figure 32: 2007-Q3 **Figure 33: 2014-Q1**
Source: Author's own figure

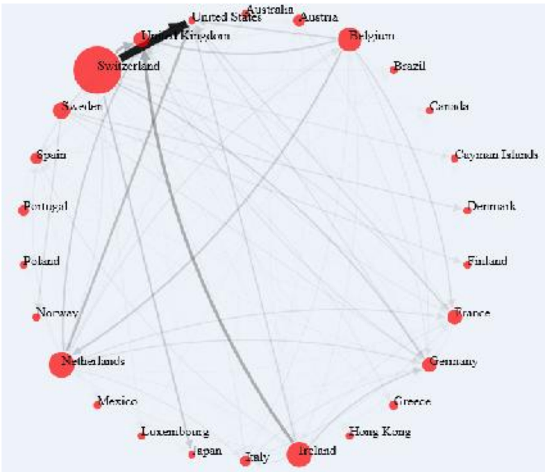
The structure of networks in EU countries sample B and C showing the same result as well. (Figures 24-31). Based on the EU banks illustration two group of Core banks including American, British, German and French Banks are peripheries, the rest of the banks, are separated. The structure of networks in EU countries and US clearly state that British, French, German and American banks play as the core of network in all periods since 2007. Figures 32 and 33 indicate the bilateral connection of the network in terms of giving and receiving of the exposures from 2007 till 2014 are almost the same. Such simple charts can already give valuable hints as to which other countries one should look for in order to assess banking sector risk at country level. At the same time, one can easily assume the reverse perspective and ask which countries will mainly be affected by problems – say – of the euro-area peripheral countries. Regional or local hotspots can thus easily be traced to the international banking system. A further possibility in monitoring bilateral exposures is to take into account the time dimension of the data. For instance, comparison of the data over time reveals to which countries domestic exposure has become significantly larger or smaller in recent times In doing so, one can also trace the build-up and decline of bank exposures to current hotspots, such as the euro area periphery (see figures 32, 33) – with the stronger movements warranting further investigation into the causes of the changes and their possible implications for banking sector risk.

4.4.2 How to develop the perspective

In order to assess structural vulnerabilities of banks in an international comparison it makes sense to look at the data not only in absolute, but also in relative terms. At the first step we looked at the perspective of selected countries banks' exposure at absolute figures of exposures. In the next step, the potential impact of banking sector problems on economic activity is measured by the relative size of the country (potential bail out in case of failing). The smaller the size of GDP to total exposure of banks, the more severely banking sector problems would affect economic activity or – in case banks need to be supported by the government – could increase public debt. By these metrics, Swiss banks were vulnerable before and after the recent financial crisis. However, the degree of vulnerability diminished during the last three years (for detailed outcomes see Figures 34-41).

Bilateral exposure relative to GDP highlights the contribution of Swiss banks to the aggregate systemic risk of the network in particular during the 2007 financial crisis (Figures 34 and 35). Although the illustration of 2014-Q1 shows the systemic risk of Swiss banks decreased but their exposure to American banks increased. (Figure 37)

A: Selected EU countries



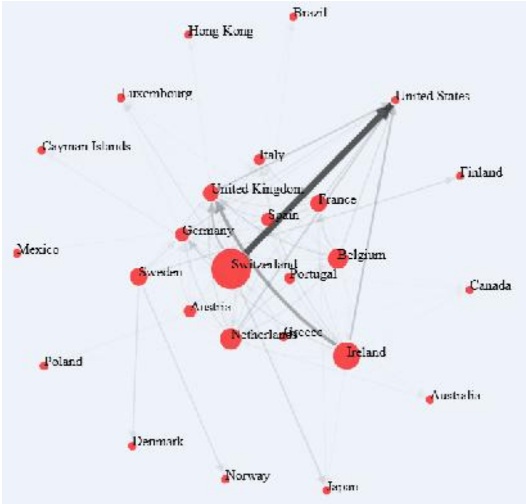
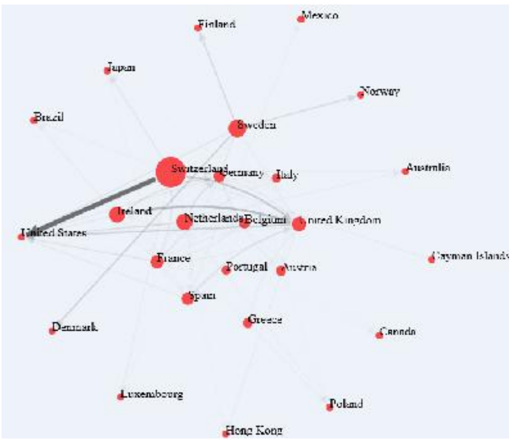


Figure 34: Bilateral Exposure relative to GDP 2007-Q3 **Figure 35: Bilateral Exposure relative to GDP 2008-Q4**

Source: Author's own figure



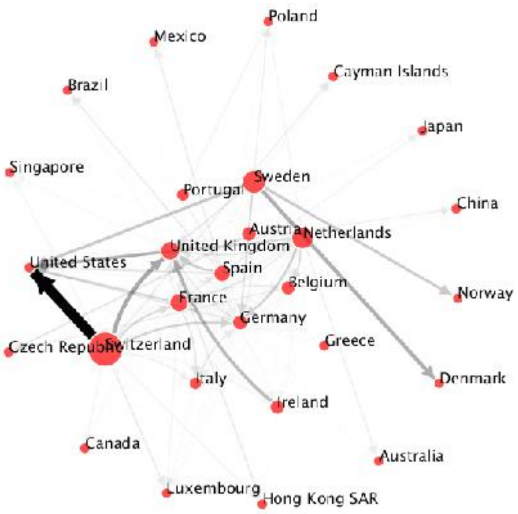
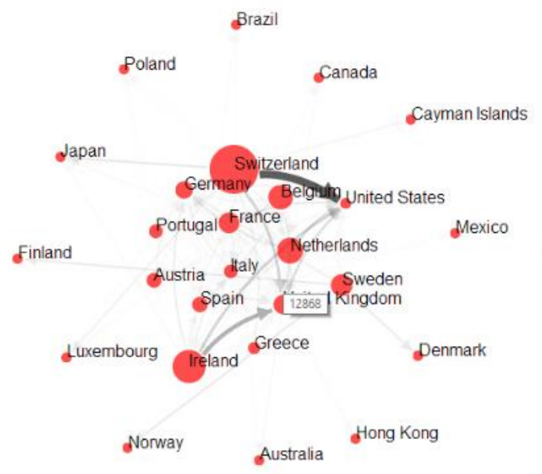


Figure 36: Bilateral Exposure relative to GDP 2011- Q3 **Figure 37: Bilateral Exposure relative to GDP 2014- Q1**

Source: Author's own figure

B: Selected EU countries & United States



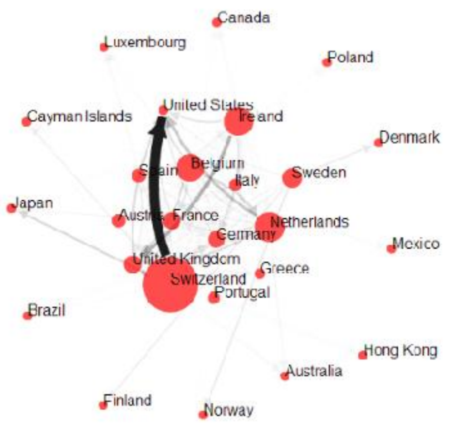
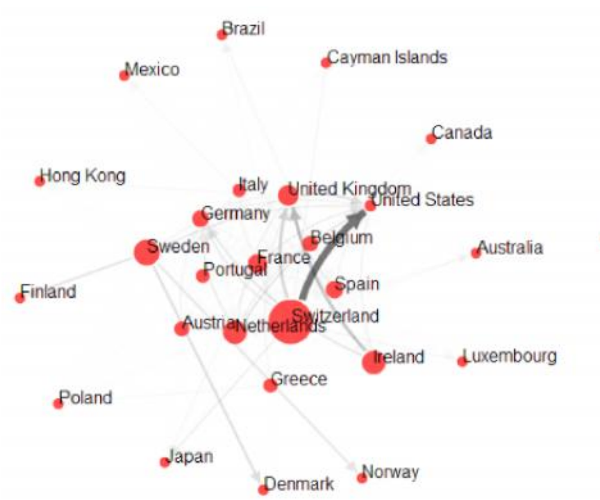


Figure 38: Bilateral Exposure relative to GDP 2007-Q3

Source: Author's own figure

Figure 39: Bilateral Exposure relative to GDP 2008-4Q



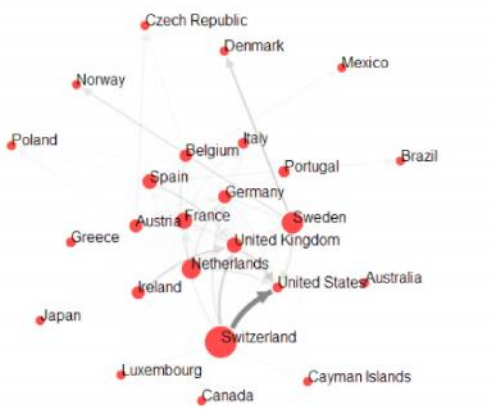


Figure 40: Bilateral Exposure relative to GDP 2011- Q3

Source: Author's own figure

Figure 41: Bilateral Exposure relative to GDP 2014- Q1

In the third step, to capture the vulnerability of the national banking sector to cross-country spill-over effects, we look at the overall exposure of banks to total exposures. In the fourth step the impact of banking sector systemic risk will be assessed by "relative size of the banking sector", i.e. the size of the banking industry could be measured by the total assets of the banks (Figures 44 and 45). The greater the size of the banking sector relative to national GDP, the more severely that country's banking sector problems would affect economic activity or – in case banks need to be supported by the government – could increase public debt. In the fifth step, we consider the ‘concentration index’, i.e. the diversification of banks’ foreign exposure across other countries. To this end, we apply the Herfindahl Index to the GDP of the country and the total assets of banks to measure concentration of a country’s top borrowers. This ratio is relevant for the analysis of banks’ vulnerability to first-round contagion effects. For a banking sector that is highly exposed to a single or very few other countries, contagion risk may be stronger than for a country that is well diversified in its foreign lending exposure. Bilateral exposure relative to index in 2007-Q4 shows the vulnerability of Swedish, Belgium and Netherland Banks. This vulnerability slightly diminished over the period and in 2014 is much smaller.

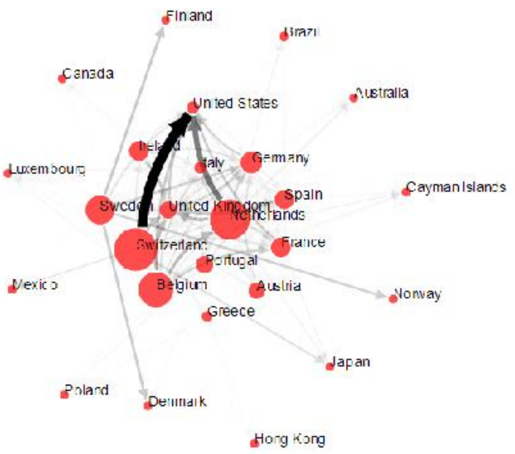


Figure 42: Bilateral Exposure relative to total assets 2006- Q4

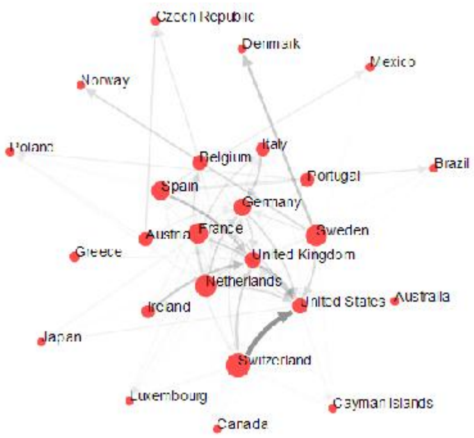
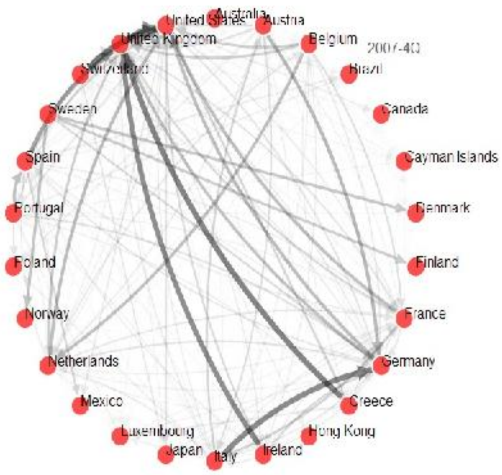


Figure 43: Bilateral Exposure relative to total assets 2014- Q1

Source: Author’s own figure



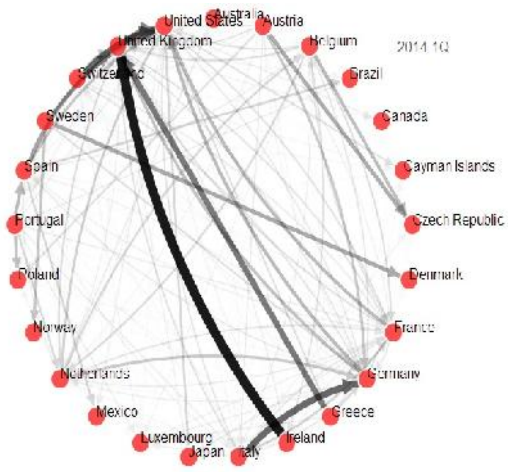


Figure 44: Bilateral Exposure relative to total Exposure 2007- Q4

Figure 45: Bilateral Exposure relative to total Exposure 2014-Q1

Source: Author’s own figure

4.5 Centrality Measures

A clique is a subset of a network (that is, a subset of the nodes and all associated links in a network) that forms a complete graph. The maximum clique is the largest possible clique in a network. Maximum clique measure shows the core of the system. (Figures 46 - 48). Maximum clique index is showing the same countries as core of the system. Basically maximum clique index confirmed the previous result in terms of core countries.

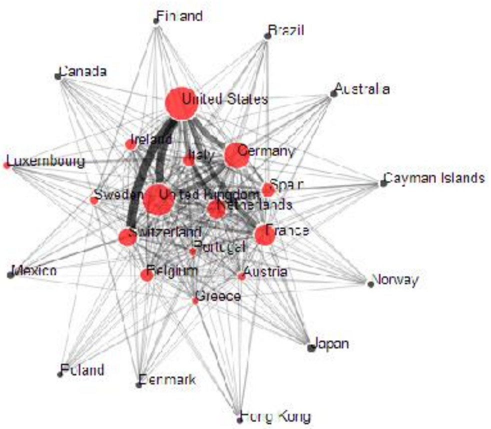


Figure 46: Maximum Clique 2006- Q4
Source: Author's own figure

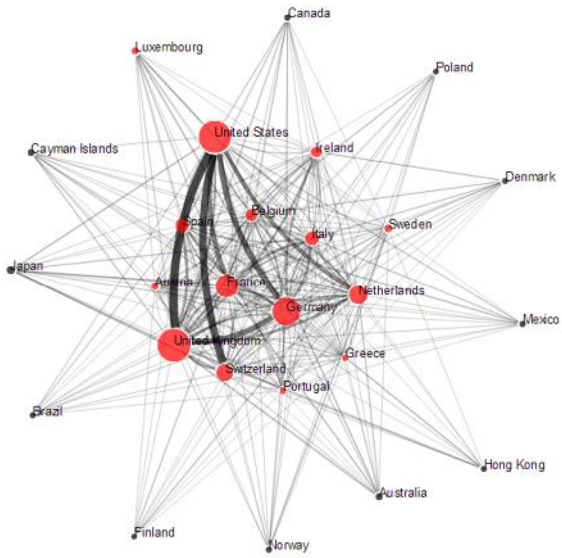


Figure 47: Maximum Clique 2007- Q3

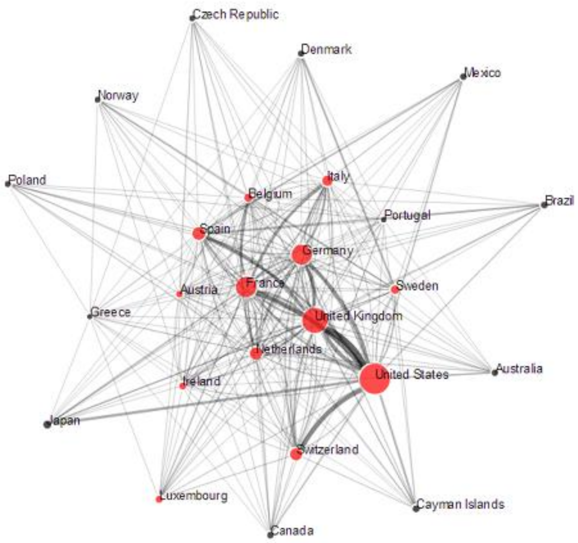


Figure 48: Maximum Clique 2014- Q1
Source: Author's own figure

Newman metrics and Max clique measure of sample A also verify the core-periphery structure of banking network (see Figures 49 and 0). These measures were used for all data from 2005 till 2014 with the same result of verifying the core-periphery structure of the banking network.

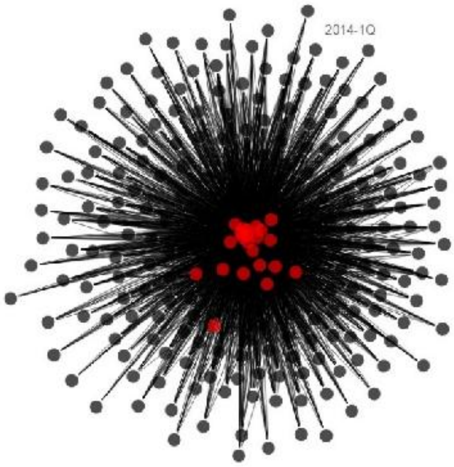


Figure 49: Maximum Clique 2014-Q1
Source: Author's own figure

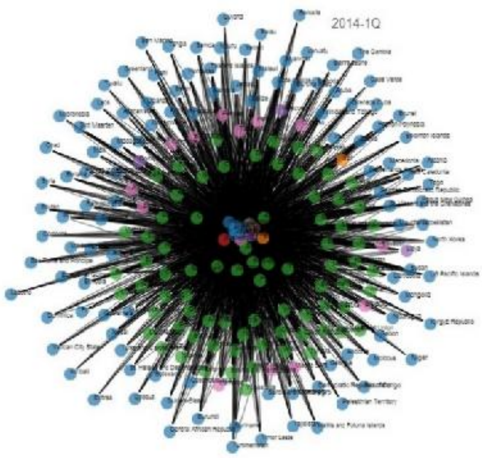


Figure 50: Newman Measure 2014- Q1

(For more details of network centrality measure and connectedness including Newman, Max clique, cheiRank and closeness for all countries in 2014-1Q see table at appendix 4.)

Betweenness is one of the most important centrality indices, which basically counts the number of shortest paths going through a node (Geisberger, Sanders and Schultes, 2008). We examine the 'betweenness' measure starting from 2005 with the index of 100, we could see this index increased the most for American banks with 4.5 times comparing to 2005. Although in 2007-Q4 (financial crisis time) the French banks' betweeness was the most remarkable (Figure 51) but in 2014-Q1 American banks led with the highest result. (Figure 51)

Table 4 Betweenness

	United States	United Kingdom	Switzerland	Germany	France
2005-2Q	100	100	100	100	100
2005-3Q	96.9	92.3	134.2	96.6	112.8
2005-4Q	107.1	97.6	106.5	89.5	100.6
2006-1Q	106.8	119.4	119	79.6	90.1
2006-2Q	119.4	100.9	120.1	85.6	98.6
2006-3Q	119	106.9	115.7	89.8	95.5
2006-4Q	124.5	107.1	138.6	87	93.9
2007-1Q	128.5	60.4	134.7	82.1	109.3

	United States	United Kingdom	Switzerland	Germany	France
2007-2Q	138.9	55.5	150.2	80.7	114.2
2007-3Q	129.4	53	121.5	89.9	105.4
2007-4Q	119.5	56.2	143.5	86	112.1
2008-1Q	158	57.4	142.8	83.9	103.9
2008-2Q	125.4	61	136.9	81.6	113
2008-3Q	115.5	65.1	129.8	99.8	104.3
2008-4Q	110.4	61.3	115.2	89	112.6
2009-1Q	121	71.3	124.8	90.3	102.8
2009-2Q	132.1	57.6	130.9	82.2	113.8
2009-3Q	123.4	57.8	122.6	75.3	118.2
2009-4Q	148.7	59.1	130.7	83.1	117.7
2010-1Q	167.6	67.9	158.5	107.3	47
2010-2Q	159.9	73.4	204.3	100.1	36.9
2010-3Q	182.7	60.6	210.1	99.1	42.6
2010-4Q	212.5	60.1	181.1	98.6	48.5
2011-1Q	187.3	52.3	232.1	102.8	55.1
2011-2Q	204	54.7	204.3	102.3	50.8
2011-3Q	195.6	62.1	174.5	108.3	63.9
2011-4Q	221	100.4	179.9	104.4	56.8
2012-1Q	235.5	77	234	121.6	0.5
2012-2Q	232.8	80.3	209.7	128.4	0.5
2012-3Q	230.3	73.5	211.2	126.6	0.5
2012-4Q	251	69.6	171.7	116.3	0.5
2013-1Q	247.8	82.9	160.1	131.5	0.5
2013-2Q	257.8	64.2	180.6	118.5	0.5
2013-3Q	259.7	84.5	173.5	121.7	0.5
2013-4Q	428.9	69.9	0.3	121.9	0.6
2014-1Q	445.8	78.8	0.3	129.3	0.6

Source: Author’s own computation

Centrality Measures

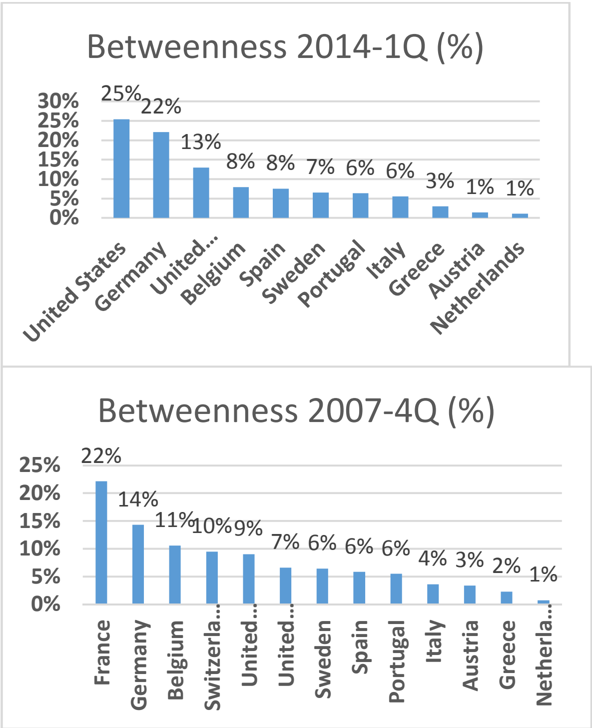


Figure 51: Betweenness 2007-Q4 & 2014-Q1
Source: Author's own figure

Figure 52: CheiRank vs PageRank

The cheiRank PageRank two dimension shows the systemic important and fragile role of American and British Banks in 2014-Q1 with different roles for American banks in 2007, which American banks were only fragile in 2007. (Figures 53,54)

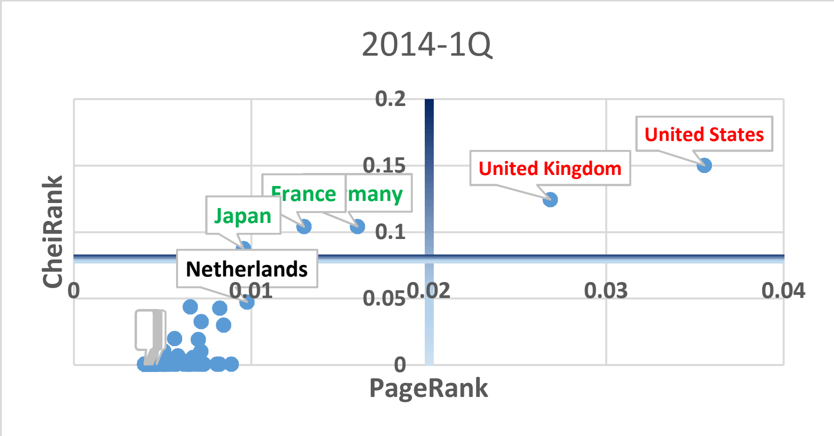


Figure 53: CheiRank vs PageRank 2014- Q1

Source: Author's own figure

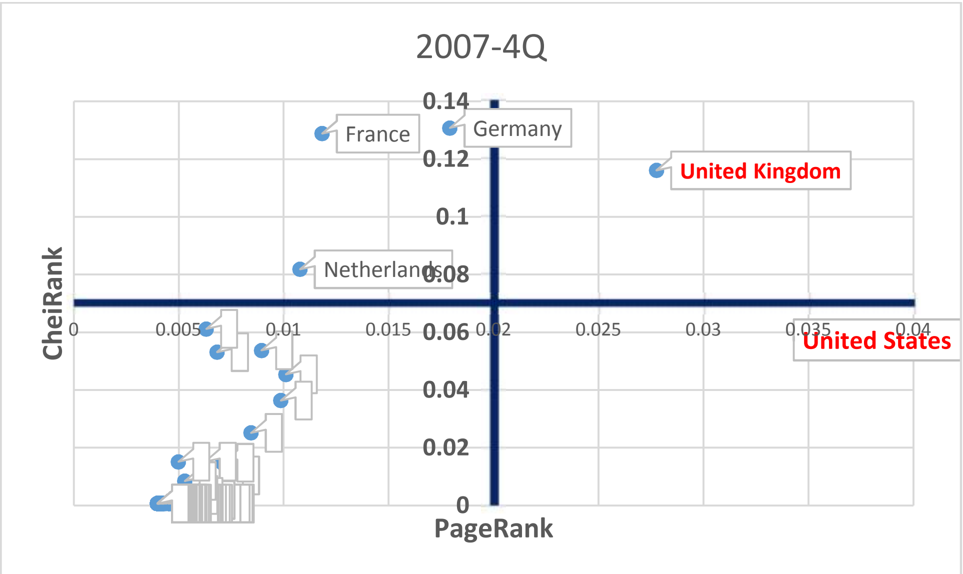


Figure 54: CheiRank vs PageRank 2007-Q4
Source: Author's own figure

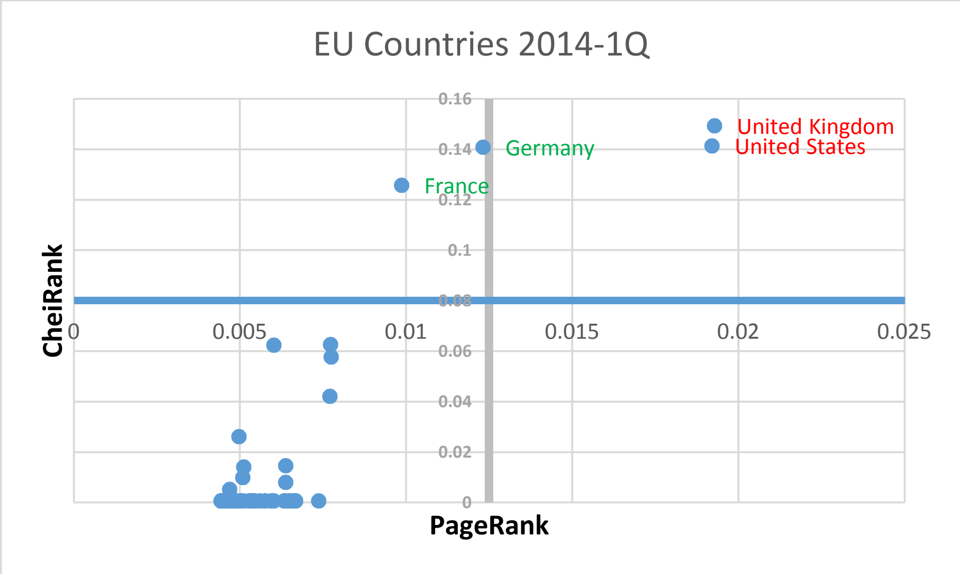


Figure 55: CheiRank vs PageRank EU countries 2014-1Q
Source: Author's own figure

4.6 Core Periphery Model

This section provides evidence that banking network at country level is tiered rather than flat, in the sense that banking network follows the core periphery structure. We capture the concept of tiering by developing a core periphery model, and devise a procedure to test the model to real-world networks. Using International Bank of Settlement data on bilateral exposures (ultimate risk) among EU banks, we find strong evidence of tiering in the banking network at country level.

Getting a better picture of the network structure will be a crucial step in developing systemic risk assessments of the interbank market. The idea of the Core Periphery model a small set of Core banks is highly connected, while Periphery banks are not connected with each other but only to the Core. Recently, attention has been shifting towards models of the network structure that might be particular to socio-economic relationships and less so to phenomena in the natural world. Its implications are mainly to account for the complexity noted by researchers Markose (2012) in terms of banks' obligations and connectivity. A number of authors have argued that interbank relations might be coming to a core-periphery structure, a setting first proposed in sociology for networks of acquaintanceships Borgatti and Everett, (2000). Craig and Von Peter (2010) apply this model to interbank data. (Fricke and Lux, 2014) have applied the core-periphery framework to data of the electronic platform e-MID that basically is used for short-term (overnight) liquidity provision. More specifically, this analysis is applied in a core-periphery (CP) analysis of the UK interbank market is provided by Langfield, Liu and Ota (2012) who use a comprehensive data set on connections between UK banks with a detailed breakdown into a large number of financial instruments across these banks.

The testable hypothesis here will be, whether banking network at county level follows the core periphery structure or not. This means that there is a small number of very interconnected banks that trade with many other banks and a large number of banks that trade with a small number of counterparties.

Similarly, to test the concept of an interbank core-periphery network in a quantitative way, Craig and von Peter (2010) introduce system that implements a strict definition. In a perfect Core Periphery structure, the following two conditions are satisfied:

Condition 1: core banks are all bilaterally linked with each other and both lend to and borrow from at least one periphery bank;

Condition 2: periphery banks are linked to core banks only and do not lend to each other.

To test the hypothesis we track the evolution of the network on a quarterly basis from 2005 Q1 through 2015 Q3.

For our procedure we first estimate the Core Periphery model, finding the number of core countries for every period. In our dataset, the core varies between 13 and 21 countries. Figure 56 plots the core size per period. Although over a long period of time the core size stays relatively stable around 15.

The structure we identified is highly persistent. First, the size of the core and the associated error score are stable over time (see Figure 56). Importantly, the composition of banks group within the core also remains remarkably stable over time. This can be shown by means of the estimated transition matrix:

$$P(s/\acute{s}) = \begin{array}{lcc} & Core & Periphery \\ Core & \%94.77 & \%5.23 \\ Periphery & \%1.04 & 0.98.96 \end{array}$$

The element $P_{\text{Core-Periphery}}$ P represents the frequency with which core banks move to the periphery over time. The fact that the values on the diagonal are close to unity confirm that banks tend to remain in the same tier (core or periphery). Estimating a separate transition matrix for each quarter demonstrates its stability over time (Figure 56).

We also calculate the transition matrix between the states of being in the core and in the periphery. Most importantly, the transition from core to core indicates that on average 98% of the core banks stay in the core the next period. As we found that the number of core banks is quite stable, the flow from and to the core is in absolute terms almost equal. The higher persistence in the periphery merely reflects that it consists of much more countries.

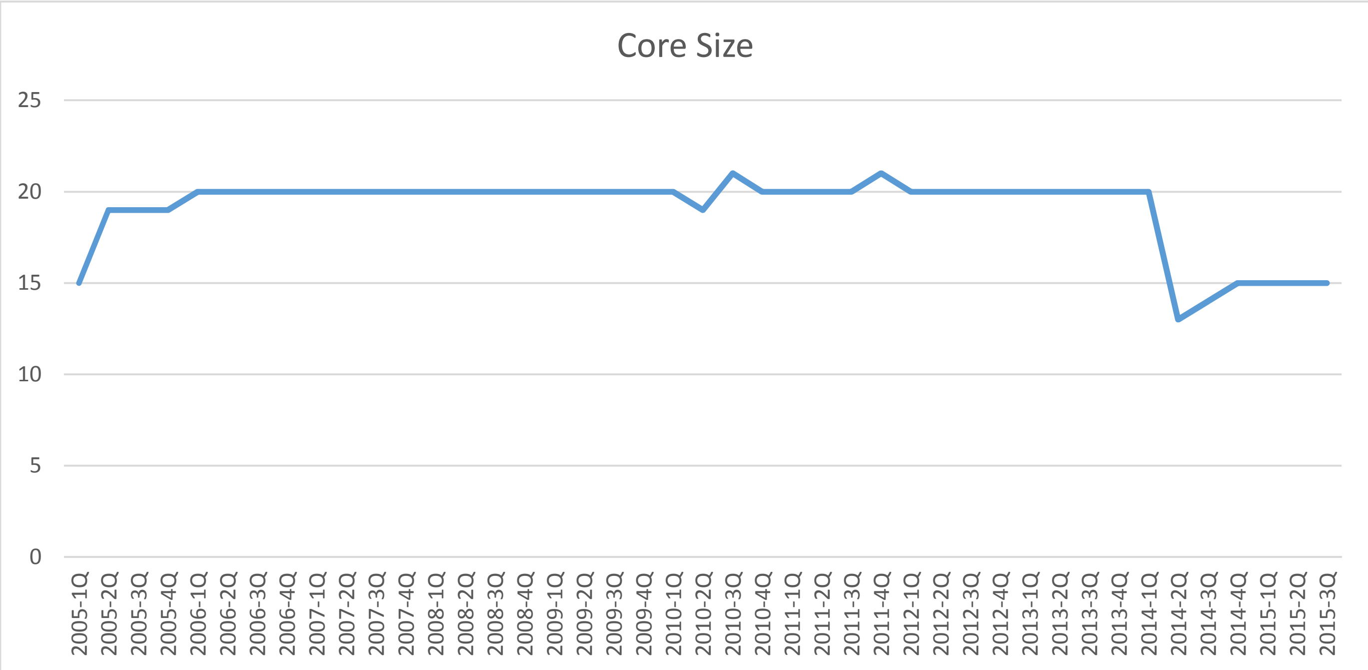


Figure 56: Structural Stability over time, size of the core (number of core banks group)
Source: Author's own figure

4.3.1 Core Membership and Bank-Specific Variables

Table 5 reports the results of probit regressions testing whether network position can be predicted by individual network variables. This will help provide insight into how core nodes and peripheral nodes are formed within the network.

Using the binary variables by Craig Von Peter Core Index, core membership takes the value 1 for banks that were determined to be in the core, and 0 for the remaining banks. (It is regressed on a constant and the regressors shown in the rows, which rely only on consolidated bank data (except for some variables, which require the network data). The columns show the different regressions, each comprising 8872 observations.

The cells show the maximum likelihood estimates of the coefficients. T statistics are shown in parentheses, Significance is denoted by *(5%) and **(1%) ***(10%).

Total banks exposures are the natural logarithm of total exposures (in 1000s USD plus 1); Betweenness is the logarithm of normalised betweenness Centrality indicator which could be used as connectedness index Freeman (1978). The fit with Betweeness is much better than that with cross border exposures.

Table 5 Core membership and bank-specific variable, probit regressions test

Dependent Variable: CORE
2005-Q1 – 2015Q3

Regresssors	1	2	3	4	5	6	7	8	9	10	11	12	13
Exposures	0.04		-0.00	0.01	0.03				0.01	-0.00	0.01		0.01
	(60.20)		(-1.17)	(24.64)	(37.58)				(28.51)	(-1.56)	(22.87)		(28.10)
Closeness			3.46			0.11	3.25		-0.64	3.29		-0.03	-0.75
			(96.41)			(2.79)	(91.93)		(-14.16)	(77.95)		(-0.84)	(-15.89)
Betweenness		0.12		0.12		0.12		0.12	0.13		0.12	0.12	0.13
		(211.29)		(178.10)		(98.49)		(165.78)	(106.75)		(156.01)	(98.72)	(106.76)
Pagerank					38.59		6.17	4.82		6.23	1.81	4.99	4.15
					(44.57)		(7.86)	(9.60)		(7.93)	(3.58)	(9.22)	(7.98)
C	-0.26	0.02	-1.70	-0.05	-0.32	-0.03	-1.62	-0.00	0.24	-1.63	-0.06	0.01	0.28
	(-40.50)	(14.79)	(-108.96)	(-16.64)	(-53.93)	(-1.79)	(-100.40)	(-0.70)	(11.45)	(-93.53)	(-16.67)	(0.75)	(12.95)
R-squared	0.29	0.83	0.65	0.84	0.42	0.83	0.66	0.84	0.85	0.66	0.85	0.84	0.85
No. of observations	8872	8872	8872	8872	8872	8872	8872	8872	8872	8872	8872	8872	8872

Dependent Variable: CVPCORE
Method: Least Squares

Sample: 1 8872
Included observations: 8872

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.053148	0.003194	-16.63756	0.0000
LNEXPOSURES	0.009674	0.000393	24.63888	0.0000
LNBETWEENNESS	0.116744	0.000655	178.1001	0.0000

R-squared	0.844865	Mean dependent var	0.092426
Adjusted R-squared	0.844830	S.D. dependent var	0.289642
S.E. of regression	0.114095	Akaike info criterion	-1.503238
Sum squared resid	115.4531	Schwarz criterion	-1.500840
Log likelihood	6671.363	Hannan-Quinn criter.	-1.502421
F-statistic	24150.30	Durbin-Watson stat	2.003872
Prob(F-statistic)	0.000000		

Dependent Variable: CVPCORE
Method: Least Squares

Sample: 1 8872
Included observations: 8872

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.275539	0.021283	12.94622	0.0000
LNEXPOSURES	0.013371	0.000476	28.10117	0.0000
CLOSENESS	-0.745856	0.046941	-15.88937	0.0000
LNBETWEENNESS	0.131220	0.001229	106.7586	0.0000
PAGERANK	4.151521	0.519977	7.984043	0.0000

R-squared	0.849377	Mean dependent var	0.092426
Adjusted R-squared	0.849309	S.D. dependent var	0.289642
S.E. of regression	0.112436	Akaike info criterion	-1.532303
Sum squared resid	112.0951	Schwarz criterion	-1.528307
Log likelihood	6802.298	Hannan-Quinn criter.	-1.530943
F-statistic	12500.48	Durbin-Watson stat	2.005499
Prob(F-statistic)	0.000000		

By using Least Square technique between core variable as independent and all other variables separately or jointly, (above figures) we show here a core-periphery network- few highly interconnected and many sparsely connected banks- endogenously emerges in our model. In other words, we show here that there is a small number of very interconnected banks that trade with many other banks and a large number of banks that trade with a small number of counterparties. This structure is consistent with that in the calibrated model of Farboodi (2014) and Gofman (2012) as well as empirical evidence on intermediation in several markets, including the federal funds market (Bech and

Atalay, 2008; Allen and Saunders, 1986;Afonso and Lagos, 2012;Afonso, Kovner and Schoar, 2012), international interbank markets Boss, et al.(2004) for Austria; Chang, et al (2008) for Brazil; Craig and Von (2010) for Germany and Lelyveld and Veld(2012) for Netherlands), and the OTC derivatives market Atkeson and Eisfeldt (2013).

The single most effective regressor in predicting whether or not a country will be a "core-bank country" (CBC) is the one that takes network data into account. A country's betweenness predicts quite reliably whether or not it is in the core, as in seen by its lack of variability in the regression table. Betweenness is the probability with which a node lies on the shortest path between any two unconnected nodes. The probit regression makes clear that connectedness predicts core membership better than does exposure values. This is not surprising: the core comprises the banks that jointly intermediate between the periphery, so a bank that helps to link pairs of unconnected banks also contributes to the core performing this role for the market as a whole. Comparing table 5 to table in appendix 1 the decrease in the relationship pre and post-2014 between the total exposures a country faces and its status as a 'core-bank country (CBC) shows that the importance of lending/borrowing to become a CBC has increased; to be counted as a CBC purely from lending/borrowing transactions, a country must be willing to allocate more of its resources to these activities.

The same can be said regarding the relationship between a country's status as a CBC and its betweenness in the banking sector; for a country post-2014 to be considered a CBC it must be much more connected to the banking activities around it. This leads to those left classified as CBCs in the core-periphery model with an average of more connections of lending/borrowing to other countries. It also points to a model of fewer even more highly connected CBCs, which can be seen as the average number of CBCs fell from 20 to 15 in the years before and after 2014. (See Figure 56)

The increase in the t-statistics of exposure and PageRank post-2014 show that there is a reduced standard error in calculating their relationship to a country's status as a CBC (as the t-statistic is the ratio of estimated correlation coefficient over standard error). Coupled with the respective correlation coefficients, this backs up the data found suggesting that countries really must lend/borrow more to be a CBC, as well as indicating that CBCs have a much higher visibility on the Web and noticeable impact on the online banking industry than pre-2014.

The general slight decrease in R-squared values in the regressions undertaken for years before and after 2014 indicates there is a little more spread of countries above and below the line of best fit for each regression. However, since the change is so small, it can be said to have little to no effect on the validity of the regression analysis.

Is the importance of bank total exposures for network position an expression of economies of scale and scope? This question should be addressed with a definition of total exposures that is unrelated to a bank's interbank activity. The intermediary function that core banks perform, by inflow exposures and outflow exposures in the interbank market, of course contributes to their reported balance sheet size. We thus compute the intrinsic exposures of a bank as (the logarithm of) total bilateral exposures (ultimate risk). Intrinsic exposures, when used alone, delivers a poor fit and the coefficient is too small to identify core banks at the default threshold (column 1). The variable remains significant but adds little explanatory power when used jointly with other centrality measures. The single most effective regressor will be one that takes network data into account. Column 2 shows that a banks' connectedness predicts quite reliably whether or not it is in the core, where we measure connectedness by betweenness centrality. Betweenness is the probability with which a node lies on the shortest path between any two unconnected nodes. The probit regression makes clear that connectedness predicts core membership better than does bank exposure. This is not surprising when one recognizes tiering as a 'group version' of betweenness: the core comprises the banks that jointly intermediate between the periphery, so a bank that helps to link pairs of unconnected banks also contributes to the core performing this role for the market as a whole.

More intriguing is the presence of outliers: for reasons of specialization, some very large banks in terms of exposures, were found to be far less connected than their total exposures and presence in the core would suggest. This touches on the open question of whether 'too-big-to-fail' or 'too-connected-to-fail' is the relevant criterion for financial stability. However, the prediction can be further improved by focusing on the size and centrality measures of interbank intermediation activity. Exposures, betweenness and PageRanks jointly predict the core membership slightly better (Column 11). Column 8 shows that connectedness variables in their own predict core membership nearly as reliably as size and betweenness (Column 4) , and better than closeness variable, without requiring the bilateral data necessary for these two regressors. Finally, we include the aforementioned variables jointly to examine their respective explanatory power. In regression 13, it is clear that each regressor remains significant in concert with the others: total bilateral exposures, betweenness, PageRank and Closeness all contribute to explaining which banks form the core.

All in all, the results of Table 5 show that network position is predictable by banks specific features. Banks are in the core because they are well-connected, both when measured by connectedness (betweenness centrality mainly); they are also in the core due to their ability to carry out large transactions, as measured by their total bilateral exposures or by the volume of interbank intermediation they perform.

4.7 Conclusion

As was seen from the models a stable financial system ought not propagate or magnify shocks to the other parts of the network. The model employed shows that the nature of systemic risk depends on the interplay of the network topology. Systemic risk as we defined is a network architecture that subjects the entire network to failure or reduced efficiency from the effect of a singular local incident or simultaneous shocks. How the banks relate with one another, the means of communication and other transfer between banks is key and the model indicated that the actual nature of financial transactions over the network, individual banks' assets and also the buffer stemming from banks' size are determinants of correlation between network topology and systemic risk. Other factors evidenced were the nature of the shocks to the network, the source of the shock, where it falls within the network topology and sub-connections within the network will show how much a network will propagate a shock.

Being too big to fail, as well as being too interconnected, too central, and too correlated to fail was also examined and were shown to be reasons why the network can arrive to unstable configurations detrimental for the entire system. The differentiation ration between global and local components of financial institutions have played a key role. In the desire to expand coverage and maximise individual profits and interests without the due care taken for the external impact such measures impose on the stability of the system as whole, banks and other key financial institutions have a role in increasing systemic risk over the financial network. In this chapter we empirically test that the interbank network structure follows the core-periphery model, a setting first proposed in sociology for networks of acquaintanceships, (Borgatti and Everett, 2000), which covers the network complexity.

The framework for studying and visualising the relationship between the financial network topology and systemic risk due to contagion of bilateral exposures is presented such that if banks were willing to minimize systemic risk when they take decisions, they would need to have sufficient information regarding the financial situations of the other banks, such as the exposures each bank has on each other. We saw that the centrality measures the fit of Core with Betweeness is a best fit for capturing centrality in this network. How much does a particular node exert influence on others? Take a scenario where one bank wants to evaluate the riskiness associated with a loan to another bank, it should be able to know the exposures of its counterparty, what other firms are affected by its counterparty? The probability of defaults depending on its own counterparties, and so on. Centrality measures will be best evaluated with crucial access to information and banks can better analyse the probability of defaults due to contagion effects.

A global view (rather than local only) is required for a more thorough assessment of the network topology. The systemic risk in a network of interlinked financial institutions in selected countries, was then analysed using a metric for the systemic importance of players in the global picture. To identify and monitor possible sources and channels of contagion in a system a robust framework is required. This allows for intervention just in time to prevent networks from descending into full blown critical situations.

The systemic risk in a network of interlinked financial institutions in selected countries, was analysed using a metric for the systemic importance of players. The methodology involved applying calculations to a dataset of consolidated cross-border mutual exposures on several bases: ultimate risk of bank default, relative bank size to size of the economy, size of the banks and concentration index, the role of balance sheet size, and the domestic network property for each country's banks. Then each regions contribution to systemic risk was analysed. The results we came to outlined the contribution of banks' size, size of economy and concentration of counterparty exposures to a given country's banks and therefore its systemic importance.

It is concluded that proactively tracking potential systemic linkage should be in the agenda of regulators globally. Unprecedented levels of financial interconnections during stress events means that although counter intuitive, actions geared at enhancing soundness of a particular bank or institution may undermine the stability of other banks or of the whole network. Interconnectedness in the financial system was part of the problem in the financial crisis, Stiglitz (2014). This chapter carefully uses the network approach to analyse interconnectedness, and therefore provides some insights to monitor systemic risk. As a result, there are suggestions of a potentially fruitful road of forming policies to mitigate against systemic risk. It is highlighted that a better regulation is at the focus of financial reform needs. This reform should encapsulate much more than the singular dimensional need for higher capital ratios or better liquidity ratios for instance. The new connected world needs a new financial architecture with a new approach to regulation that takes as a major variable the multi-tiered complexity interconnectedness involves. Similarly, supervising cross border resolutions of banks and financial institutions should get more attention in the risk management approach of financial systems, and a more assertive global supervisory for financial systems is needed, to capture and monitor proactively the interconnectedness between countries' financial systems. The findings of the network approach attempts to answer the question of the ideal structure of a more stable banking system and highlights that we don't know enough yet. However, these findings could provide part of a puzzle even if not the whole picture. The study succeeds in making firm contributions to the existent literature by developing a framework that explains how interdependencies between banks at country level emerge endogenously.

Chapter 5 Network Structure & Systemic Risk in European Banks

5.1 Introduction

Coupled biological and chemical systems, neural networks, social interacting species, the Internet and the World Wide Web, are only a few examples of systems composed by a large number of highly interconnected dynamical units. The first approach to capture the global properties of such systems is to model them as graphs whose nodes represent the dynamical units, and whose links stand for the interactions between them. On one hand, scientists have to cope with structural issues, such as characterizing the topology of a complex wiring architecture, revealing the unifying principles that are at the basis of real networks, and developing models to mimic the growth of a network and reproduce its structural properties. On the other hand, many relevant questions arise when studying complex networks' dynamics, such as learning how a large ensemble of dynamical systems that interact through a complex wiring topology can behave collectively.

Schweitzer et al. (2009) state that the financial crisis 2007-8 illustrates a critical need for a new and fundamental understanding of the structure and dynamics of economic networks. The main feature of this structure is complexity which is mainly built on interdependencies. To study such a system, the holism approach that stresses the systemic complexity of economic networks is needed. The main goal would be reducing the risk of global failure by making economic networks more robust. Deep understanding of financial network architecture, structure and its function is essential to assess the robustness of financial network. Finally, to establish rules and regulation that will effectively monitor and manage this financial network, while also understanding the probability or measure of systemic risk in the network is a first step. One of the effects of the financial crisis was the development of a risk management approach, in particular in risk hedging area, Stiglitz (2014) when addressing the diversification effect in conference on interconnectedness in May 2104 mentioned before the 2007–8 crisis, "the thrust of economic discussion was that diversification, or interconnectedness, was a great thing" However, the belief that diversification enables risk to be spread was proven wrong during the crisis. In the same conference he addressed the role of interconnectedness by saying the high degree of interconnectedness in the financial system 'facilitated the breakdown' and became 'part of the problem', of the financial system (Stiglitz, 2014). In fact, interconnectedness involves not only linkages within the financial sector, but also linkages between the financial sector and the real economy. Stiglitz (op. cit.) argued for policies that limit interconnectedness and for a 'richer diversity of financial institutions'. Such policies may imply restrictions on the kinds of activities that banks are allowed to undertake and limit the uniformity of business models and size. While "specialized institutions as opposed to universal banks can be better at information gathering, […] they may also be more subject to shocks in their particular area of specialization"). However, the benefits of a diverse financial system may well outweigh the costs. A "rich ecology of financial institutions would address the problem of too-correlated-to-fail financial structures and may result in a more robust and resilient financial system". Various arguments over the last few years on systemic risk in the financial market has one common feature, the comments on the role of financial linkages, financial network, interconnectedness of financial market in creating a system wide risk are increasing significantly between academic and executives (see Buch, 2014). Dale (1996) hen outlining the key causes of the system's failure highlighted the cross border financial transactions, in his views financial markets have been transformed over the past two decades by three key developments. Firstly, the dismantling of barriers to international capital flows and the process of globalisation have resulted in a massively increased volume of cross-border financial transactions. Secondly, the functional integration of hitherto discrete areas of financial activity has led to the emergence of financial conglomerates combining traditional banking with securities operations and other non-bank business. Finally, financial innovation has produced a vast new market in derivative products that simply did not exist 15 years ago. With interconnected financial markets around the world, the analysis of 'networks' in the financial system would help deepen understanding of systemic risk and is key to preventing future financial crises.

5.2 Stability and fragility in network

Conjectures in stability & fragility in networks could be classified into three categories. The first common conjecture in network literature about stability goes back to an article from Kiyotaki and Moore (1997) in the context of credit. This concept is then later developed by Allen and Gale, (2000) and financial contagion is modeled as an equilibrium phenomenon, as financial linkages are modelled by assuming that each project requires two participants and each participant requires two projects. Also implementing financial multipliers modeled by Kiyotaki and Moore (1997). In their model, the impact of illiquidity at one link in the credit chain travels down the chain. Also Freixas, Parigi and Rochet (2000) provided some of the first formal models of contagion over networks. They argue that ring networks are unstable, rings are structures with a cycle in them. They concluded that the resilience of the financial system to idiosyncratic shocks will be increased by more interbank connections, whereas 'sparser' network structures are more fragile. (see Acemoglu, et al, 2012; Allen and Gale, 2000;Kiyotaki and Moore, 1997;Freixas, Parigi and Rochet, 2000).

Then also a second category argue that more densely connected financial networks are more prone to systemic risk. In the complete network where every firm is connected to every other in an equal proportionate manner those are very stable, in fact there is an opposite conjecture, where distress in the financial market is modelled like an epidemic, this perspective is also shared by Blume et al.(2011), Blume et al. (2013) and Vivier-Lirimont (2006) who model interbank contagion as an epidemic.

The third category was presented by Acemoglu et al. (2012). They argue that in the context of input-output economies with linear interactions, sparsity is not relevant. Rather, it is the symmetry that matters. So we should be careful on the nature of economic interaction or financial interaction that takes place over the network. They conclude that the form of interactions and magnitude of shocks are crucial for understanding systemic risk and fragility. For small shocks, sparsity implies fragility and interconnectivity implies stability. With larger shocks, the more complete networks become most fragile, whereas 'weakly connected' networks become stable, (phase transition). This third category's viewpoint adds that in the presence of intersectoral input output linkages, microeconomic idiosyncratic shocks may lead to aggregate fluctuations. They follow this by outlining that as the economy becomes more disaggregated, the rate at which aggregate volatility decays is determined by the structure of the network capturing such linkages. Such higher-order interconnections capture the possibility of 'cascade effects' whereby productivity shocks to a sector propagate not only to its immediate downstream customers, but also to the rest of the economy. They highlight that sizable aggregate volatility is obtained from sectoral idiosyncratic shocks only if there exists significant asymmetry in the roles that sectors play as suppliers to others. That the 'sparseness' of the input–output matrix is unrelated to the nature of aggregate fluctuations.

In contrast to the third class of assessment, a recent study **(**Acemoglu et al., 2012) shows that in context of linear models, rings are exactly as stable as complete network but it might be a problem to apply this linear model in finance and it is not the same as economics. In finance there are first order non-linearity that we cannot avoid, for example such a non-linearity is generated when a standard debt contract is defaulted by the borrower. Being in default is a very discontinuous thing, as (Acemoglu et al. 2013) argue that in the presence of financial non-linearity we will see that intuitive linear models fall short, while rings and complete networks are not equivalent, yet the density of connection is what matters. In fact, we say rings are unstable, but the submission in any of these financial network models is that there is also going to be a phase transition and when this phase transition happens, we find that complete networks/ more densely connected networks also fall short. Such that instead of being stable they flip and become extremely unstable, so the stability or fragility of the network (rings or complete network) depends on various parameters: not only on the nature of interaction but also on what type of shocks, as well as the stages of shock transmission.

Then why is the stability of ring and complete network models in financial institutions considered different from input-output economy models? The most thorough explanation is because in input-output economies, shocks are averaged and it causes networks with equal degrees to appear robust and stable. However, with non-linearity failures the shocks cannot be averaged or failures cannot be averaged out by successes. The network needs to minimise failure and rings are not good for minimising failure, as all obligation goes to another firm in case of failure. So in line with what Haldane (2009) says "Interconnected networks exhibit a knife-edge, or tipping point, property. Within a certain range, connections serve as a shock-absorber. Likewise, the system acts as a mutual insurance device with disturbances dispersed and dissipated. But beyond a certain range, the system can tip the wrong side of the knife-edge. Interconnections serve as shock-amplifiers, not dampeners, as losses cascade" (p. 9).

5.3 Contribution

Our approach builds on previous theoretical and empirical studies of default contagion in banking systems (see Gabrieli, Salakhova and Guillaume, 2014;Degryse, Elahi and Penas, 2010), which shows results of the strong impact on the domestic and cross-border propagation of losses of heterogeneity and concentration in the structure of interbank exposures. While Gropp, Duca and Vesala, 2009;Cont, Moussa and Santos, 2010) use a methodology applied to financial institutions in Brazil (see, also, De Bandt and Hartmann, 2000), and provide a comprehensive approach for the simulation of the financial system, discussing the sensitivity of contagion to a change in aggregate network parameters: connectivity, concentration of exposures, heterogeneity in degree distribution and network size. Upper, (2011), Acemoglu, et al.(2013) and Franklin and Babus(2009) hold similar views.)

Although, our study also differs from them in terms of the methodology used by capturing multifaceted market data and aggregating at macro level, modelling using a mixed determined by level of contagion transmission, then the scope of study looks at individual countries and their cross border activity within the sample; and then finally, level of measurement (country level) used give a somewhat new viewpoint in terms of the results obtained. In particular, we are led to revisit some of the conclusions in previous literature on the magnitude of contagion risk in interbank networks providing perspectives from concentration, heterogeneity, interlinkage, and level of transmission and susceptibility of contagion.

5.4 An Empirical Analysis of Banking Network

In this part we will identify systemic risk of banking networks using disaggregated data, these analyses attempt to capture systemic risks stemming from common exposures, interbank linkages and funding concentrations. Another key question of the chapter is the impact of network structure on aggregate volatility. To answer this question, we analyse the behaviour of network structure on aggregate volatility. By analysing the network structure model, we explain why the stability of ring and complete structured networks in financial institutions are different from input-output economies. We measure the first order and second order interconnectivity of nodes in selected networks. We then map out aggregated first order and second order interconnectivity and rank the banks at country's level based on first and second order interconnectivity. The empirical density of first and second order connectivity will be calculated.

5.4.1 Data

The analysis of the study is based on two categories of EU selected countries' banks plus American banks; and then the first category plus banks in Canada, Turkey, Japan, Chile, India, South Korea, and Australia. The primary data for this report was the total banking system exposure (loans at risk of being defaulted) for selected countries to the rest of the world since 2005 up until the end of March 2014. This data compiled on a quarterly basis was gathered. We implement the empirical study through the quarterly data of Bank of International Settlements consolidated banking statistics[29] data bank (see McGuire and Wooldridge, 2005, for more information on consolidated banking statistics) To answer the question of selected banks interconnections, we use foreign claims by nationality of the reporting banks with the ultimate risk basis consisting of selected countries from 2005 Q1 to 2014 Q1 (for more detail see appendix 3).

5.4.1.1 BIS Consolidated Banking Statistics (CBS)

The CBS track banks' worldwide consolidated gross claims and other exposures to individual countries and sectors. They thus provide internationally comparable base measures of national banking systems' exposures to country risk (e.g. cross-border asset exposure).[30] Reporting banks' foreign claims are composed of several pieces.

Using Figure 57, Cross-border claims (A) are claims on non-residents booked by either a bank's head office or a foreign affiliate (branch or subsidiary) in a third country. Local claims are those booked by a foreign affiliate on borrowers residing in the host country of the affiliate. Local claims can be denominated in foreign currencies (B) or in the local currency of the host country (C).

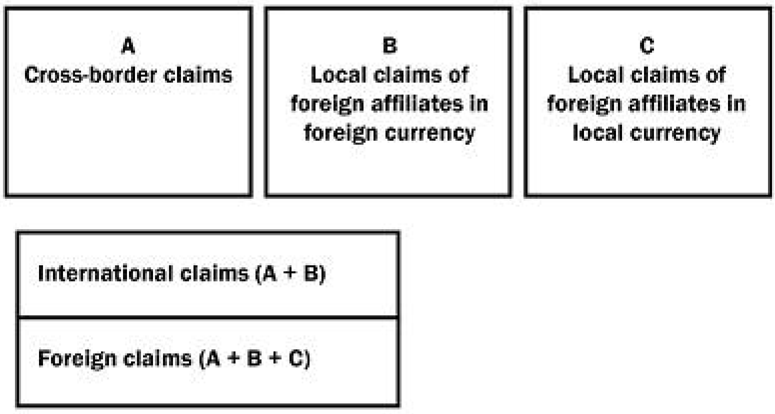
Banks report foreign claims (A+B+C) on borrowers in individual countries on both an immediate borrower (IB) basis and an ultimate risk (UR) basis. In the CBS, (IB) banks' claims are allocated directly to the country where the borrower resides. In addition, banks' foreign claims are reported as international claims (A+B) and local claims in local currency (C). In contrast, in the CBS (UR), banks allocate their claims

[29]These statistics measure banks' country risk exposures. They capture the worldwide consolidated claims of internationally active banks headquartered in BIS reporting countries. The consolidated statistics include the claims of banks' foreign affiliates but exclude intragroup positions, similarly to the consolidation approach followed by banking supervisors. They detail the transfer of credit risk from the immediate counterparty to the country of ultimate risk (where the guarantor of a claim resides). Available at: http://www.bis.org/statistics/consstats.htm?m=6%7C31%7C7

[30] Banks net out intergroup positions and consolidate positions across offices worldwide, an advantage over residence-based data, such as the BIS locational banking statistics (LBS) and the IMF's Coordinated Portfolio Investment Survey (CPIS).

to the country where the ultimate obligor resides, defined as the country where the guarantor of a claim resides or the head office of a legally dependent branch is located. Here, banks' foreign claims are reported as cross-border claims (A) and local claims in all currencies (B+C). Also in the CBS (UR), banks separately report off -balance sheet items such as derivative contracts and contingent exposures (undisbursed credit commitments and guarantees).[31]

Figure 57: Consolidated banking statistics



Source: author's own compilation

5.4.1.2 Consolidated data

Systemic risk assessment cannot proceed adequately without consolidated exposure and funding data. Not only do we need consolidated data, but we need these data with geographical detail. That is, supervisors in Germany need to be able to see both the subsidiaries of UK banks operating in Germany, which they already know, and the exposure and funding-related activities of German subsidiaries in the United Kingdom, which they may not know. Consolidated banking statistics at ultimate risk basis capture the claims to the country where the ultimate risk lies in a manner consonant with banks' own systems of risk management. This provides a breakdown of foreign claims into: (i) direct cross-border claims, capturing direct lending from banks to a foreign borrower without any presence in the borrower country; and (ii) affiliates' claims, including claims by either branches or subsidiaries operating in the borrower countries.

[31] Derivative exposures include the positive market value of outstanding contracts covering foreign exchange, interest rate, equity, commodity, and credit risks. Contracts with negative market value are classified as liabilities, and are not reported and/or netted out. Guarantees and credit commitments are reported at face value, i.e. at maximum possible exposures.

The BIS consolidated international banking statistics on an ultimate risk basis are the most appropriate source for measuring the aggregate exposures of a banking system to a given country (See Avdjiev (2010)). Unlike the consolidated international banking statistics on an immediate borrower basis, they are adjusted for net risk transfers.

5.4.2 Model of Input-output network

An important question is what are the effects of shocks on interconnected networks of banks? To answer this question firstly we need to understand the intersectoral network structures of banks, in fact we imply the network theory concepts on financial systems. In line with other studies our analysis on the structure of the intersectoral relations of banks explain how in selected networks a majority part of the network (EU banks) exposed themselves to a small part of the network (core sectors). This is in line with the scenario where a few sectors in the real economy are main suppliers of the other sectors. Consequently, the interplay of shocks in the network (banking sectors) and the network structure may generate a significant aggregate fluctuations.

To develop this ideas, we consider a sequence of countries' banks $\{\varepsilon_n\}$, $n \in$N, corresponding to different levels of disaggregation. Each network ε_n consists of n sectors (countries' banks) whose exposures are captured by an $n \times n$ matrix W_n'. Entry (i, j) of this matrix captures the share of banks' j's exposure in banks' i's output. Its $jt\square\ row$ sum, as out-degree banks group j explains the share of banks group exposure j of the entire network exposures. Given the sequence of networks $\{\varepsilon_n\}$n∈N, we used the other studies result to show *aggregate volatility*, defined as the standard deviation of log exposures, vanishes as $n \rightarrow \infty$.

Applying the conjecture in network studies and real economies we explain what is the consequence of the failing law of large numbers in a star network of selected banks, and how in the case of failing, the aggregate risk does not concentrate around a constant value. To describe the systemic risk in the banking network, we implement input-output network studies starting with the real economy and then apply the model to banks' network. The economy consists of n disaggregated sectors, one of the models used to explain the output is Cob Douglass equation production function of different sections which is:

Equation 1:

$$X_i = Z_i^{\propto} \ell_i^{\propto} \prod_{j=1}^{n} X_{ij}^{(1-\propto)W_{ij}}$$

where

ℓ_i: Labour employed by sector *i*

$\propto \in (0,1)$: Labour Share

X_{ij}: amount of commodity *j* used in the production of good *i*

$W_{ij} \geq 0$: input share of sector *j* in sector *i* 's production

$\in_i = \log(Z_i) \sim F_i$ Productivity shock to sector *i*.

Degree of sector *j*:

We use the notions of the intersectoral network and input–output matrix interchangeably as equivalent representations of the structure of intersectoral trades. We also define the weighted out-degree, or simply the degree, of sector *i* as the share of sector *i*'s output in the input supply of the entire network normalized by the constant 1−α; that is,

Equation 2:

$$d_j = \sum_{i=1}^{n} Wij$$

Before elaborating systemic risk let's clarify the equilibrium's characters. Cob Douglas' equation gives us log linearity input-output, based on Leontief:

Equation 3:

$$y_n = \log(output) = V_n' \, \mathcal{E}$$

y_n in the network (or economy) of size *n* is just given by Ɛ which is the vector of those Ɛ shocks (proportional shocks) that hit every sector, *v* is the vector which we call influence vector, y_n is the inter product of two vectors , or in another words every sector get some shocks and those shocks are weighted according to the influence vector, if the first entry is very large for the influence vector it means the shock to the first sector is very important, in aggregate.

Where $\mathcal{E} \equiv [\varepsilon_1, \varepsilon_2, \varepsilon_3, \ldots, \varepsilon_n]$, and the *n*-dimensional vector *v*, called the influence vector, is defined as:

Equation 4:

$$V_n \equiv \frac{\propto}{n}\ \mathrm{I} - \ \ 1-\propto\ W_n'\ ^{-1}$$

The vector *v* is also the "sales vector" of the network (or the economy, in real economy model). In particular, the i_{th} element of the influence vector is equal to the equilibrium share of sales of sector i,

Equation 5:

$$V_{in} = \frac{P_i X_i}{\sum_j^n P_i X_i}$$

With P_i denoting the equilibrium price of good i. This is not surprising in view of the results in Hulten (1978) and Gabaix (2011), relating aggregate total factor productivity (TFP) to firm- or sector-level TFPs weighted by sales.[32] Acemoglu, et al.(2012) argue that this observation also implies that there exists a close connection between their results on the network origins of output fluctuations and Gabaix's (2011) results on their granular origins. A major difference is that the distribution of sales shares across sectors (or other micro units) in their model is derived from input–output interactions. Meanwhile they argue that this not only provides micro foundations for such size differences, but also enables them to sharply characterize the role of important structural properties of the network in shaping aggregate volatility. Furthermore, unlike in Gabaix (2011), the structure of interconnections also determines the co-movements between different sectors, placing a range of additional restrictions on the interplay of aggregate and more micro-level data.

Finally, note that rather than deriving (3) and (4) as the equilibrium of a multisector economy, one could have started with a reduced form model

Equation 6:

$$\tilde{y} = \tilde{w}\tilde{y} + \varepsilon$$

[32] Note that, in contrast to (Hulten 1978) formula, the logarithms of sectoral shocks (i.e., the ε's) are multiplied by sales shares, and not by sales divided by value added. This is due to the fact that shocks in our model correspond to Harrod-neutral changes in productivity ($z_i = \exp(\varepsilon_i)$ is raised to the power α), whereas Hulten (op. cit.) considered Hicks-neutral changes in productivity.

where:

a. $\tilde{y}$ is the vector consisting of the output levels, value added, or other actions (or the logarithms thereof) of *n* economic units,

b. $\tilde{w}$ is a matrix capturing the interactions between them,

c. ε is a vector of independent shocks to each unit or idiosyncratic shock

Equations and model also described in more detail in appendix 2.

5.4.3 Periphery and Core in selected countries

The first order interconnectivity of the European banks indicates strong connectivity between a small numbers of countries. Aggregated figures since 2005 put UK, Germany, France and US as the most interconnected among the network. However, comparing first order interconnectivity of 2014 Q1 and 2007 Q1 showing US Banks getting more interconnected in 2014 compared to the financial crisis time, 2007. ((Table 6). In 2014, the core countries alone (UK, Germany, France, US) have 65% of the whole network interconnectivity. Figures 58 - 60 shows how the role of countries in terms of first order interconnectivity changes overtime from 2005. (For more detail of first order interconnectivity measurement see appendix 5)

Table 6 First order interconnectivity 2005-2014
source: author's own computation

Banks	Mean	Standard Deviation	Aggregated First Order Interconnectivity
British Banks	0.184515	0.016538	6.827048
German Banks	0.161063	0.028932	5.959327
French Banks	0.141087	0.015761	5.220231
American Banks	0.116167	0.042691	4.298183
Swiss Banks	0.093689	0.025767	3.466499
Dutch Banks	0.083339	0.022931	3.08354
Spanish Banks	0.060365	0.014653	2.233494
Italian Banks	0.039022	0.010135	1.443812
Swedish Banks	0.035465	0.009284	1.312192
Belgian Banks	0.035396	0.020476	1.309653
Austrian Banks	0.021201	0.003812	0.784452
Irish Banks	0.017503	0.010597	0.647599
Portuguese Banks	0.006327	0.000534	0.234111
Greek Banks	0.004861	0.001712	0.179857

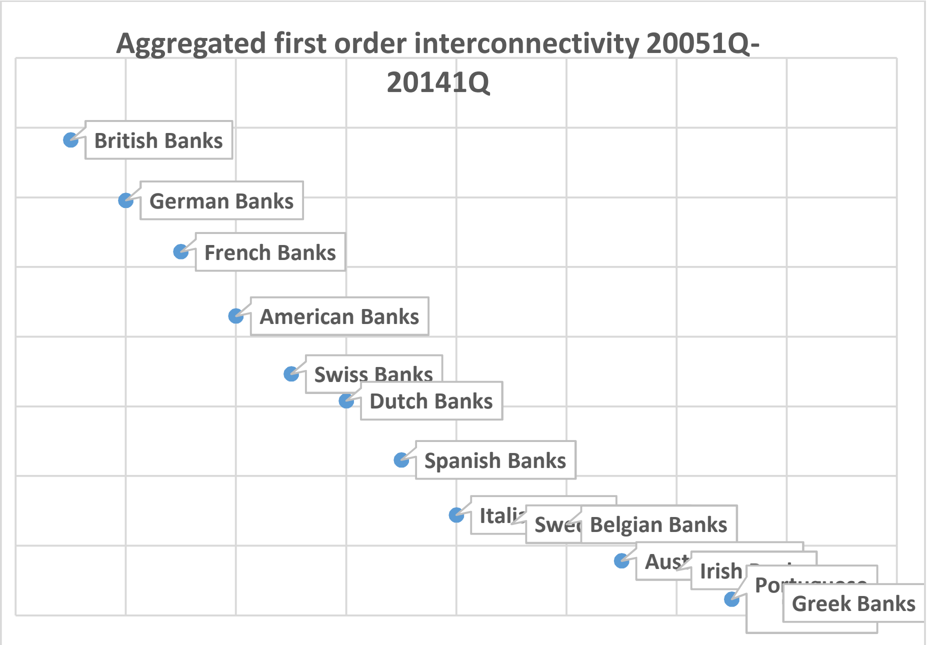


Figure 58: Aggregated first order interconnectivity
Source: author's own figure

Over 2005 – 2014, the first order interconnectivity aggregated shows that British banks have the highest interdependence and German banks come a close second, and although they have had huge effect globally, US banks only come fourth.

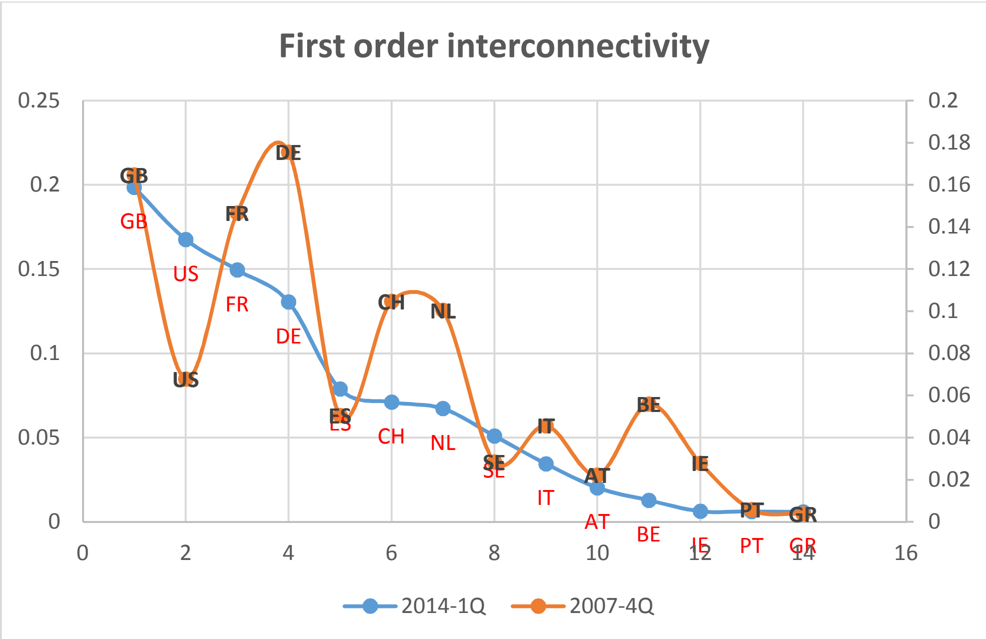


Figure 59: First order interconnectivity comparison
Source: author's own figure

In comparing the values from both ends of the time period in question provides a view on the range of interconnectivity achieved over time. There is a huge disparity in the start and end values over the period shown and this can be tied to a change in regulations or hefty fines. For example, US and German banks seemingly swap positions while Greek, Portuguese and Austrian Banks make no changes.

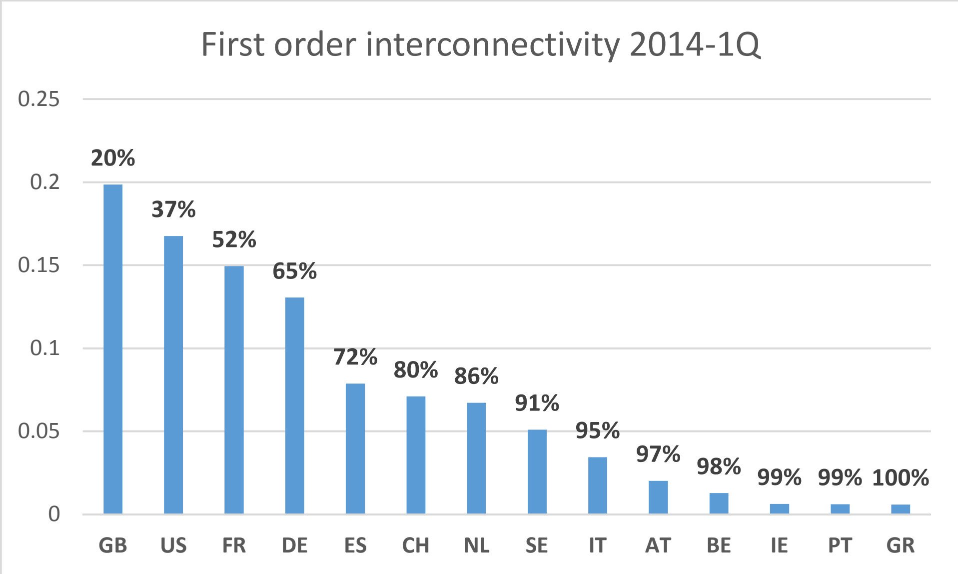


Figure 60: first order interconnectivity aggregated amount
Source: author’s own figure

This shows that actual level of true diversification in the relationship between financial firms, and the UK is just as interdependent as China is not.

Table 7 Ranking of banks based on first order interconnectivity 2005-2014 (Largest value on top). Source: author’s own computation

	Austrian Banks	Belgian Banks	Swiss Banks	German Banks	Spanish Banks	French Banks	British Banks	Greek Banks	Irish Banks	Italian Banks	Dutch Banks	Portuguese Banks	Swedish Banks	American Banks
2005-1Q	10	6	10	1	10	4	2	9	10	7	3	8	10	5
2005-2Q	11	7	3	1	8	4	2	13	14	10	5	12	9	6
2005-3Q	11	7	3	1	8	4	2	13	14	10	5	12	9	6
2005-4Q	10	8	3	1	7	4	2	13	14	11	5	12	9	6
2006-1Q	11	7	3	1	8	4	2	14	10	12	5	13	9	6
2006-2Q	11	7	3	1	8	4	2	14	10	12	5	13	9	6
2006-3Q	11	7	3	1	8	4	2	14	10	12	5	13	9	6
2006-4Q	11	7	4	1	8	3	2	14	10	12	5	13	9	6
2007-1Q	12	7	4	1	8	3	2	14	11	9	5	13	10	6
2007-2Q	12	7	4	1	8	3	2	14	11	9	5	13	10	6
2007-3Q	12	7	4	1	8	3	2	14	11	9	5	13	10	6

2007-4Q	12	7	4	1	8	3	2	14	11	9	5	13	10	6
2008-1Q	12	7	4	1	8	3	2	14	11	9	5	13	10	6
2008-2Q	12	7	4	1	8	3	2	14	11	9	5	13	10	6
2008-3Q	12	7	4	2	8	3	1	14	11	9	5	13	10	6
2008-4Q	12	9	4	3	7	2	1	14	11	8	5	13	10	6
2009-1Q	12	9	5	2	7	3	1	14	11	8	6	13	10	4
2009-2Q	12	9	5	3	7	2	1	14	11	8	6	13	10	4
2009-3Q	12	9	5	2	7	3	1	14	11	8	6	13	10	4
2009-4Q	11	12	5	3	7	1	2	14	10	8	6	13	9	4
2010-1Q	10	12	5	3	7	2	1	14	11	8	6	13	9	4
2010-2Q	11	12	5	3	6	4	1	14	10	8	7	13	9	2
2010-3Q	11	12	5	3	6	2	1	13	10	8	7	14	9	4
2010-4Q	10	11	5	3	6	2	1	13	12	8	7	14	9	4
2011-1Q	10	11	5	3	6	2	1	13	12	8	7	14	9	4
2011-2Q	10	11	5	3	6	2	1	13	12	8	7	14	9	4
2011-3Q	10	11	5	4	6	3	1	13	12	8	7	14	9	2
2011-4Q	10	11	5	3	6	4	1	13	12	9	7	14	8	2
2012-1Q	10	11	5	3	6	4	1	13	12	9	7	14	8	2
2012-2Q	10	11	5	3	6	4	1	13	12	9	7	14	8	2
2012-3Q	10	11	5	3	6	4	1	14	12	9	7	13	8	2
2012-4Q	10	11	5	3	6	4	1	13	12	9	7	14	8	2
2013-1Q	10	11	5	3	6	4	1	12	14	9	7	13	8	2
2013-2Q	10	11	5	3	6	4	1	12	14	9	7	13	8	2
2013-3Q	10	11	5	3	6	4	1	12	13	9	7	14	8	2
2013-4Q	10	11	6	4	5	3	1	13	12	9	7	14	8	2
2014-1Q	10	11	6	4	5	3	1	14	12	9	7	13	8	2

By isolating the banks within the sample region, we are able to see the role each country's banks play before and after the crisis especially in the 2005 – 2014 duration.

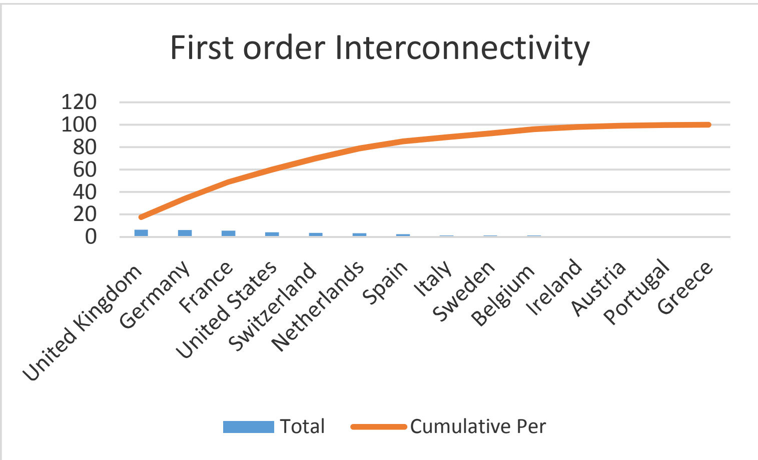


Figure 61: First Order Interconnectivity
Source: author's own figure

The cumulative display on the interconnecting banks data where the lowest performing countries are also among the top values for total interconnectivity.

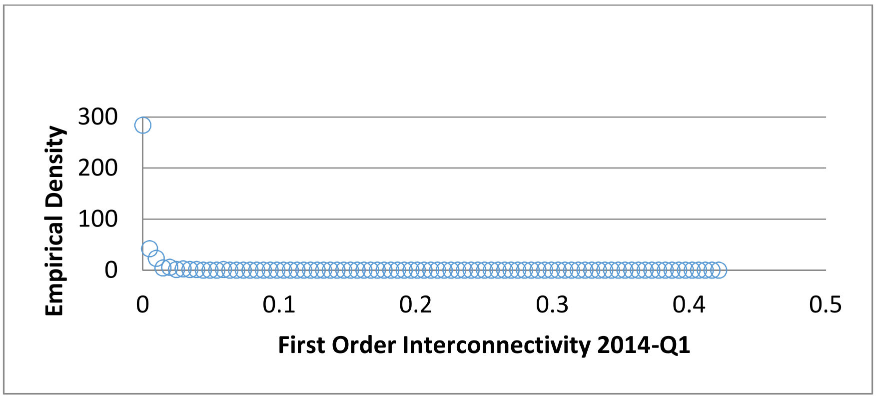


Figure 62: First Order Interconnectivity 2014-Q1Source: author's own figure

The empirical density for first order interconnectivity reaches values up to 300 for the UK as the highest value obtained, painting a picture in line with already seen results of strong interconnectedness. The remaining countries stay within a standard range as visible on the graph.

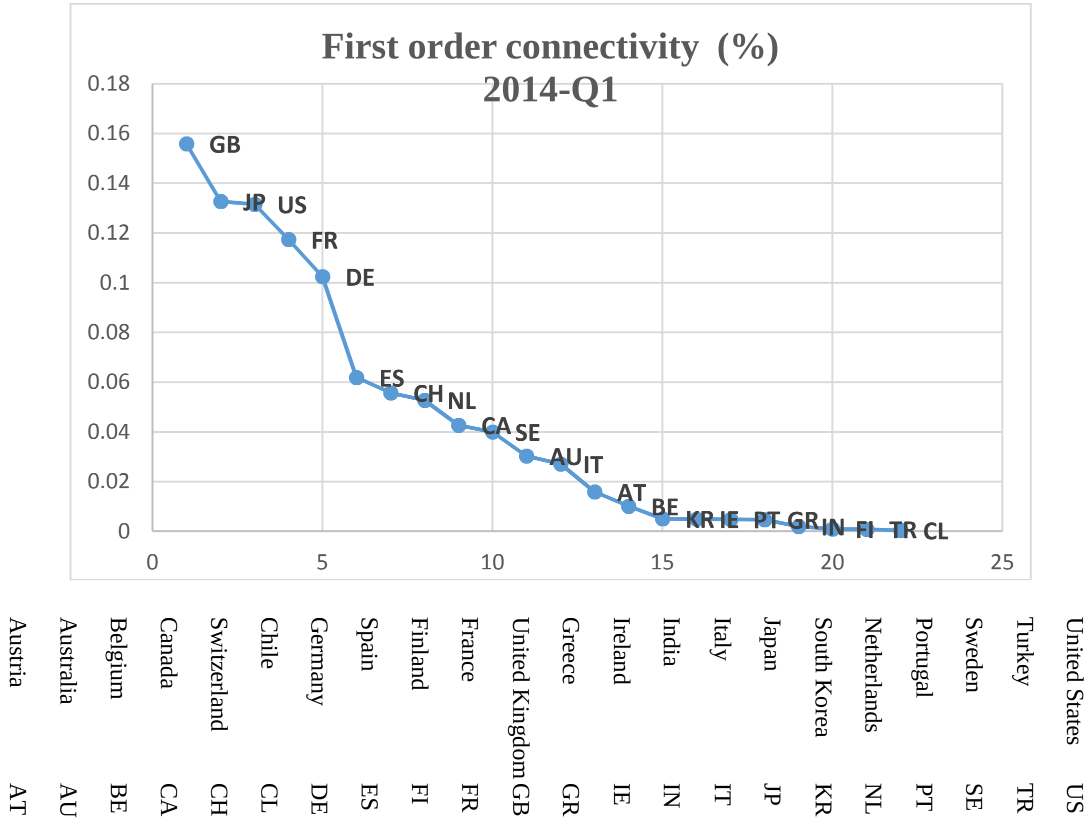


Figure 63: First Order Interconnectivity (%) 2014-Q1
Source: author's own figure

Even when a more comprehensive sample network is constructed with the EU, US, Japan, Canada, Japan, Chile, India, South Korea, and Australia as nodes, we get similar results. The hub is almost the same, but for the fact that Japan and the US tie in the second position. In selected countries' network, we find that the core of the network belongs to four countries' banking sectors, and these supply many other banking sectors. On the reverse, banks in the periphery have a low degree (very minimal links to other banks) so they prove to not be very important. The banks in the middle of the network (*Core* banks,) have high out-degrees. As we explain in the model, the selected networks have a star topology, with the core sectors being: German Banks, British Banks, French Banks, and American Banks. This core when applied to the bigger sample turns out to be German Banks, British Banks, French Banks, American Banks and Japanese Banks. There is an inequality of out-degrees in the network.

5.4.4 Measuring systemic risk:

5.4.4.1 Systemic risk in a network

The simplest way to measure systemic risk, after seeing the various parameters at play, is to use a natural measuring method of: aggregate volatility, we define aggregate volatility as standard deviation of log real (aggregate) value added.

Equation 7:

$$\sigma_{agg} = (var\, y_n)^{1/2} = \sqrt{var\, y_n}$$

The aggregate output of a network (or economy in real economy model) can be characterized in terms of its influence vector as y_n = log $Output = V_n' \varepsilon$. Independence of sectoral productivity shocks imply that the standard deviation of aggregate output, which we refer to as aggregate volatility, is given by:

$$\sigma_{agg} = (var\, y_n)^{1/2} = \sqrt{\sum_{i=1}^{n} \sigma_{in}^2\, v_{in}^2}$$

where v_{in} denotes the i_{th} element of v_n.

5.4.4.2 Network structure and aggregate volatility

To fully outline what properties of the network have an impact, we need to ask some questions. First, how can we show that ring networks are more stable or more fragile than complete networks? There are two ways of doing that, firstly we can take two different networks of fixed size *n* and so we take a single economy with n sectors and we hypothesize that if we were to change the nature of interconnection in this economy how would this change the system-wide risk or systemic risk and aggregate volatility? Or we could use this asymptotic analysis approach and look at the limit when n goes to infinity. We then scrutinise the changes in aggregate volatility as n goes to infinity, as well as define the asymptotic property. To characterise the impact of network properties on aggregate volatility as $n \to \infty$, what are the requirements? In this case the question is equivalent to whether the law of large numbers applies, or to put it differently does the range of values obtained centre mostly around its mean and if so how quickly does it hold it? Or rather how rapidly or slowly does σ_{agg} converge to *zero*. The classic law of large numbers holds at the speed of $\frac{1}{\sqrt{n}}$, if it's slower, this implies aggregate volatility would remain for much longer.

Meanwhile let's assume that $\sigma_i = \sigma$ for each i for simplification. Acemoglu et al. (2012) argue that all regular networks[33] achieve the lowest level of aggregate volatility which is given by $\sigma_{agg} = \frac{\sigma}{\sqrt{n}}$. (See (Acemoglu, Carvalho, et al. 2012)). A key question is, 'What is the impact of the network structure on aggregate volatility?' To answer this question, we should analyse the behaviour of the network structure on aggregate volatility. The fascinating point of this analysis is that essentially, both ring and complete financial networks just average the shocks out in an efficient manner. Basically, these are idiosyncratic shocks, such that at every point in time, some sectors get positive shocks, while some sectors get negative shocks (or no shocks at all). What happens is essentially that those positive and negative shocks are being averaged.

In both ring and complete networks, if some of the sectors are negative while some are positive and they've been averaged, it's obvious the aggregate output is the net and

[33] The network is regular if $d_i = d$ for each i. So for a regular network, every sector has not only the same in-degree but the same out-degree. Both ring and complete network are regular. In both of them every sector has out-degree equal to one. In the ring every sector has an out-degree of 1 which is going to the next neighbour, and in a complete network, it is distributed to the rest of the network but in an equal manner. So complete and ring networks are equally robust.

there is a little bit of co-movement, which is key in a linear structure. However, financial networks are not so readily modelled as stable, except in a ring and complete network model. An example of an unstable network is one with sectors in the middle that supply many other sectors, yet sectors in the periphery have a low degree, as mentioned previously. In a regular network we would have an equality of out-degree with different distributions but every node would have the same out-degree. This model is a *star* network, which is very unstable, and we must note three quite important things: Firstly, that the network structure matters so the degree of distribution matters here. Second, if you look at that expression $\sigma_{agg} = \frac{\sigma}{\sqrt{n}}$ you will see there is nothing like $\sqrt{n}$ in value of the denominator, in fact for large n , n will have disappeared Acemoglu, et al. (2012). This result relates to the robust-yet-*fragile* idea, which Haldane (2009) addresses, n does not matter because the volatility of the system here comes from the fact that every now and then there will be a shock hitting the network in the middle. This is also why this is a system-wide collapse, simply because when you hit the middle everything collapses (everybody suffers). That is the correlation across all the sectors. Most times, the network will be fine because most of the time, there is no huge negative shock hitting the network the middle, but sporadically or every now and then, when the middle is hit the network suffers significantly. Therefore, the network is robust most of the time because most of the shocks experienced are fine but then the network is also very fragile because when these specific shocks hitting the middle the system hits, then the system is affected very badly. So the highest level of aggregate volatility is generated by star network and is equal to:

Equation 8:

$$\sigma_{agg} = \frac{\sigma}{\sqrt{1 - (\frac{n-1}{n})\alpha(1-\alpha)}}$$

In fact, this is not just high volatility but systemic volatility, shocks to the central sector spread to the rest creating co-movement. Consider a sequence of economies (with many disaggregate sectors) with $n \rightarrow \infty$, suppose $\sigma_i \in (\sigma, \bar{\sigma})$, taking n to infinity to obtain a sharper result, then the greatest degree of "robustness" (least systemic risk) corresponds to:

$$\sigma_{agg} \sim \frac{1}{\sqrt{n}}$$

(So it goes to Zero with the speed of $\frac{1}{\sqrt{n}}$) as in standard law of large numbers for independent variables. This highlights an important feature, which is that the structure property of the network depends on out-degree distribution, the key object of which is the coefficient of variation of degrees. How unequal are the out-degrees across the different sectors of the economy?

Define the coefficient of variation of degrees as:

Equation 9:

$$CV_n = \frac{1}{d_{avg}} \left[\frac{1}{n-1} \sum_{i=1}^{n} (d_i - d_{avg})^2\right]^{1/2}$$

(Given an economy $\mathcal{E}_n$ with sectoral degrees $\{d_1^n, d_2^n, d_3^n \ldots, d_n^n\}$, the coefficient of variation is as above, where $d_{avg} = \frac{1}{n}\sum_i d_i$ is the average degree.

Here is the proposition:

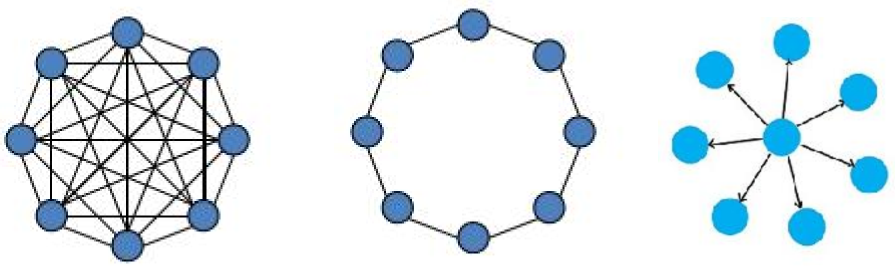
Equation 10:

$$\sigma_{agg} = \boldsymbol{\Omega}\left(\frac{\mathbf{1} + CV_n}{\sqrt{\boldsymbol{n}}}\right)$$

The fancy $\boldsymbol{\Omega}$ means it doesn't go to Zero faster than that. Obviously it cannot go to zero faster than $\frac{1}{\sqrt{n}}$, but in fact it might go to zero much slower than that, as coefficient of variation pops up there. So if the coefficient of variation is large it is going to limit how fast it goes to zero so aggregate volatility is going to remain even if we make the economy very disaggregated.

What does the coefficient of variation look like? If there is complete network CV_n=0, (all nodes have the same out-degrees) if we have a ring network CV_n=0 those are extremely well but if the network is star then $CV_n \sim \sqrt{n}$.

Figure 64: Ring Networks with Various *CV_n*



$CV_n = 0$ $CV_n = 0$ $CV_n = \sqrt{n}$

Source: Acemoglu, (20014) p.31,33

High variability in the out-degrees implies slower rates of decay and thus, higher levels of aggregate volatility. So replace $CV_n \sim \sqrt{n}$ in $\sigma_{agg} = \boldsymbol{\Omega}(\frac{\mathbf{1+CV_n}}{\sqrt{\boldsymbol{n}}})$**,** it never goes to **zero.** In fact, the law of large numbers fails for the star network as $\sigma_{agg} \nrightarrow 0$, because the shocks wouldn't be averaged out.

Ring and complete networks average the shock value as a result of aggregation, whereas star network model does not. There is a different way of seeing this by looking at the special case where degree distribution has a Pareto Shape or power law shape, in particular, we say the degree distribution for a sequence of economies has power law tail structure if, there exists a high β such that for each n and for a large, such that after k the counter-cumulative distribution (1- cdf of degrees) is pareto, or has a power law structure with coefficient of β.

$$Pn(K) \propto K^{-\beta}$$

where $Pn\ K$ is the counter-cumulative distribution of degrees and β is the shape parameter. A smaller β corresponds to a thicker tail and thus higher coefficient of variation and greater fragility, it means that within the network model, there are many sectors that have large degrees.

Consider a sequence of economies $\{\mathcal{E}_n\}_{n \in N}$ with a power law degree sequence and the corresponding shape parameter β. Then, aggregate volatility satisfies:

$$\sigma_{agg} = (var\ y_n)^{1/2} = \boldsymbol{\Omega}(\boldsymbol{n}^{-\frac{(\beta-1)}{\beta}-\delta})$$

where $\delta > 0$ is arbitrary. High β means thin tails and low β corresponds to a thick tail. If β *is low* the effect of this on the limit is that it will converge very slow, hugely slow in fact. The limit fails to converge into washing out, giving them the law of large number. This means if the degree sequence of the intersectoral network exhibits relatively heavy tails, aggregate volatility decreases at a much slower rate than predicted by the standard diversification argument. The equation provides only a lower bound on the rate at which aggregate volatility vanishes. Thus, even if the shape parameter of the power law structure is large, higher-order structural properties of the intersectoral network may still prevent the output volatility from decaying at rate √n, as we show next.

Table 8 Systemic risk of the selected network- first order interconnectivity (14 countries)

	Network				American Banks		British Banks		German Banks		French Banks	
	Standard Deviation	CVn	Aggregate volatility	No of Observation	No of Observation	Aggregate volatility	No of Observation	Aggregate volatility	No of Observation	Aggregate volatility	No of Observation	Aggregate volatility
2005-2Q	0.159	5.521	0.159	1672	130.000	0.324	175	0.456	175	0.399	181	0.192
2005-3Q	0.158	5.484	0.158	1678	130.000	0.328	174	0.449	171	0.394	186	0.188
2005-4Q	0.158	5.467	0.158	1682	130.000	0.325	175	0.456	169	0.404	183	0.192
2006-1Q	0.155	5.387	0.155	1706	129.000	0.342	183	0.453	166	0.413	182	0.196
2006-2Q	0.153	5.332	0.153	1720	136.000	0.339	176	0.447	170	0.412	182	0.197
2006-3Q	0.153	5.363	0.153	1728	135.000	0.339	178	0.449	171	0.402	184	0.200
2006-4Q	0.151	5.313	0.151	1743	135.000	0.326	181	0.438	169	0.394	184	0.207
2007-1Q	0.148	5.156	0.148	1727	135.000	0.343	153	0.447	168	0.402	185	0.204
2007-2Q	0.143	5.003	0.143	1758	142.000	0.341	158	0.428	170	0.399	186	0.204
2007-3Q	0.141	4.841	0.141	1726	138.000	0.338	151	0.427	170	0.393	184	0.201
2007-4Q	0.135	4.659	0.135	1755	139.000	0.331	153	0.417	172	0.378	189	0.197
2008-1Q	0.134	4.658	0.134	1772	148.000	0.329	155	0.415	171	0.372	188	0.204
2008-2Q	0.131	4.504	0.131	1770	143.000	0.319	158	0.407	173	0.359	193	0.200
2008-3Q	0.138	4.814	0.138	1766	140.000	0.323	159	0.447	176	0.361	190	0.201
2008-4Q	0.136	4.695	0.136	1754	136.000	0.335	158	0.434	173	0.346	191	0.210
2009-1Q	0.136	4.698	0.136	1766	139.000	0.377	161	0.449	172	0.347	185	0.207
2009-2Q	0.133	4.573	0.133	1766	145.000	0.370	155	0.432	169	0.346	189	0.205
2009-3Q	0.129	4.402	0.129	1741	140.000	0.366	150	0.416	167	0.344	189	0.200
2009-4Q	0.131	4.456	0.131	1731	147.000	0.374	153	0.415	168	0.345	188	0.201
2010-1Q	0.134	4.502	0.134	1691	148.000	0.367	155	0.427	175	0.343	141	0.227
2010-2Q	0.138	4.606	0.138	1662	145.000	0.375	156	0.416	169	0.357	132	0.233
2010-3Q	0.132	4.407	0.132	1669	146.000	0.357	152	0.397	170	0.348	138	0.228
2010-4Q	0.132	4.375	0.132	1651	150.000	0.342	148	0.396	168	0.347	137	0.224
2011-1Q	0.131	4.353	0.131	1672	150.000	0.343	148	0.389	171	0.351	143	0.221
2011-2Q	0.131	4.396	0.131	1688	154.000	0.345	151	0.388	171	0.356	140	0.222
2011-3Q	0.134	4.482	0.134	1669	152.000	0.360	152	0.394	173	0.367	147	0.216
2011-4Q	0.137	4.570	0.137	1663	154.000	0.359	164	0.391	171	0.365	146	0.217
2012-1Q	0.138	4.428	0.138	1551	155.000	0.355	154	0.389	171	0.360	34	0.603
2012-2Q	0.138	4.401	0.138	1537	150.000	0.356	153	0.383	174	0.362	34	0.602
2012-3Q	0.137	4.384	0.137	1553	150.000	0.350	151	0.389	172	0.363	34	0.602
2012-4Q	0.136	4.372	0.136	1555	154.000	0.346	152	0.387	173	0.361	34	0.602
2013-1Q	0.134	4.268	0.134	1551	153.000	0.339	155	0.377	176	0.363	34	0.602
2013-2Q	0.136	4.355	0.136	1546	153.000	0.332	150	0.398	173	0.358	34	0.603
2013-3Q	0.134	4.289	0.134	1551	153.000	0.335	154	0.385	176	0.362	34	0.603

2013-4Q	0.137	4.148	0.137	1409	171.000	0.321	148	0.380	169	0.365	34	0.604
2014-1Q	0.139	4.218	0.139	1414	176.000	0.321	151	0.385	173	0.377	34	0.604

Source: author's own computation

Using the definition of output, aggregate volatility is the standard deviation. Table 8 shows side by side the competitive data from the different top interconnected countries. Also included is the overall value for the network which sees aggregate risk decrease from 15% to 13% over the period. Although in 2009, a 12% level of risk is recorded. For each country observed there is a correspondent dip in aggregate volatility supporting the general network position with the exception of France where aggregate volatility rises by a huge margin, 0 – 4% but it must be noted that the number of observed banks in that period were reduced and possibly affected aggregate value.1

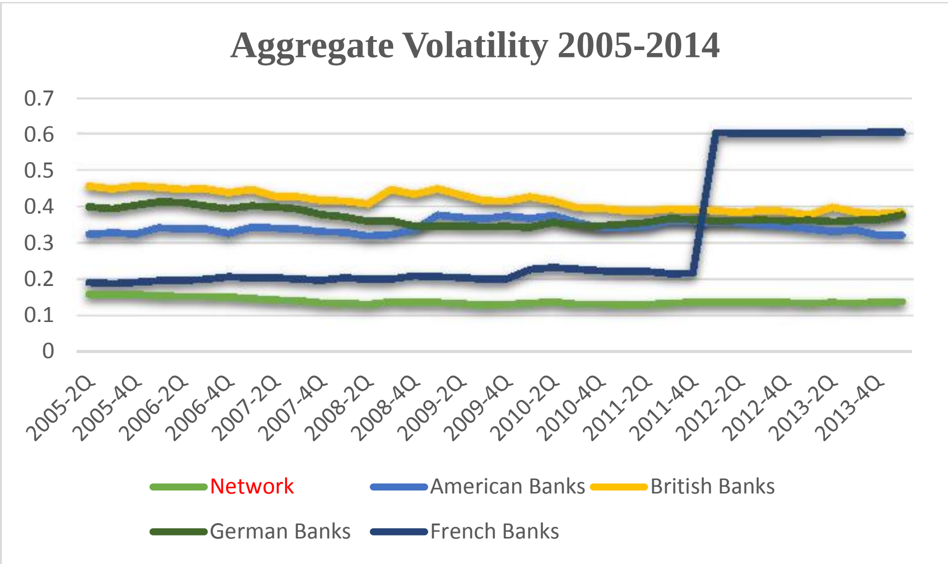


Figure 65: Average Volatility 2005-2014
Source: author's own figure

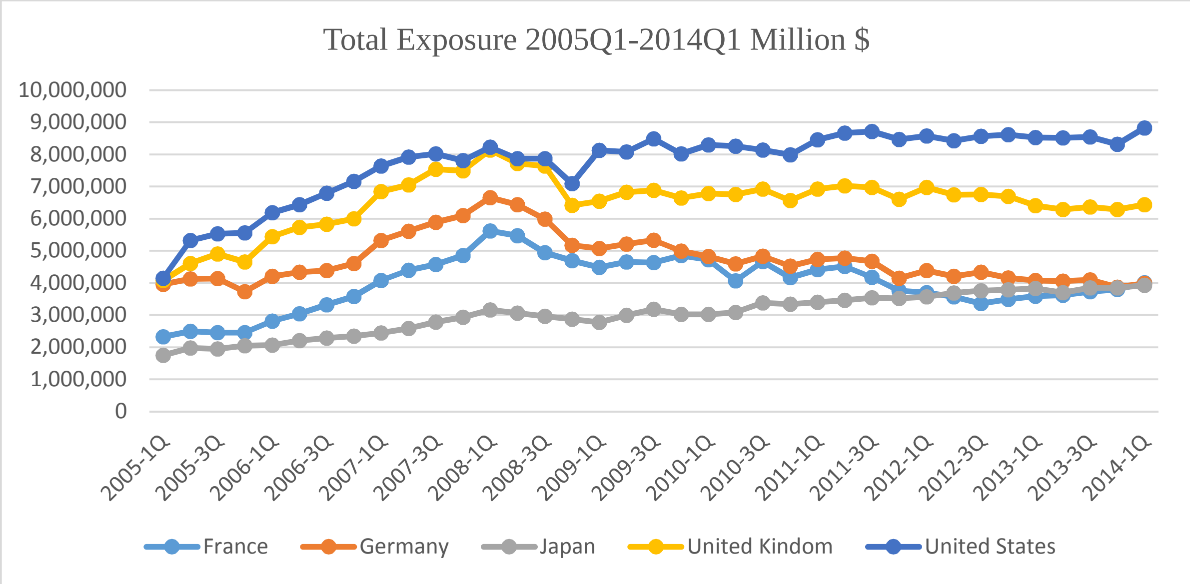


Figure 66: Total exposures of core banks 2005-2014
Source: author's own figure

A similar strong correlation over the duration as seen in Figure 66. Observing the US markets, we see the influence of size, as the leading country it takes a value from $4 - $10 million in exposure. Japanese exposure on the other hand goes from $2 - $4 million. Overall there is an increase over time minus the dip which can be accounted for by the bailout and contingency plans of the recession.

5.4.5 Second-Order Interconnections and Cascades

We discussed the first order interconnectivity in a banking network but, two networks with identical first order interconnectivity might have different systemic risk due to the fact that indirect supply to the rest of the network through chains of downstream sectors could be different. This grading of degree appreciates links and their different tiers. We explained this under the second order interconnectivity part. The second order out-degree of banks' i is defined as the weighted sum of the degrees of banks group that demand input from i with weights given by the input share of i in the total exposures of this banking group.
Do the following networks shown in Figure 67 have the same structure? Although they have identical degree sequences, their structures differ and as a consequence aggregate volatility in the two could be considerably different.

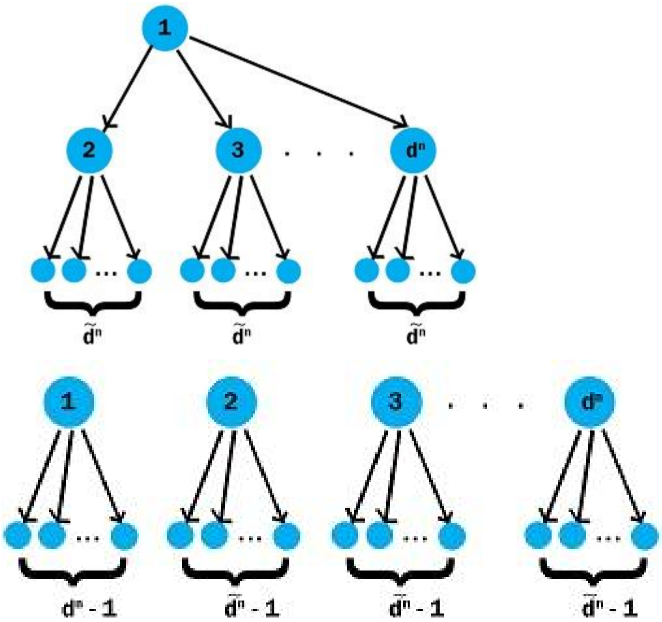


Figure 67 The two structures have identical degree sequences for all values of n. However, depending on the rates of d^n and $\widetilde{d}^n$, aggregate output volatility may exhibit considerably different behaviors for large values of n. (a) $\mathcal{E}_n$: high degree sectors share a common supplier. (b) $\mathcal{E}_n$: high degree sectors do not share a common supplier.
Source: Acemoglu et al. (2012, p.1992).

Acemoglu et al. (2012) argue that two economies with the same degree distribution can have very different structure of connections and very different nature of volatility. These two models in turn have different associated systemic risks, the left exhibits star network properties, in that it has one sector at the middle, which is most vulnerable to causing system-wide failure: if it fails it has negative consequences on the rest of economies as it acts as a parent of every other sector of the economy. In effect we can't get to the distinction of these two networks just by looking at their out-degrees distribution, we need other distinct properties of the network. Acemoglu, et al. (2012) defined the second-order interconnectivity coefficient of economy $\mathcal{E}_n$ as:

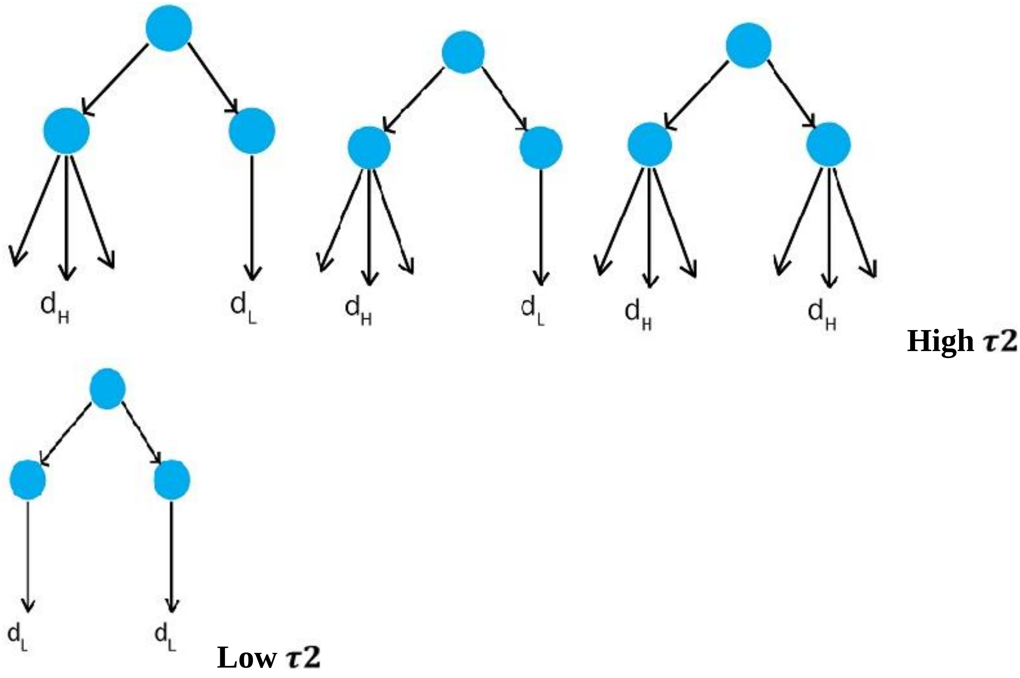
Equation 11:

$$\tau_2(W_n) \equiv \sum_{i=1}^{n} \sum_{j \neq i} \sum_{k \neq i,j} w_{ji}^n \, w_{ki}^n d_j^n d_k^n$$

This value will be higher when higher degree sectors share parents. This coefficient measures the extent to which sectors with high degrees (those that are major suppliers to other sectors) are interconnected to one another through common suppliers.

More specifically, τ_2 takes higher values when high-degree sectors share suppliers with other high-degree sectors, as opposed to low-degree ones.

Figure 68: Degrees



Source: Acemoglu et al. (2012, p. 1992).

In other words, the interpretation is τ_2 is high when important sectors (the sectors have high degrees themselves) have common parents. On the left we have low τ_2 as there are two sectors, they have two children each, and the children have some children themselves. On the right the same number of children (two) but both children themselves have a lots of children. Finally, it is worth stressing that the information captured by τ_2 is fundamentally different from the information encoded in the degree sequence of a network. We have the following result:

Given a sequence of economies $\{\mathcal{E}_n\}_{n \in N}$, aggregate volatility satisfies

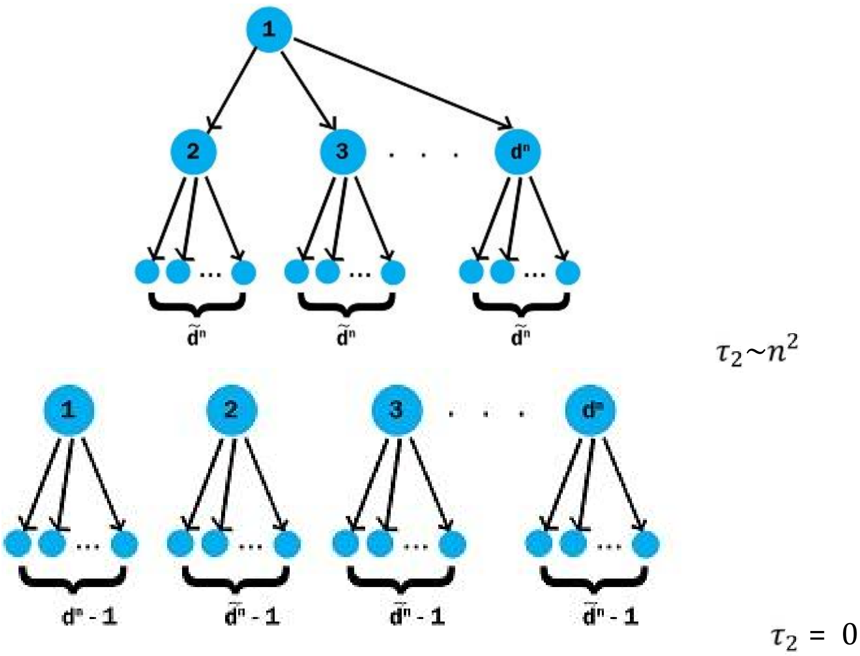
Equation 12:

$$\sigma_{agg} = (var\ y_n)^{1/2} = \boldsymbol{\Omega}\left(\frac{\mathbf{1}}{\sqrt{\boldsymbol{n}}} + \frac{CV_n}{\sqrt{\boldsymbol{n}}} + \frac{\overline{\tau_2(w_n)}}{\boldsymbol{n}}\right).$$

(Acemoglu et al., 2012)

The above theorem shows how second-order interconnections, captured by coefficient τ_2, affects aggregate volatility. It also shows that even if the empirical degree distributions of two sequences of economies are identical for all *n*, aggregate volatilities may exhibit considerably different behaviours. In this sense, Equation 12 is a refinement of Equation 10, taking both first- and second-order relations between different sectors into account. It can also be considered to be the economically more interesting result, as it captures not only the fact that some sectors are "large" suppliers, but also the subtler notion that there is a clustering of significant sectors, caused by the fact that they have common suppliers. Thus, in essence, Theorem 3 captures the possibility of the cascade effects in the economy, as a result of shock.

Figure 69: Sectors for different value τ_2



Source: Acemoglu et al. (2012, p. 1992).

The above both have the same degree sequence, but τ_2 *is different*. On the left hand side, the law of large numbers fail why? If we replace $\tau_2 \sim n^2$ in $\boldsymbol{\Omega}(\frac{\mathbf{1}}{\sqrt{\boldsymbol{n}}} + \frac{CV_n}{\sqrt{\boldsymbol{n}}} + \frac{\sqrt{\tau_2(w_n)}}{\boldsymbol{n}})$**.** It does not go to Zero. The aggregate volatility remains and there is correlated systemic movements in the economy. We can also summarize the effects of second-order interconnection in terms of the tail of the second-order degree sequence of the economy, where the second-order degree of sector *i* is defined as the weighted sum of the degrees of the sectors that use sector *i*'s products as inputs, with weights given by the corresponding input shares, that is,

Equation 13:

$$q_i \equiv \sum_{j=1}^{n} d_i w_{ji}$$

To further explain, say I give each of my children the weight equal to their degree (or connections, using the previously seen model, Figure 69), I am in fact summing over my grandchildren. So rather than looking at my children I am instead looking at my grandchildren and the weighted sum of degrees therefore produces the next level degrees. So the more disperse the distribution of q_i , then the more disperse the distribution of degrees, like more unequal connections in the economy. So we will have a similar equation but we introduce a new variable. Suppose that $\{\mathcal{E}_n\}_{n \in N}$ is a sequence of economies whose second-order degree sequences have power law tails with shape parameter, zeta $\zeta \in (1,2)$ (cf. definition). Then, aggregate volatility satisfies

Equation 14:

$$\sigma_{agg} = (var\ y_n)^{1/2} = \boldsymbol{\Omega}(\boldsymbol{n}^{\frac{-(\zeta-1)}{\zeta} - \delta})$$

for any $\delta > 0$.

Again if $\zeta=2$ we will be back to $\sqrt{\boldsymbol{n}}$ but if ζ is close to 1, we will have lots of aggregate volatility or lots of systemic risk remaining. If both first and second order degrees have power laws then, whichever has thicker tails, that's the dominant one:

Equation 15:

$$\sigma_{agg} = (var\ y_n)^{1/2} = \boldsymbol{\Omega}(\boldsymbol{n}^{\frac{-\zeta-1}{\zeta} - \delta} + \boldsymbol{n}^{\frac{-\zeta-1}{\zeta}})$$

The result of second order interconnectivity is very similar to the first order. There is still strong interconnectivity among a few countries (hubs, see table 9). However, the second order interconnectivity is reduced in 2014 compared to 2007 Q4 (Figure 70). This pattern is seen again with the first order interconnectivity in 2014 for the core countries (UK, Germany, France, US) having 70% of the total network interconnectivity (for more detail of second order interconnectivity measurement see appendix 5).

Table 9 Second order interconnectivity 2005-2014

Banks	Mean	Standard Deviation	aggregated second order interconnectivity
British Banks	0.254013	0.023396	9.398484
German Banks	0.165031	0.063997	6.106134
French Banks	0.140692	0.031981	5.205617
American Banks	0.118366	0.06293	4.379531
Swiss Banks	0.070376	0.036876	2.603915
Spanish Banks	0.062753	0.016273	2.321874
Swedish Banks	0.062575	0.016217	2.315261
Dutch Banks	0.050381	0.023782	1.864081
Italian Banks	0.029084	0.01246	1.076117
Austrian Banks	0.01949	0.004001	0.721139
Belgian Banks	0.01742	0.01378	0.644542
Irish Banks	0.004172	0.00302	0.15438
Greek Banks	0.003576	0.001455	0.132297
Portuguese Banks	0.002071	0.000885	0.076629

Source: author's own computation

Given the second order aggregated connectivity will be similar to the interconnectivity we expect a reduction in aggregate value which is evident but the order is maintained with the country banks.

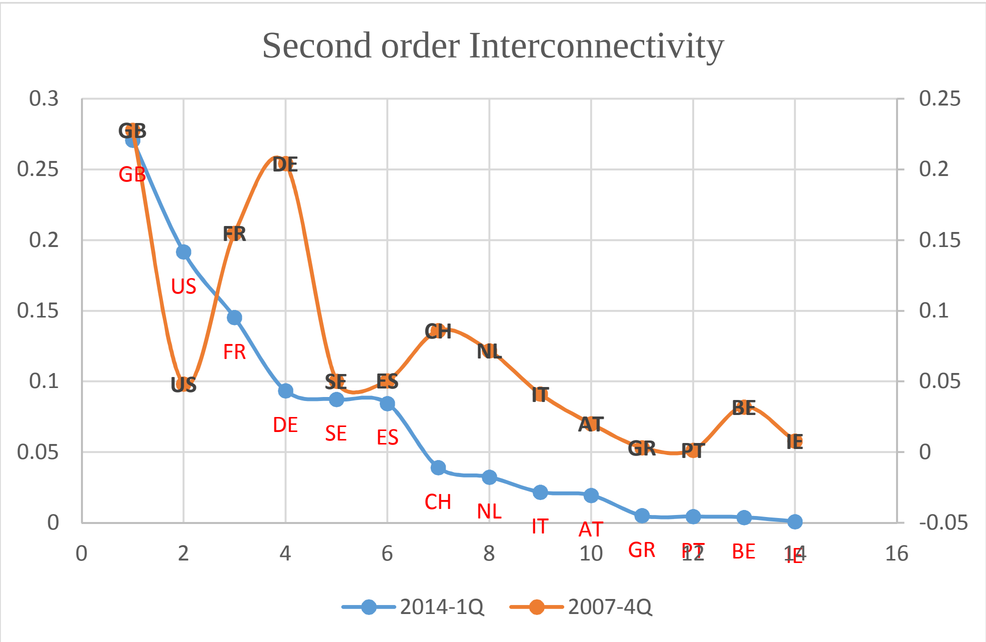
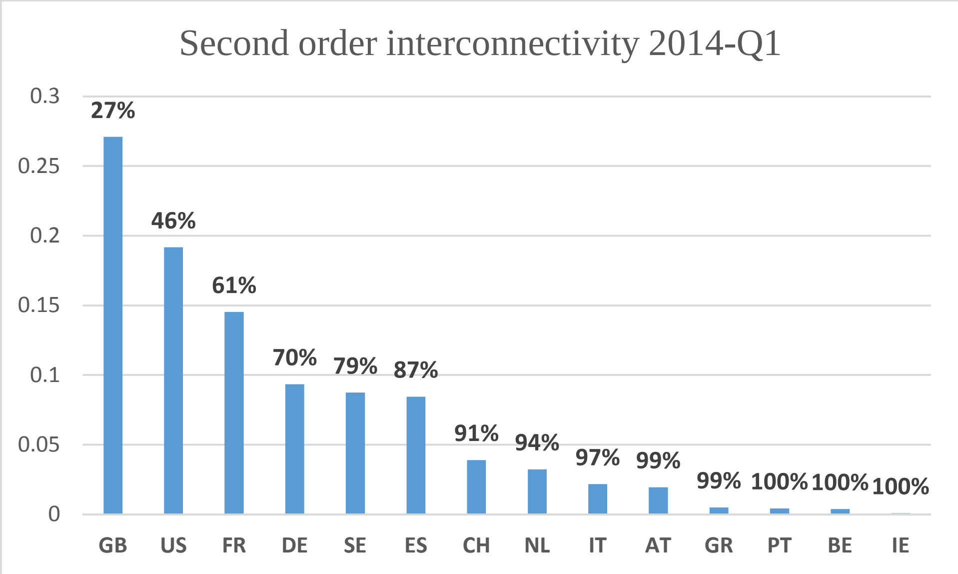


Figure 70: Second Order Interconnectivity Comparison
Source: author's own figure

The values obtained by countries over the period of the crises shows second order interconnectedness has more disparity between 2007 and 2014, which may not have been evident with purely first order levels. Interestingly, there is a recorded increase for all countries here except for the US.



Country	Code
Austria	AT
Australia	AU
Belgium	BE
Canada	CA
Switzerland	CH
Chile	CL
Germany	DE
Spain	ES
Finland	FI
France	FR
United Kingdom	GB
Greece	GR
Ireland	IE
India	IN
Italy	IT
Japan	JP
South Korea	KR
Netherlands	NL
Portugal	PT
Sweden	SE
Turkey	TR
United States	US

Figure 71: Second Order Interconnectivity Aggregated Percentage
Source: author's own figure

Overall, values for second order interconnectivity show a reduction, but the top countries stay on top i.e. UK, US, France and Germany.

Table 10 Ranking of Banks Based on Second Order Interconnectivity 2005-2014 (First is Biggest)

	Austrian Banks	Belgian Banks	Swiss Banks	German Banks	Spanish Banks	French Banks	British Banks	Greek Banks	Irish Banks	Italian Banks	Dutch Banks	Portuguese Banks	Swedish Banks	American Banks
2005-1Q	10	6	10	1	10	4	2	8	10	7	3	9	10	5
2005-2Q	10	9	3	1	7	4	2	12	14	11	5	13	6	8
2005-3Q	10	9	3	1	7	4	2	13	14	11	5	12	6	8

2005-4Q	10	9	3	2	7	4	1	13	14	11	5	12	6	8
2006-1Q	10	9	3	2	6	4	1	14	11	12	5	13	7	8
2006-2Q	10	9	3	2	7	4	1	13	11	12	5	14	6	8
2006-3Q	10	9	3	2	7	4	1	13	11	12	5	14	6	8
2006-4Q	10	9	3	2	7	4	1	13	11	12	5	14	6	8
2007-1Q	11	10	4	2	7	3	1	13	12	9	5	14	8	6
2007-2Q	11	10	4	2	7	3	1	13	12	9	5	14	8	6
2007-3Q	11	10	4	2	7	3	1	13	12	9	5	14	8	6
2007-4Q	11	10	4	2	6	3	1	13	12	9	5	14	7	8
2008-1Q	11	10	4	2	7	3	1	13	12	9	5	14	6	8
2008-2Q	11	10	4	2	7	3	1	13	12	9	5	14	6	8
2008-3Q	11	10	4	2	5	3	1	13	12	9	7	14	6	8
2008-4Q	10	11	4	3	5	2	1	13	12	8	7	14	6	9
2009-1Q	10	11	6	3	5	2	1	13	12	9	8	14	7	4
2009-2Q	10	11	7	3	5	2	1	13	12	9	8	14	6	4
2009-3Q	10	11	7	4	5	3	1	13	12	9	8	14	6	2
2009-4Q	10	12	7	4	5	2	1	13	11	9	8	14	6	3
2010-1Q	10	11	7	4	5	2	1	13	12	9	8	14	6	3
2010-2Q	10	11	7	4	5	3	1	13	12	8	9	14	6	2
2010-3Q	10	11	7	4	5	2	1	13	12	8	9	14	6	3
2010-4Q	10	11	7	4	5	2	1	12	13	8	9	14	6	3
2011-1Q	10	11	7	4	5	2	1	12	13	8	9	14	6	3
2011-2Q	10	11	7	4	5	2	1	12	13	8	9	14	6	3
2011-3Q	10	11	7	4	6	3	1	12	13	8	9	14	5	2
2011-4Q	10	11	7	4	6	3	1	12	14	8	9	13	5	2
2012-1Q	10	12	7	4	6	3	1	11	14	8	9	13	5	2
2012-2Q	10	12	7	4	6	3	1	11	14	8	9	13	5	2
2012-3Q	10	12	7	3	5	4	1	11	14	8	9	13	6	2
2012-4Q	10	12	7	4	6	3	1	11	14	8	9	13	5	2
2013-1Q	10	12	7	4	5	3	1	11	14	8	9	13	6	2
2013-2Q	10	12	7	4	5	3	1	11	14	8	9	13	6	2
2013-3Q	10	12	7	4	5	3	1	11	14	8	9	13	6	2
2013-4Q	10	12	7	4	6	3	1	11	14	8	9	13	5	2
2014-1Q	10	13	7	4	6	3	1	11	14	9	8	12	5	2

Source: author’s own computation.

The values shown in Table 10 stay consistent over the period and in few cases a reduced correlation is noted in general.

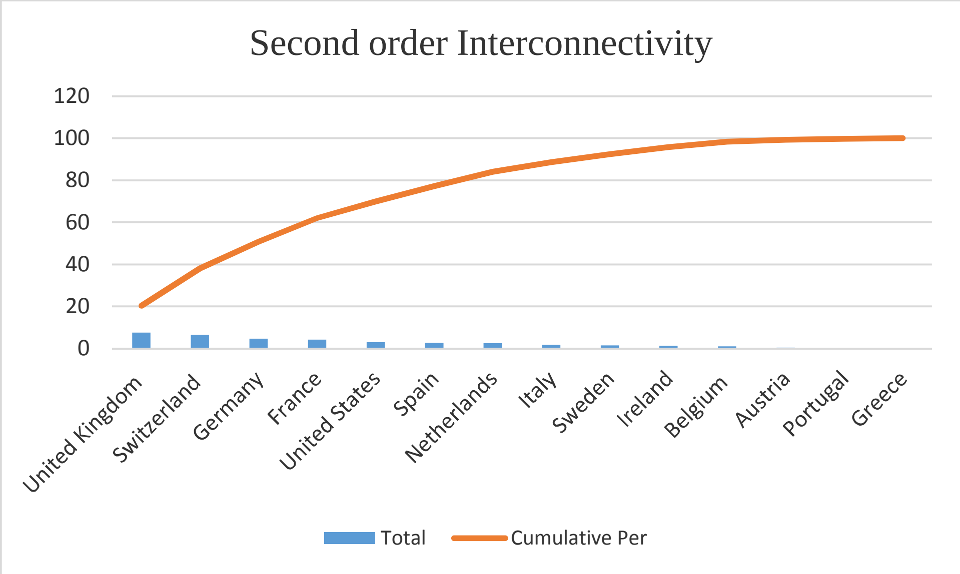


Figure 72: Second Order Interconnectivity Cumulative
Source: author's own figure

When aggregated we find that all the countries maintain the pattern as seen with first order connectivity, as shown above

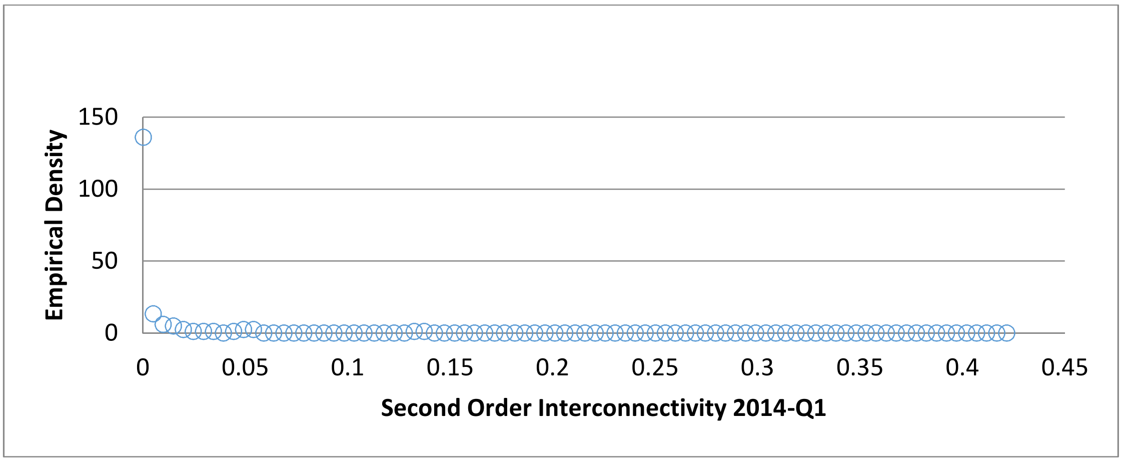


Figure 73: Second Order Interconnectivity Empirical Density
Source: author's own figure

The empirical density of second order interconnectivity is less than half of the first order value, which is intuitive.

Table 11: Systemic risk of the selected network- second order interconnectivity (14 countries)

	Selected Banks as network				American Banks		British Banks		German Banks		French Banks	
	STD Deviation	CVn	aggregate volatility	Observation No	Observation No	aggregate volatility	Observation No	aggregate volatility	Observation No	aggregate volatility	Observation No	aggregate volatility
2005-1Q	0.006	6.687	0.227	1145	132	0.381	173	0.504	173	0.446	176	0.371
2005-2Q	0.004	7.011	0.196	1672	130	0.347	175	0.462	175	0.434	181	0.364
2005-3Q	0.004	6.843	0.191	1678	130	0.348	174	0.444	171	0.419	186	0.352
2005-4Q	0.004	6.633	0.186	1682	130	0.348	175	0.452	169	0.415	183	0.346
2006-1Q	0.004	6.748	0.188	1706	129	0.342	183	0.449	166	0.444	182	0.357
2006-2Q	0.004	6.604	0.183	1720	136	0.336	176	0.442	170	0.444	182	0.359
2006-3Q	0.004	6.615	0.183	1728	135	0.340	178	0.444	171	0.417	184	0.377
2006-4Q	0.004	6.312	0.175	1743	135	0.338	181	0.423	169	0.392	184	0.393
2007-1Q	0.004	6.235	0.174	1727	135	0.338	153	0.442	168	0.414	185	0.383
2007-2Q	0.003	5.934	0.165	1758	142	0.341	158	0.418	169	0.417	186	0.387
2007-3Q	0.003	5.741	0.162	1726	138	0.341	151	0.424	170	0.401	184	0.392
2007-4Q	0.003	5.563	0.157	1755	139	0.335	153	0.419	172	0.383	189	0.406
2008-1Q	0.003	5.645	0.158	1772	148	0.331	155	0.422	171	0.387	188	0.393
2008-2Q	0.003	5.435	0.153	1770	143	0.330	158	0.413	173	0.363	193	0.397
2008-3Q	0.003	6.115	0.169	1766	140	0.332	159	0.477	176	0.363	190	0.403
2008-4Q	0.003	5.782	0.162	1754	136	0.347	158	0.451	173	0.335	191	0.409
2009-1Q	0.003	5.883	0.164	1766	139	0.406	161	0.483	172	0.332	185	0.407
2009-2Q	0.003	5.705	0.160	1766	145	0.400	155	0.460	169	0.334	189	0.413
2009-3Q	0.003	5.511	0.156	1741	140	0.400	150	0.445	167	0.336	189	0.417
2009-4Q	0.003	5.632	0.159	1731	147	0.408	153	0.446	168	0.338	188	0.407
2010-1Q	0.003	5.821	0.166	1691	148	0.400	155	0.464	175	0.336	141	0.427
2010-2Q	0.003	5.812	0.167	1662	145	0.409	156	0.442	169	0.346	132	0.462
2010-3Q	0.003	5.535	0.160	1669	146	0.396	152	0.418	170	0.347	138	0.424
2010-4Q	0.003	5.472	0.159	1651	150	0.384	148	0.418	168	0.349	137	0.418
2011-1Q	0.003	5.426	0.157	1672	150	0.389	148	0.409	171	0.359	143	0.416
2011-2Q	0.003	5.428	0.156	1688	154	0.390	151	0.402	171	0.360	140	0.418
2011-3Q	0.003	5.543	0.160	1669	152	0.405	152	0.410	173	0.369	147	0.414
2011-4Q	0.003	5.639	0.163	1663	154	0.412	164	0.404	171	0.365	146	0.425
2012-1Q	0.004	5.516	0.165	1551	155	0.397	154	0.401	171	0.358	34	0.713
2012-2Q	0.004	5.473	0.165	1537	150	0.403	153	0.392	174	0.361	34	0.716
2012-3Q	0.004	5.525	0.166	1553	150	0.398	151	0.406	172	0.367	34	0.724
2012-4Q	0.004	5.567	0.167	1555	154	0.392	152	0.407	173	0.362	34	0.724
2013-1Q	0.003	5.389	0.162	1551	153	0.386	155	0.395	176	0.371	34	0.717
2013-2Q	0.004	5.553	0.167	1546	153	0.388	150	0.419	173	0.365	34	0.716
2013-3Q	0.003	5.410	0.163	1551	153	0.387	154	0.402	176	0.374	34	0.714
2013-4Q	0.004	5.082	0.162	1409	171	0.370	148	0.390	169	0.371	34	0.702
2014-1Q	0.004	5.113	0.163	1414	176	0.366	151	0.393	173	0.384	34	0.697

Source: author’s own computation.

Table 11 shows values for second order connectivity and systemic risk over the thirteen-year period form 2005 Q1 to 2014 Q1. The trend is towards less risk with initial values at 22% and final at 16%.

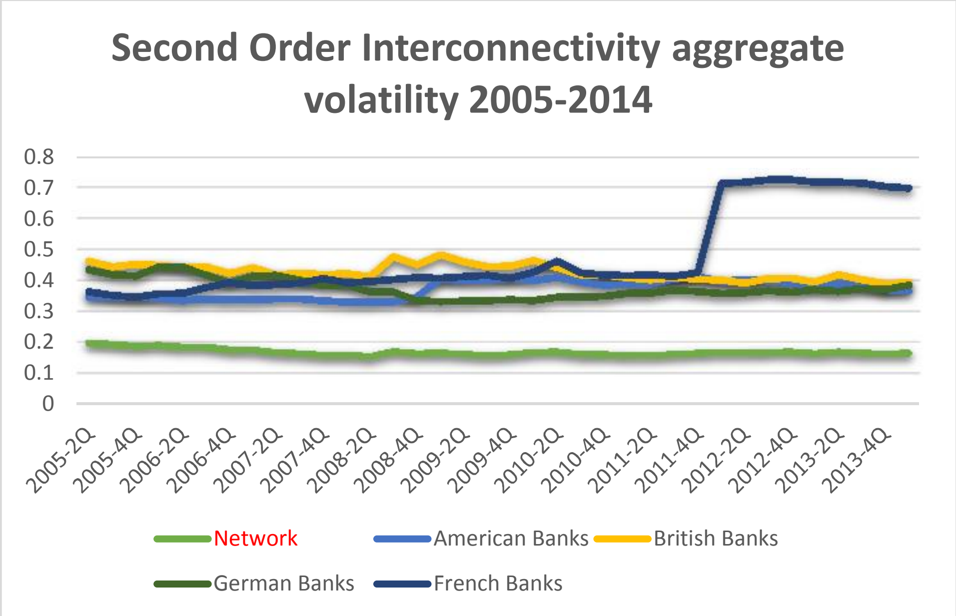


Figure 74: Second Order Interconnectivity Aggregate Volatility 2005-2014
Source: author’s own figure.

Similarly, a trend towards less volatility is recorded for the second order level of connectivity. However, the observations cause France to record an anomaly (jumps from 37% to 69%)

The aggregate volatility in the selected network and the slow rate of decay were explained in relation to first and second order interconnectivity. The shocks to core countries’ banks (British banks, American Banks, German and French Banks) which were disproportionately exposed to a large number of other banks propagate directly to those banks. Higher variation in the degrees of different banking groups could imply lower rates of decay for systemic risk. In line with other studies we showed how lower bounds in terms of the extent of asymmetry across sectors is captured by variations in their degrees. Then we examined distribution of out-degrees of selected banking groups. If the empirical distribution of degrees of the intersectoral network can be approximated by a power law (Pareto distribution) with shape parameter β, then aggregate volatility decays at a rate slower than $n^{(\beta-1)/\beta}$(see Acemoglu et al, 2012).

5.5 Stability of Regional Banking

As we explained the ring network structure is unstable because of the scenario where failure of one unit can result in all failing, as if one bank defaults, all of its obligations go to another, and in complete network the obligation of a firm is distributed broadly so when a firm fails the effect on any other firm is minimal because the obligations of a firm is only a small part of their portfolio. Extend the result starting with any regular network (every bank owes money to every other bank) with unequal distribution of liabilities across banks; if we compress the distribution we will end up with a more stable network. So it is not only comparing ring to complete network, but showing that anything between them has the same result. We've seen how the selected banks' network rely on core banks in a star network model. But what about the complete network model? Is it desirable to have a complete network structure in banking interactions? There are a number of studies which refer to this, the complete network could also be very stable but only for some parameter values. (Acemoglu, et al., 2013) argue that for any $m < n$ (m financial institutions out of n financial institution in network fails) and for $\varepsilon < \bar{\varepsilon}(m)$, where ε is the estimated shock which banks in the network are susceptible to. The complete network is the most resilient and stable financial network. But if $\varepsilon > \bar{\varepsilon}(m)$ there is a phase transition, and the complete network becomes the least stable. We could say in the case where $\varepsilon > \bar{\varepsilon}(m)$, weakly connected structure in banks will be more stable.

This structure is similar to old style unit banking or regional banking (the banks have links to the other regional banks but the link to the rest of economy is weak). Why is a regional banking structure more stable in a banking network? As we illustrated and explained the complete network is stable when the shock is small and the network can absorb it by distributing the shocks widely, but when the shocks are large this process of absorbing the shocks does not work. So a complete network transmitting the shocks to the rest of economy (as all units are related together) but a weakly connected structure such as regional banks structure, keeps the shocks where they originated, so if the banks in region A fails, this shock wouldn't be transmitted to other regions. (Figure 75)

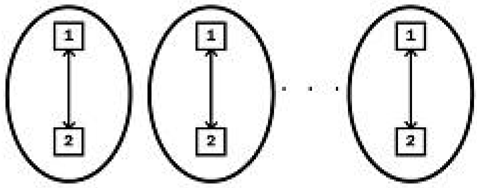


Figure 75: Regional Banks structure
Source: author's own figure

However, and as Erol and Vohra (2014) argue, the structure of the network formed depends crucially on whether the shocks to the system are believed to be correlated or independent of each other. This underlines the importance of specifying the shock structure before investigating a given network, as a particular network and shock structure could be incompatible. At the country level increasing cross-border financial linkages may lead to reducing exposure to local originated shocks (diversification effect). However increased interconnectedness, by facilitating shocks transmission internationally, makes financial networks more prone to systemic risk accordingly. Enhancing the structural complexity of cross border financial linkages makes specific exposure's trace more difficult and this leads to systemic amplification effects from panic responses to shocks, due to less certain information. In summary, increasing cross-border financial linkages with the purpose of diversification and reducing risks might lead to systemic instability in said networks. The main idea here is that network properties really matters, networks are not just externalities, understanding network structure is crucial, however the nature of interactions over the network and types of the shocks could have effect on stability or fragility.

5.6 Impact on Regulation and Rating Agencies

Traditional banking supervision relies mostly on the analysis of single institutions. The idea behind this approach and the regulatory framework which is focused on individual bank balance sheets is, that there is little insolvency risk in the banking system as long as the default of individual banks is low. Before the financial crisis 2007/8 while individual institutions were encouraged by regulators to take a portfolio perspective on their internal financial operations, regulators had not implemented this portfolio perspective at the level of the banking system. In majority of cases regulators didn't see the banks under their jurisdiction as a portfolio, they didn't consider correlations between them, and the ideas and tools of modern risk management have not found their way into prudential banking supervision.

A network approach could be implemented into a regulatory approach, with the network approach; and the regulator could create broader rather than detailed and simple rules. The regulator could broadly monitor the structure of the network, changing the network properties, also follow the interactions over the network and the impact of shocks. They will find out easier the moment the shock absorber transforms into a shock amplifier. Our analysis shows that banks located in the countries with shallow domestic financial markets are more prone to synchronized shifts in cross-border flows to diversify their risks. These banks could increase their cross border exposures to the banks with higher individual ranking to reduce their overall risks. However, increasing the interconnectedness to the individual banks (financial institutions) with higher ratings increases the network systemic risk itself. These common factors such as global risk aversion and diversifying risks by exposing to higher rated individual firms or assets, increasingly drive global financial markets and tend to intensify abruptly during periods of stress, amplifying shock transmission. These features not only increase the systemic risk within the network but also potentially increase the costs of systemic shocks to countries with relatively strong fundamentals for which the likelihood of an idiosyncratic crisis is normally low. As Erol and Vohra (2014) argue, fundamentally 'safer' economies generate much higher interconnectedness, which in turn leads to higher systemic risk. One of the suggestions based on our analysis is that the rating agencies should take into account embedded interconnected systemic risk through network approach in rating the firms or sovereign. In other words the correlation of fundamentally 'safer' economies and higher systemic risk should be incorporated in rating the fundamentally 'safer' economies. More connection or less connection within the network structure and economic interactions could have impact on firm or sovereign ratings. The banks' risk management approach to diversify away from riskier counterparties could connect them in more connected nodes in the network (with better credit rating) and increase the systemic risk consequently.

5.7 Conclusion

This chapter explains how financial system structures may exacerbate contagion during a crisis. It highlights that ignoring the structure can lead to an underestimation of the extent of contagion in the network. It shows the subtle differences that occur as a result of the kind of relationships - or interconnectedness – between banks will be key in determining the associated systemic risk. Then on the other hand, the duration of the shock and its potency will also be important factors to consider for each network model. To measure adequately the systemic impact of the failure of the entire financial system, one needs to account for the combined effect of correlation of market shocks, the structure of financial system and financial transactions over the network; recognising that the structure may increase the impact of the shock.

This chapter also shows that the topology of selected network being studied is star and the core sectors are: German Banks, British Banks, French Banks, and American Banks. Within the network we have an inequality of out-degrees and as a result during a financial crisis, when the middle of the network (German Banks, British Banks, French Banks or American Banks) is hit, the entire network suffers significantly. Although most of the time, the network is robust as most shocks experienced lower than a threshold level could be absorbed in the structure. In contrast, the network becomes very fragile when the specific shock over the threshold level hits the middle of the structure.

We illustrated how idiosyncratic shocks could be filtered by the network structure. It verifies the finding of other studies, in particular those studies indicated the same result for the whole economy structure (see Burlon, 2012). Burlon (op. cit.) addressed in his study that aggregate fluctuations depend on the geometry and magnitude of cross-effects across establishments, measured by the eigenvalues and eigenvectors of the representative network matrix. Moreover, the equilibrium levels and their dispersion depend on the Bonacich centrality of establishments within the network structure of the economy. Different network structures entail different aggregate volatilities due to the fact that the presence of direct relations averages out the idiosyncrasies across establishments.

In line with the findings of Acemoglu et al. (2013) we have explained that financial contagion exhibits a form of phase transition as interbank connections increase: as long as the magnitude and the number of negative shocks affecting financial institutions are sufficiently small, more ‘complete’ interbank claims enhance the stability of the system. However, beyond a certain point, such interconnections start to serve as a mechanism for propagation of shocks and lead to a more fragile financial system. Then we saw that the rate of decay or to put it simply, how quickly a system collapses, is dependent upon the aggregate volatility which we derived from looking at the order of interconnectivity. Two seemingly similar networks will react differently to aggravation simply because of this. Such that if the nodes in a network had identical parents then the parental decomposition will affect the children. Hence the shocks to core countries' banks in our sample that were disproportionately exposed to a large number of other banks (or shared similar 'parents' received contagion from those banks. On the reverse, a higher variation in the degrees of different banking groups could imply lower rates of decay when studying systemic risk. In fact, this was illustrated through the relative lower/non-existent spread of contagion seen with regional banks. Various networks such as star, ring and scale-free (displaying the power law) network structures have differing stability variables. The ring network for example was shown to be very unstable because each node fed into the next and therefore any scenarios that modelled failure to one node collapsed the entire system. Whereas, in a weakly connected network as seen with regional banks which model a robust network based on the complete network model but only within specific parameters (outside of these parameters, it also displays a level of instability).

This chapter highlights how the monitoring system should have a more comprehensive approach on not just the structure of the network in the financial market but also the nature of transactions over the network, and recommends taking into account the types of shocks as an important variable. The chapter concludes that rating agencies for example, should take into account embedded interconnected systemic risk through network approach in rating the firms or sovereign. The chapter suggests that regulators with limited resources should concentrate their efforts not on the largest banks in the network but on the most connected ones in terms of significant linkages (in line with Beyeler et al., 2007).

Chapter 6: Structural Vulnerability of the Banking Network – A Systemic Risk Approach

6.1 Introduction

In this chapter we analyse the structural vulnerability of the banking system with network approach. The aim of the chapter is to explain to what extent were EU banks exposed to systemic risk at a country level during and after the financial crisis of 2007/8? In tune with our exposition thus far, that the complexity of interconnectedness in the financial system and by consequence the real economy must be in consideration when relating to the networks that are affected. That we need an approach which, stresses the systemic complexity of economic networks and that can be used to revise and extend established paradigms in economic theory. To this end, we proposed a set of ratios that aim to assess possible vulnerabilities at the country level. In order to capture bilateral relationships, we described the data in a network context. The network perspective helps to develop an overview of mutual interlinkages and to uncover less obvious interdependencies. Furthermore, it has become clear that, proactively tracking potential systemic linkages is very crucial for regulators and policymakers worldwide. Tracking potential systemic linkages and interconnectedness highlighted the role of network analysis. There are some studies which aid in this challenge (See (Allen and Babus, 2007)). Allen and Babus' (2007) study allows regulators and policymakers to assess externalities to the rest of the financial system, by tracking the rounds of spillovers likely to arise from direct financial linkages. (Allen and Babus, 2007). However, effective financial system surveillance requires the monitoring of direct and indirect financial linkages, whose disruption could have important implications for the stability of the entire financial system. Indeed, the financial crisis 20078 has underscored the need to go beyond the analysis of individual institutions' soundness and assess whether the linkages across institutions may have systemic implications. Due to financial interconnections, the actions geared to enhance the soundness of an individual institutions may undermine the stability of other institutions. Therefore policy makers and regulators have become aware of the importance of proactively tracking potential systemic linkages.

6.2 systemic risk through cross border exposure

, Haldane (2009), among others, has shown that the interconnectedness of the financial market potentially increases the probability of contagion of financial distress across the network. The interconnectedness of financial institutions as a major agent of systemic risk has been highlighted repeatedly in the study thus far. Some of the research before the financial crisis 2007/8 and after that shows that one of the main concern of network models are these externalities resulting from counterparty risk, significant amount of these researches have provided a framework for addressing this concern. The role of cross-border capital outflows that can ultimately affect credit, diversify risk or transmit shocks to the domestic economy, with adverse consequences for the financial sector and the real economy. Data which suggests that, on average, countries which are net importers of capital prior to a recession experience a sharper decline in their stock of money than those that were net exporters of capital. Secondly, the prevalence of cross-border finance and the impact on domestic credit especially in our sample banks, shows that this can exceed over and above that implied by domestic monetary conditions. We will see how this particular scenario was the case with most banks. Our methodology applies a measure called the Herfindahl Index. This value is mostly used for determining level of concentration and was initially used for checking monopolisation where it is in breach of the law, against market shares for businesses. Then we check how much of the banking activity is dependent on cross-border activity for these banks. Using matrices to represent the vulnerabilities of banks with respect to their foreign lending (see (Gai and Kapadia 2010), (Nier, et al. 2007) and regulators (Hellwig 1995) and Haldane (2009). For the purpose of assessing contagion risk in banking system studies based on network models have been used mainly in two categories of financial networks (see (Allen and Gale, 2000), (Freixas, Parigi and Rochet, 2000), (Gai, Haldane and Kapadia, 2011), (Caballero and Simsek 2013), (Alvarez and Barlevy, 2014), (Elliott, et al., , 2014) or input-out network (See Jovanovic(1987), (Long and Plosser 1983), Durlauf (1993), (Acemoglu, et al., 2013), (Bigio and LaO, 2013))

Network models studies have been used by central banks and regulators to measure contagion risk in banking system, the pioneering works of (Elsinger, Lehar and Summer, 2006) and Upper (2011) are solid examples of this approach. There are number of studies who apply network analysis to the Bank for International Settlements (BIS) consolidated banking statistics with the same approach of this research ((McGuire and Tarashev, 2008) (Rönnqvist and Sarlin, 2014) (McGuire and Tarashev ,

2006) , (Hattori and Suda, 2007) , (Espinosa-Vega and Solé , 2010) Okuma, (2012) as well as to a report published by Deutsche Bank Research (Weistroffer and Möbert,2010) or another report which was published by Fitch Rating (Murray and Rawcliffe , 2010) . By contrast, von (2010) looks at the BIS locational banking statistics to identify important banking centers and (Castrén and Kavonius, 2009), in turn, use the euro area flow of funds data to identify sectors and channels through which local shocks may propagate through the financial system cross-border. Identifying systemic risks using disaggregated data including maturity and currency mismatches, banks' asset &liabilities were used by central banks and regulators. In this study for identifying sectorial interlinkages, we recompile the aggregate bilateral cross-border exposures into the interlinkage of selected countries' banks. The aggregate cross-border exposures, published by BIS, is statistics that record consolidated banking individual data and banking transactions and resulting claim held by each countries banks

6.3 Systemic risk and vulnerability of banking sector

The current financial crisis reveals new dimensions of the concept of systemic risk in banking. This crisis has shown how interconnected the financial world has become and showed how a shock coming from a region can propagate very quickly, with an impact on financial stability around the world. History has shown once again the fragility of the banking sector. Compared to other sectors banking financial contagion spreads faster and negative externalities have much stronger effects. One of the most feared events in banking is the alarm of systemic risk.

Identifying systemic risk using disaggregated data is the approach often taken at central banks and supervisory agencies. These disaggregated data include information on the composition of banks' assets and liabilities, maturity and currency mismatches, and other balance sheet and income metrics. These analyses attempt to capture systemic risks stemming from common exposures, interbank linkages, funding concentrations, and other factors that may have a bearing on income, liquidity and capital adequacy conditions. (Examples of such quantitative approaches are (Gabrieli, Salakhova and Guillaume, 2014) or (Boss, et al., 2006) (Alessandri, et al. 2009) for Austria and the UK, respectively.

There are number of studies, which show that the systemic risk in the banking sector is significantly larger than in all other sectors of the economy. (See (Bühler and Prokopczuk 2010), (Laeven, Ratnovski and Tong, ,2014). (Bühler and Prokopczuk,

2010) in their article "Systemic risk; is the banking sector special?" empirically investigate the degree of systemic risk versus other industry sectors. In their study they compare the degree of systemic risk in the banking sector with other sectors in the economy and investigate the systemic risk during the financial crisis 2007-8. The study shows that systemic risk in the banking sector is significantly larger than in all other sectors of the economy. Moreover, the degree of systemic risk for the banking sector is higher under adverse market conditions. Finally, they document a substantial increase of systemic risk during the financial crisis.

6.4 Data

In order to quantify systemic risk, data on the total assets of banks at country level, the GDP of the countries, total banking system exposure to the rest of the world, Herfindahl indices were analysed from 2005 till the end of March 2014 on a quarterly basis. We implement the empirical study through the quarterly data of consolidated exposures from the Bank for International Settlements (BIS) and value for GDP among selected countries (from OECD statistics, The OECD National Accounts Statistics database includes annual and quarterly data of a wide range of areas from 1955, such as gross domestic product)[34]. To explore an analytical tool, the selected countries banks' exposures were analysed in light of the countries' total banks' assets (mainly from the European Central Bank, and Federal Reserve Economic data) and the total exposure and the country's GDP, also collated on a quarterly basis. (See Appendix 3)

6.5 Analysing Models

In network modelling the relationship between j banks and i banks could be shown in directed weighted graph.

[34] OECD iLibrary is the online library of the Organisation for Economic Cooperation and Development (OECD) featuring its books, papers and statistics and is the gateway to OECD's analysis and data. It replaced Source OECD in July 2010. OECD iLibrary also contains content published by the International Energy Agency (IEA), the Nuclear Energy Agency (NEA), the OECD Development Centre, PISA (Programme for International Student Assessment), and the International Transport Forum (ITF). Available at http://www.oecd-ilibrary.org/

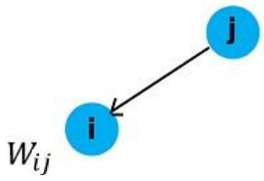


Figure 76: Weighted Graph
Source: author's own figure

There is a link between i and j, which means j is exposed to i but not necessarily in the opposite direction. Also this is a weighted link meaning there is an important (or not important) link between i and j.

6.5.1 Vulnerability measures at country-level (country level)

The risk of looking at the data in an absolute manner to evaluate the structural vulnerabilities of banks in global comparison could be mitigated with considering the relative terms of data to have a more comprehensive picture. In order to assess the structural vulnerabilities of banks in an international comparison it makes sense to look at the data not only in absolute, but also in relative terms. At the country level, we deem essential at least three ratios;

1. The potential impact of the banking sector problems on economic activity is measured by the 'relative size of the banking sector', i.e. the size of the banking industry relative to GDP. The greater the size of the banking sector relative to GDP, the more severely banking sector problems would affect economic activity or – in case banks need to be supported by the government – could increase public debt.
2. Overall exposure of banks to foreign borrowers – the 'foreign lending ratio' is another metric. This metric captures the vulnerability of the national banking sector to cross-country spill-over effects. It is calculated by taking foreign exposure over total bank assets (i.e. domestic and foreign exposure). A large ratio implies that write-downs on the foreign exposure may have a substantial impact on the stability of the national banking system.
3. The third metric is the 'borrower concentration ratio', i.e. the diversification of banks' foreign exposure across other countries. To this end, we apply the

Herfindahl Index – usually a common market concentration measure – to measure concentration of a country's top ten borrowers. This ratio is relevant for the analysis of banks' vulnerability to first-round contagion effects. For a banking sector that is highly exposed to a single or very few other countries, contagion risk may be stronger than for a country that is well diversified in its foreign lending exposure.

4. To calculate the fourth metric 'Concentration Index', we apply the Herfindalh index to measure GDP share for the financial institutions in country $\boldsymbol{i}$ plus the size of banks' sector in country $\boldsymbol{i}$.

Equation 16:

$$\text{Relative size of banking sector} = \boldsymbol{S_b} = \frac{\textit{size of banks sector in country i}}{\textit{size of the economy of country i}}$$

Equation 17:

$$\text{Foreign lending ratio} = \boldsymbol{L_r} = \frac{\textit{total foreign exposures of banks sector in country i}}{\textit{size of banks sector in coutnry i}}$$

Equation 18:

$$\text{Borrower concentration ratio} = \boldsymbol{C_r} = \sum_{i=1}^{n} \left(\frac{X_i}{X}\right)^2$$

Where:

$$n = \textit{total number of countries which country } i\textit{'s banks are exposed to}$$
$$X_i = \textit{total exposure of country } i\textit{'s banks}$$
$X = \sum_{i=1}^{n} X_i$=*total exposures of country i's banks to all other countries*

Equation 19:

$$\textbf{Concentration Index} = \textbf{Total banks assets of country } \boldsymbol{i} + \boldsymbol{HI} * \textbf{GDP of country } \boldsymbol{i}$$

The HI is Herfindahl Index –usually a common market concentration- which is obtained by summing the squares of the market shares of all the *credit institutions,* CIs in the banking sector of each country and calculated with the following formula:

$$HI = \sum_{i=1}^{n} (\frac{X_i}{X})^2$$

Where:

$$n = \ total\ number\ of\ credit\ institutions\ in\ the\ country$$
$$X_i = \ total\ assets\ of\ CI_i$$
$X = \ \sum_{i=1}^{n} X_i$=total assets of all $CI_s\ of\ the\ coutnry$

6.6 Structural Vulnerability

Modern financial systems and the banking network covers a large number of institutions, markets and agents and is exposed to a variety of potential sources of vulnerability (Johnston, Chai and Schumacher, 2000):

1. A first type of vulnerability is associated with the non-diversified risks on and off the balance sheets of individual institutions.
2. A second type of vulnerability concerns the vulnerability of the financial system as a whole- systemic vulnerability.
3. A financial system can be considered vulnerable to crisis where it is not readily able to absorb shock.

An assessment of potential vulnerabilities in the banking network requires an examination of a range of factors including the balance sheet position, the degree of development of the banking network where risks can be managed, and types of incentive structures. See (Johnston, Chai and Schumacher, 2000), who highlight taking account of incentive structures in a systematic way as already approached in the investigative science field. In our developed model we shed light on relative size of banking sector, traditional hubs of banking network and their changes over time, foreign lending ratio of banks, borrower concentration ratio, economic exposure to cross-border lending and country's position, in-degree concentration index, Herfindahl Index and exposure concentration index.

The importance of the banking industry in the whole economy is reflected in the relative size of a banking sector (see Figures 78, 80 and 82). There are a few traditional hubs such as Swiss Banks and British Banks at the top of the list but also Irish banks- where the financial sector is fairly new and grew strongly between the 1990s and 2008- take the fourth position in 2014 reducing the relative size since 2006 where they had the first position. The interesting point is that the US which hosts the most important financial hub worldwide is at the bottom of the list before and after the financial crisis in 2006, 2007 and 2014 due to its large economic capacity and its market-based financial system in which bank financing assumes a smaller role. The foreign lending ratio shows how much the banking sector of a particular country depends on cross-border activities (see Figure 77, 79 and 81). 2014 Figures indicate 40% of Swiss banks activities depends on cross border transaction followed by Dutch and Swedish Banks with 33%. The combination structure of a limited house market, trade openness and competitiveness in national banks in particular seems to result in a high ratio for cross-border interaction. Geographical proximity and cultural distance to other major countries or regions play an important role, too. For instance, Canada's exposures vis-à-vis the US increased to 36% in 2014 from 30% in 2007 Q4. (See Figure 88 and 89).

In Switzerland it is mainly the two large banks (UBS AG and Credit Suisse AG) with international investment banking operations that are responsible for relatively high foreign exposures. All this is reflected in the ranking according to the foreign lending ratio, led by Swiss, Dutch and Swedish and French banks, with ratios between 29% and 40% (see Figure 79). The list is followed by the largest European countries France, Spain, Germany and UK. Finally, Italian, Irish and Greek Banks are ranked as the lowest according to this measure. The borrower concentration ratio identifies those countries that have concentrated their foreign lending activities on specific regions or countries – often their neighbouring countries (see Figure 83 and 84). At the top of the list of 2014-Q1, are Ireland and Canada, of which Ireland is exposed primarily to the UK in over 80% of its total foreign exposure and followed by Canada which is exposed primarily to the US in over 72% of its total foreign exposure, Swiss banks at the next level are exposed to US primarily as well with over 48% of their foreign exposure. The list is followed by Australia which lends heavily to New Zealand (over 40% of its foreign lending) and Japanese Banks which are exposed heavily to the US (over 40% of their foreign lending). To illustrate the countries which are more vulnerable in more than one measure, we display the ratios in a matrix combining the size of the banking sector with foreign lending ratio for 2014- Q1, and compare this with the financial crisis time 2007- Q4. (See Figures 85 and 86). The figure for 2014 identifies Switzerland, Sweden and Netherlands as having relatively high exposure & high foreign lending ratio (Figure 85) and Belgium improved in this regard since 2007 (Figure 86).

Meanwhile the status of Ireland which was an outlier due to the relative size of its banking sector in 2007, was then improved in 2014. Looking at the development of these ratios over time can be helpful in tracing the vulnerabilities and identify the hotspots in any period. The in-degree concentration index in 2014 display very important insight as USA, UK and Germany together, hold over 70% of the network exposures. (Figure 88). The result of comparing the in-degree concentration index with 2007-Q4, (Figure 89) shows the same group having over 70% of the network exposure, however, the UK gets a more important role. For the purpose of better illustration for the first three countries (US, UK and Germany) detailed in-degree concentration index was shown for 2014-Q1 compared to 2007-Q4, the financial crisis period (Figures 87,88,89,91,92,93 and 94). Figures 88 and 89 show that in 2014-Q1, 36% of American Banks' foreign exposures coming from Canadian Banks. Or rather, Canadian banks' exposure increased since 2007 and they were heavily exposed to American banks. In the case of British Banks, the case is even worse, 68% of British banks foreign exposures come from Irish Banks. Irish Banks increased this ratio from 29% in 2007-Q4 to 68% to stay heavily exposed to British Banks. (Figures 91, 92). German Banks in-degree concentration index indicates Italian Banks share increased from 40% in 2007-Q4 to 57% 2014-Q1. (Figures 93, 94).

Comparing the shares of the 5 largest credit institutions in total assets between end of 2013 and end of 2007 shows that in big EU countries banks got bigger over that period. The ratio is increased for Italy from 33 to 40, for the UK from 41 to 44, for Germany from 22 to 31, for Spain from 41 to 56, and for France from 52 to 46 (Figure 95 and 96).

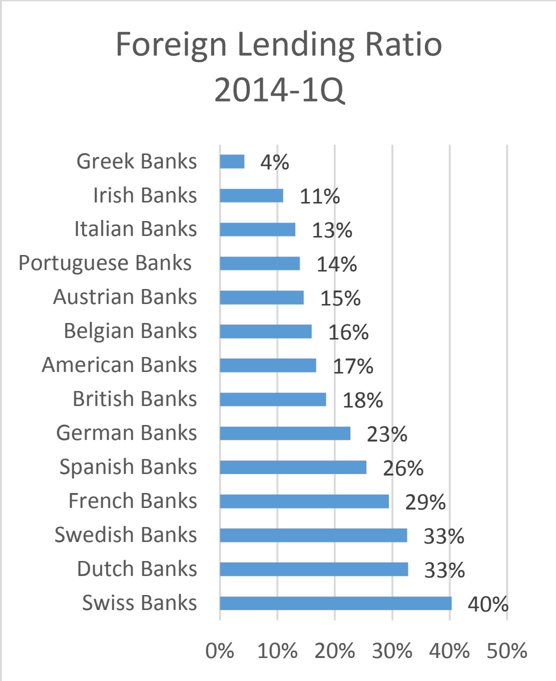


Figure 77: Foreign Lending Ratio 2014

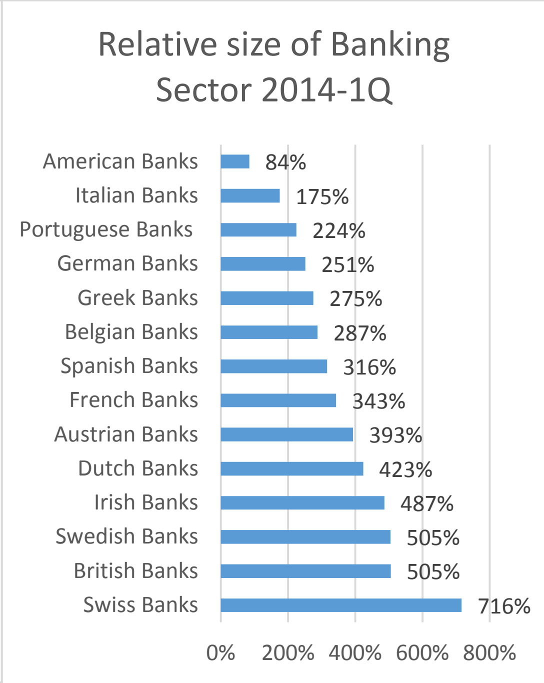
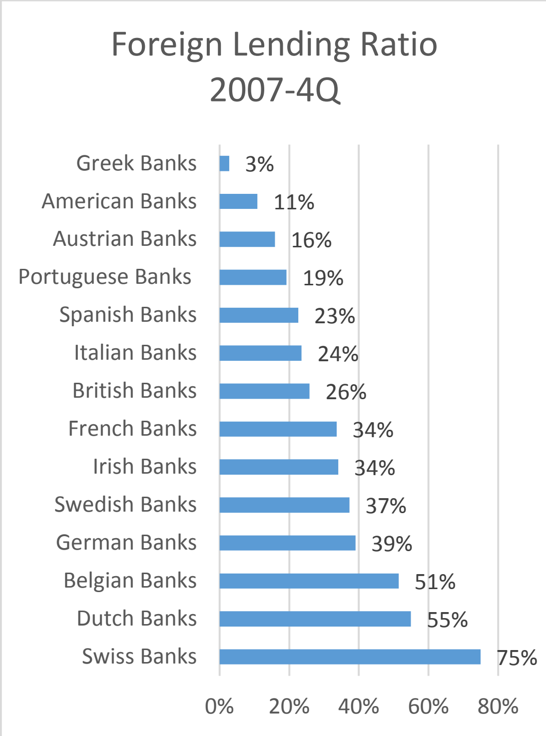


Figure 78 Relative size of banking sector 2014

Source: author's own figure

Figure 77 is an indication of which banks lend to foreign entities the most and the Swiss banks lead with a 40% lending ratio. While on the other hand, Greek banks are rated the lowest for their 4% ratio, in the post-crisis era Q1 2014.

While Figure 78 illustrates the banks which dwarf their domestic economies the most. The period in which this is displayed is similar to Figure 81 and one can see the similarities between a high *foreign lending ratio* and the relative size of the banking sector, compared to the domestic economy. Swiss banks offer a case in point with a GDP of 716%.



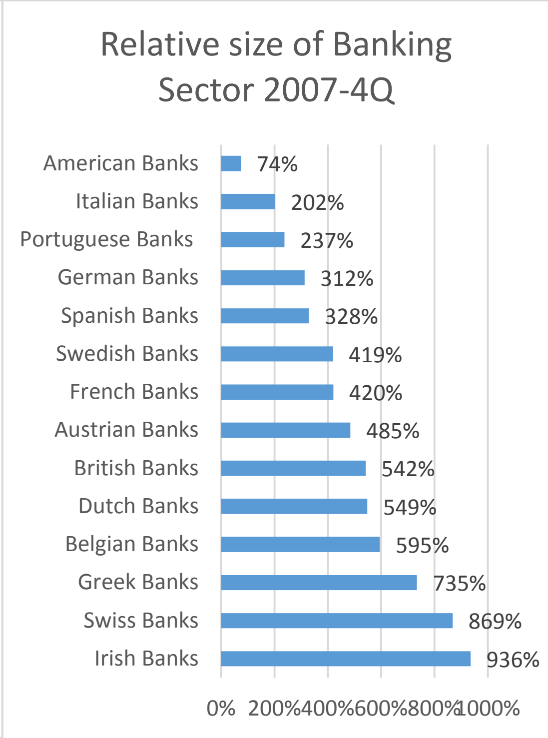
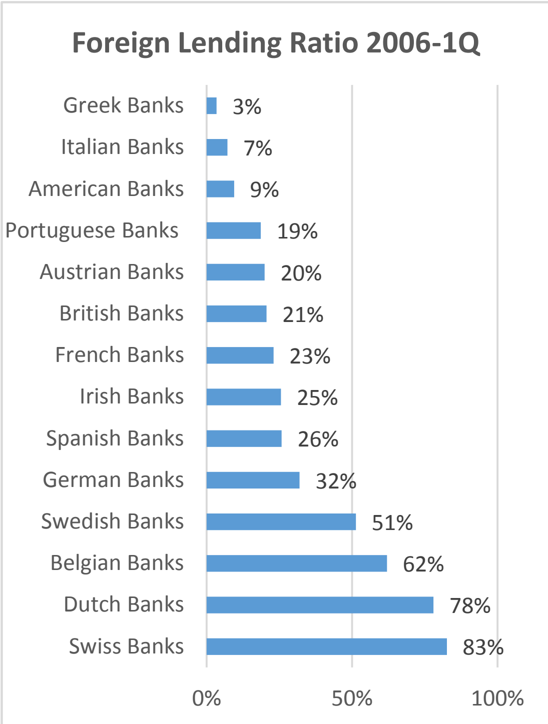


Figure 79: Foreign Lending Ratio 2007 **Figure 80: Relative size of banking sector 2007**

Source: author's own figure

In a similar vein, Figures 79 and 80 shows the overall reduction in these indicators post-crisis. The Q1 2007 value for British banks recorded at 26% for foreign lending ratio and 542% for banking sector relative size is reduced to 18% and 505% respectively.



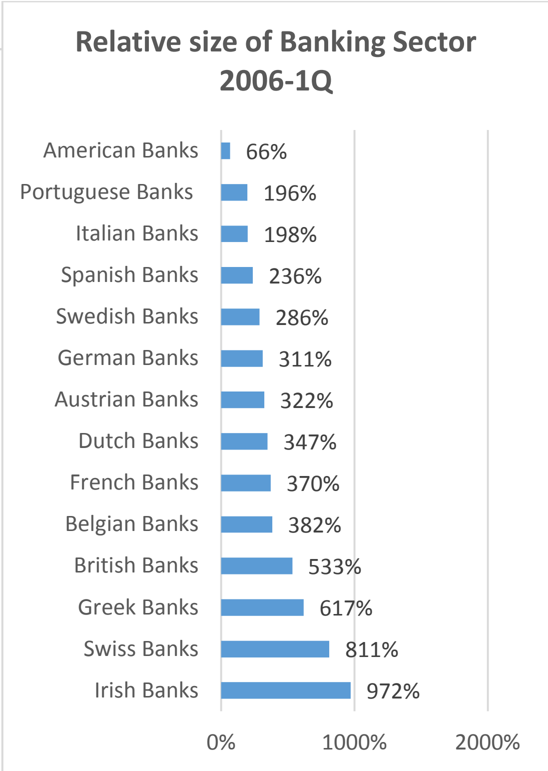
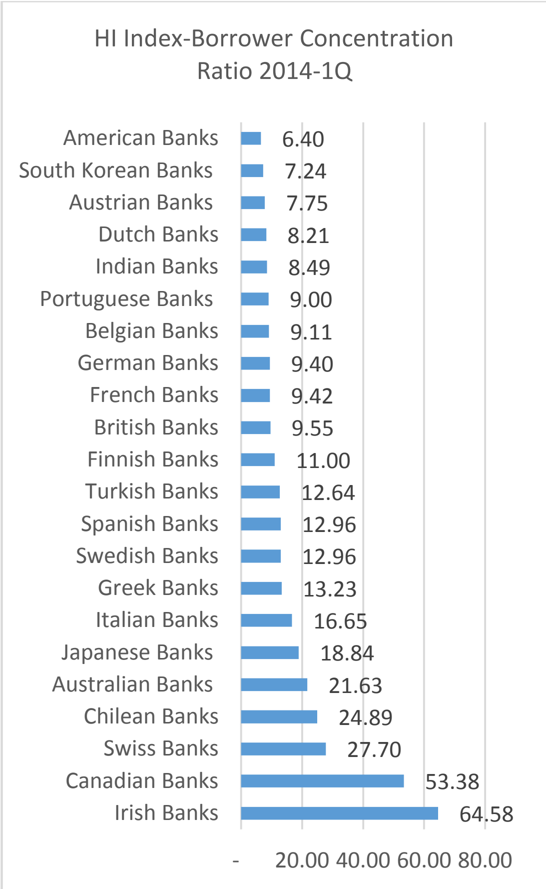


Figure 81: Foreign Lending Ratio 2006 **Figure 82 Relative size of banking sector 2006**
Source: author's own figure

Furthermore, Figures 81 and 82 present a perspective prior to the incidents of 2007. These pre-crisis figures show the trend was that interconnectivity was still yet to increase to crisis-causing levels and that can be seen again with British Banks foreign lending ratio of 21% (later 26%) and 533% for banking sector relative size (later 542%) The low-yielding Swiss currency is also to be noted as accounting for a high percentage in foreign ratio lending. While Greek banks on the other hand are low scorers due to tumultuous events in that country's economy.

The interconnected nature of global banks in Figure 81 means that nations with favourable conditions and financial legacies like the Irish, Swiss and UK banks, have the largest banking systems.



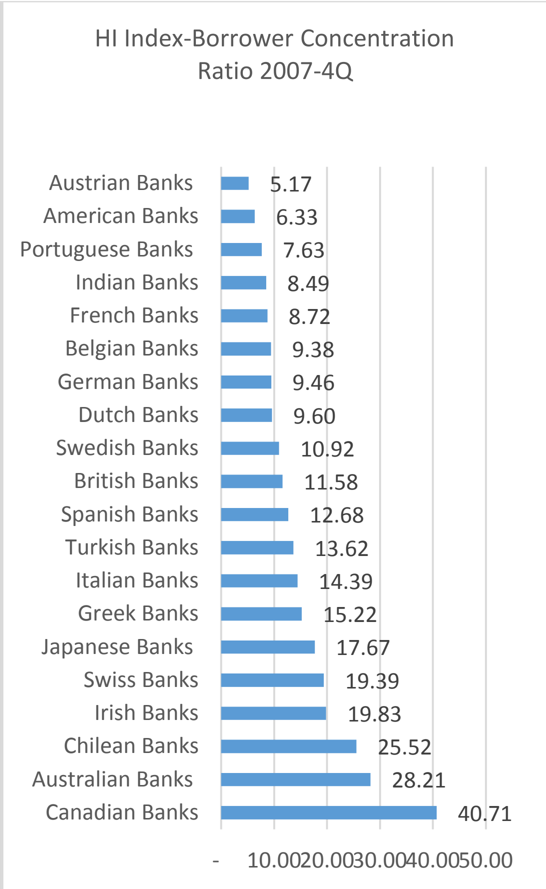


Figure 83 HI index Borrower Concentration Ratio 2014 **Figure 84 HI index Borrower Concentration Ratio 2007**
Source: author's own figure

Figures 83 and 84 offer comprehensive analysis of two key periods for the financial sector. 2007 Q4 (Figure 84) was the immediate after effect of the crisis. However, by 2014 Q1, recovery had set in to some degree The HI-index of borrower concentration shows diversity of borrowers and for major economies affected by the crisis, there is a needed reduction in borrower concentration ratios. This could occur as a result of more diverse borrowers or a smaller lending capacity.

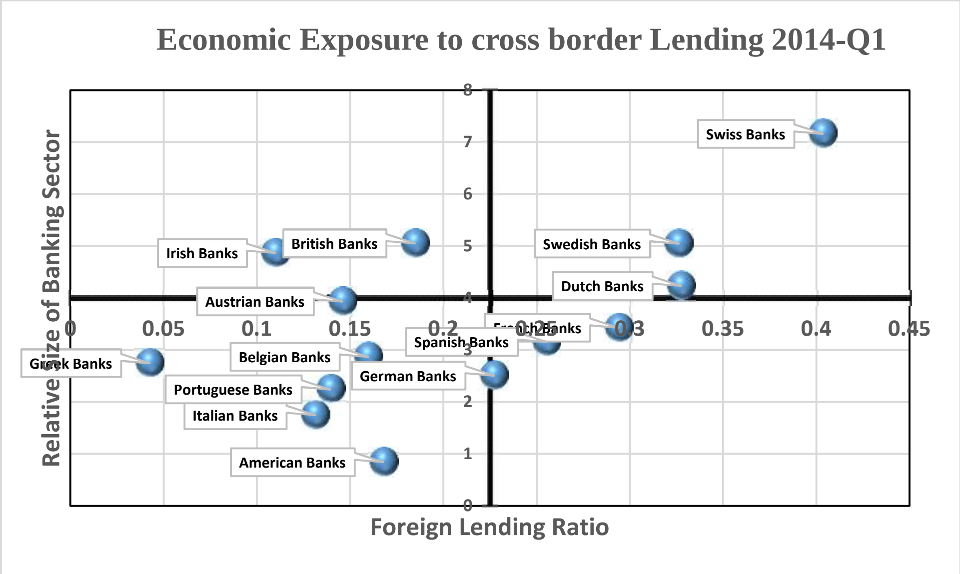


Figure 85: Economic Exposure to Cross Border Lending 2014
Source: author's own figure

Non-performing loan yields in domestic markets are one of the reasons for foreign lending and the resultant growth in banking sector size. Figure 85 shows the 2014 Q1 comparative illustration of Banking Sector Size against Foreign Lending Ratio. High scores on both parameters is a recipe for systemic risk, because the economy is exposed, a potential trigger point.

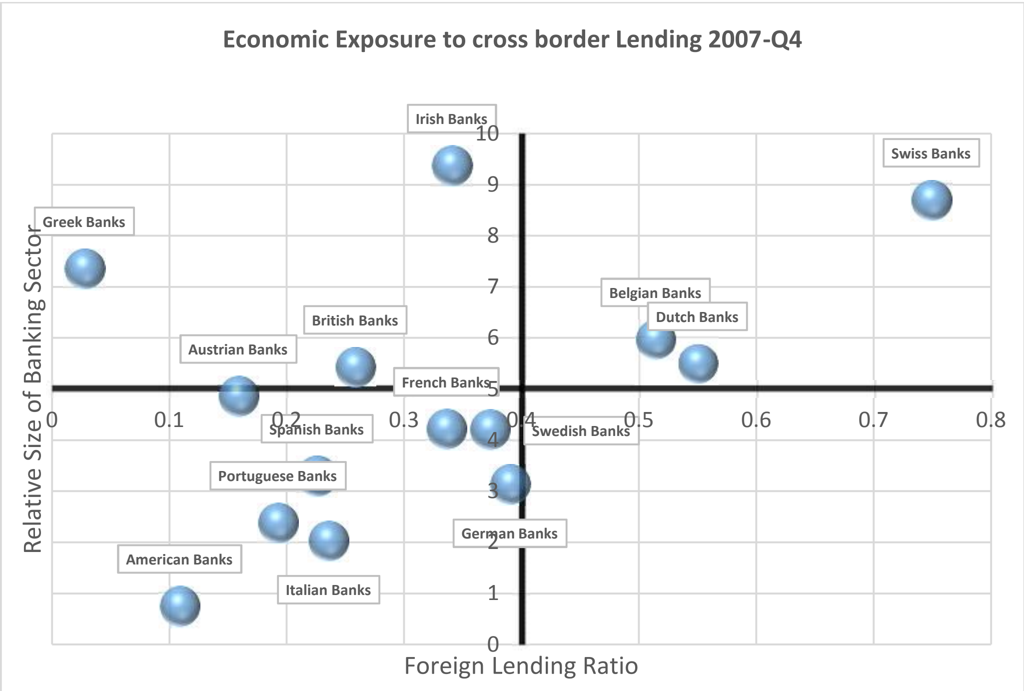


Figure 86: Economic Exposure to Cross Border Lending 2007
Source: author's own figure

Post-crisis (Figure 85), the values obtained are much lower than pre-crises level as shown here in Figure 87. Here we see Irish banks with a foreign lending ratio above 9, as compared to below 5 in 2014.

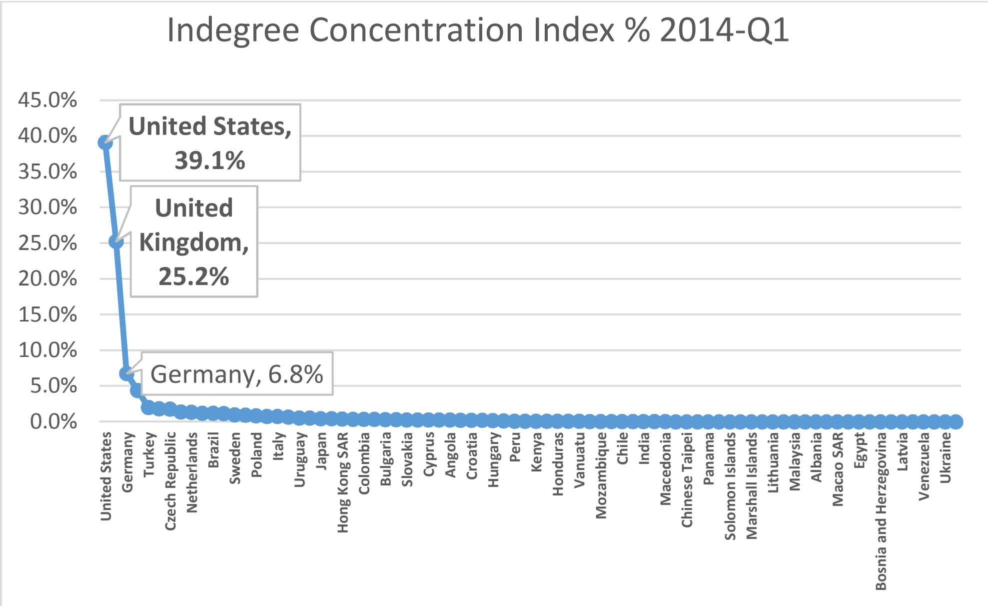
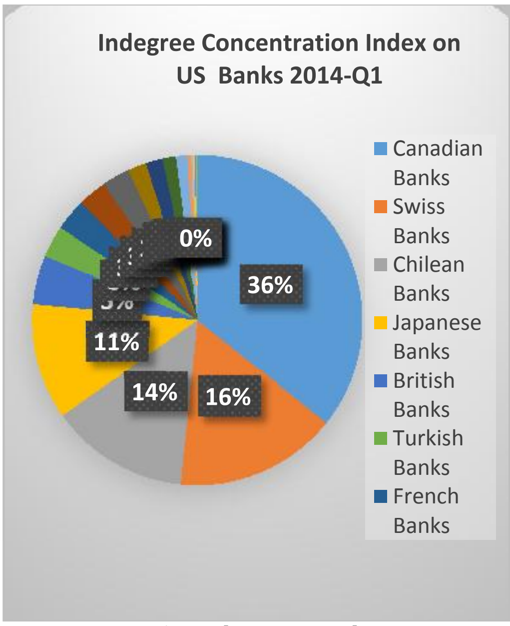


Figure 87: Exposure Concentration Index 2014
Source: author's own figure

In the graph, the US and UK have the highest indegree concentration index measuring the kind of bilateral relationships that exist in the links between financial institutions.



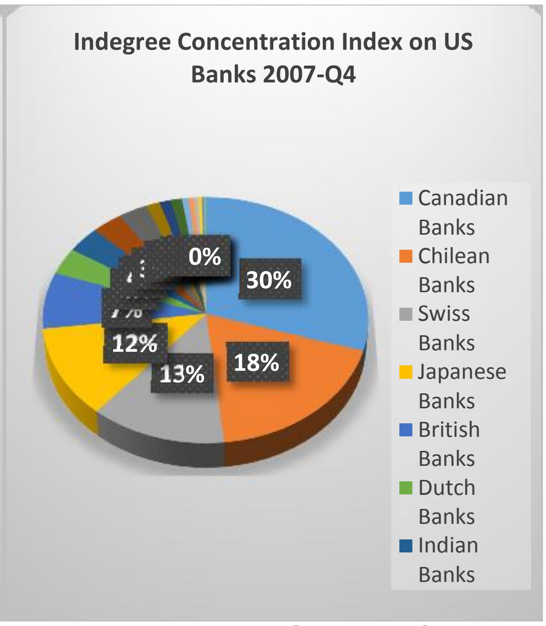


Figure 88: Concentration Index on US Banks 2014 **Figure 89: Concentration Index on US Banks 2007**
Source: author's own figure

US banks are able to provide in bound links for these economies, with Canadian banks exhibiting the largest share at 36%. There is a reduction however in the total amount from 2007 to 2014, where again Canada features as largest market share with a lower 30%.

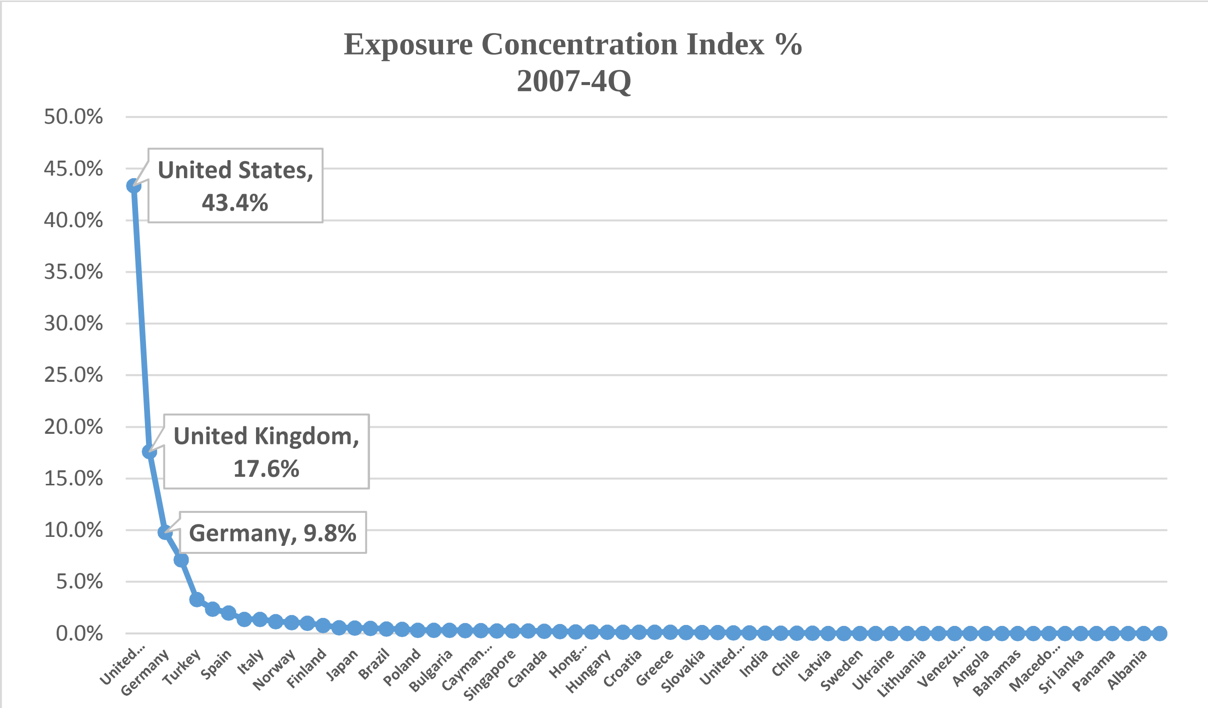
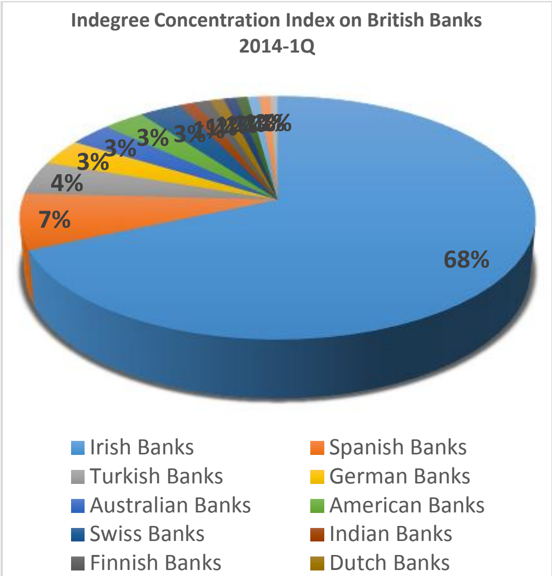


Figure 90: Exposure Concentration Index 2007
Source: author's own figure

Inadvertently, after the crisis the exposure concentration index shows that US banks have a higher exposure concentration



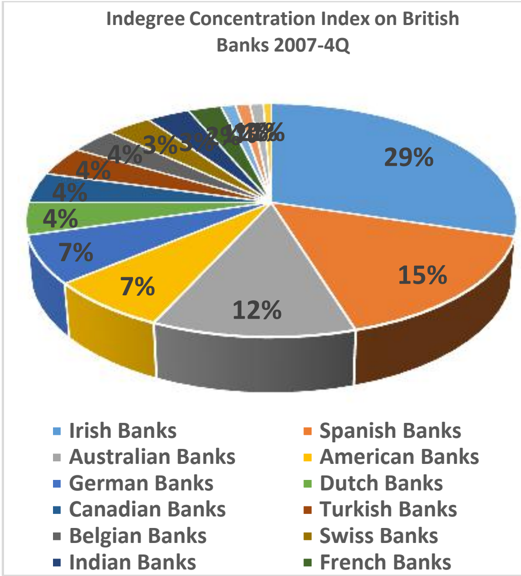
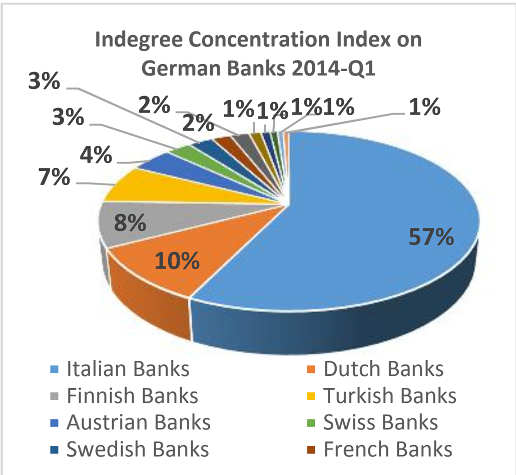


Figure 91 Concentration Index on British Banks 2014 **Figure 92: Concentration Index on British Banks 2007-4Q**

Source: author's own figure

British banks on the other hand have a concentration indegree to various economies with Irish banks at 29% share, however post crisis, UK banks are a larger share of Irish banks although for every other economy shares are reduced drastically.



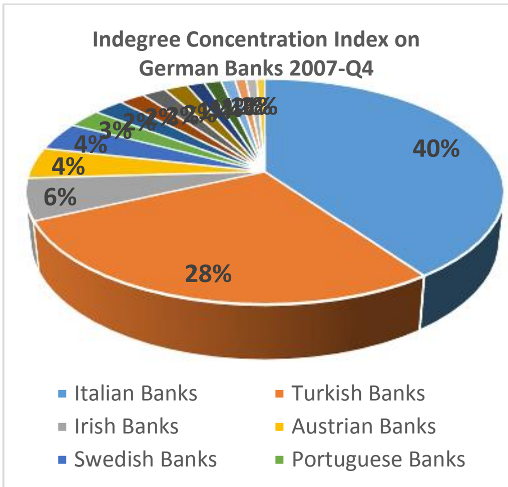


Figure 93: Concentration Index on German Banks 2014 Q1 **Figure 94: Concentration Index on German Banks 2007 Q4**

Source: author's own figure

Big German banks have major shares in the Italian banks, while post crisis (2014 Q1) this reduces for most banks such as Turkish banks having shares go down from 28% to 7%.

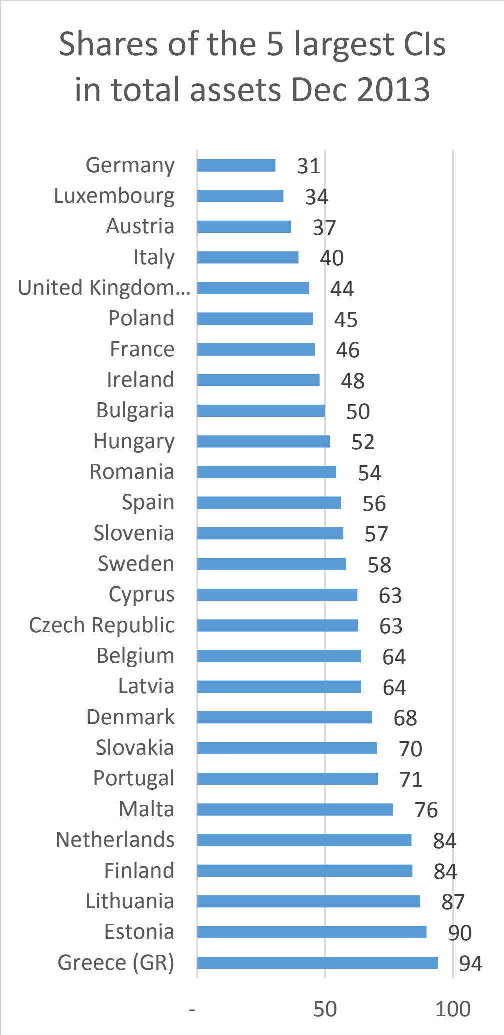


Figure 95: Shares of the 5 Largest CIs in total assets 2013

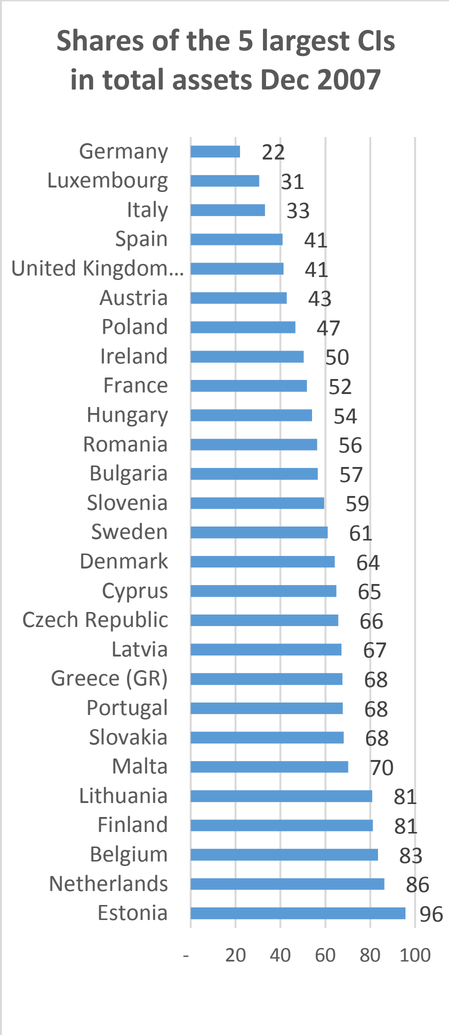


Figure 96: Shares of the 5 Largest CIs in total assets 2007

Source: author's own figure

The largest Credit Institutions (CIs) assets gives a structural indication of the Banking system with Greece and Estonia scoring highly in both periods (prior to and post the crisis).

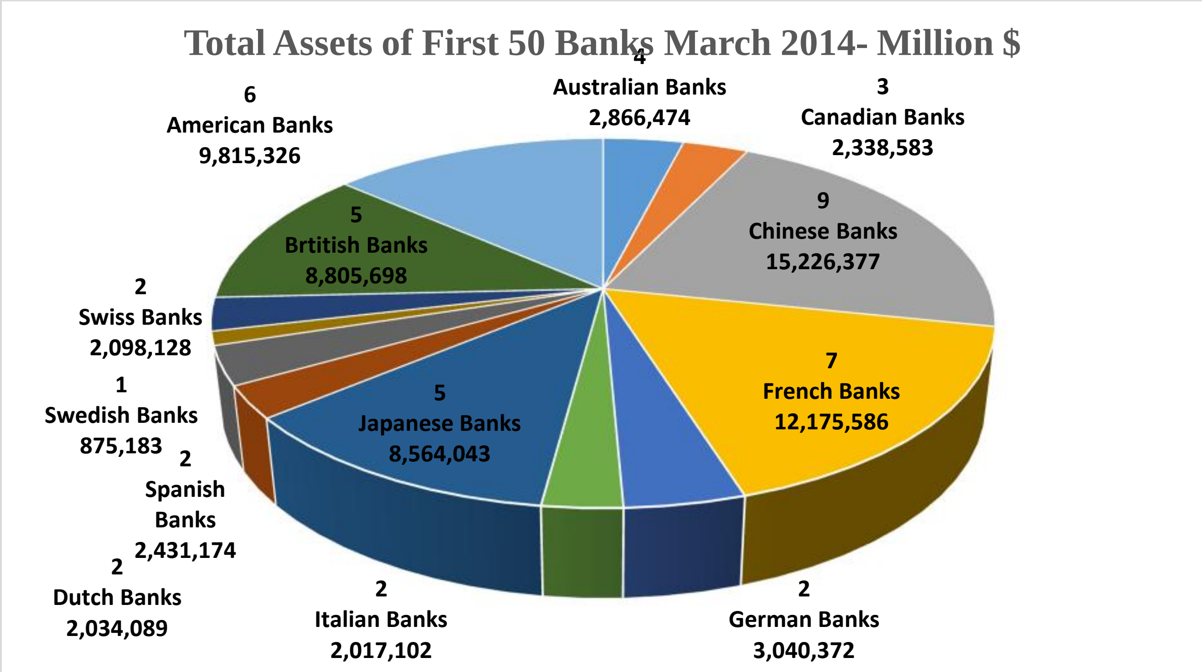


Figure 97 Total Assets of Top 50 Global Banks March 2014
Source: author's own figure

Chinese banks and French banks are able to cover close to $30 Trillion of the global share among the top 50 banks.

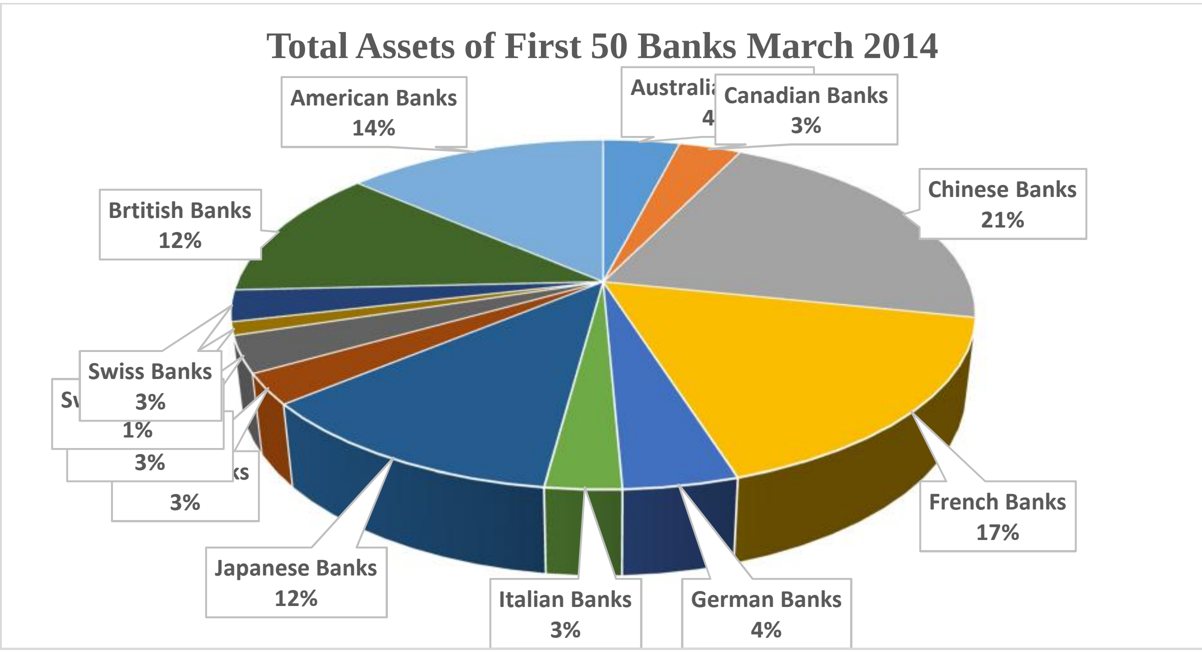


Figure 98: Total Assets of First 50 Banks March 2014 %
Source: author's own figure

The global reach and diversity offered by French banks coupled with the size of the Chinese economy allows for this domination by both countries, making a combined 38% share**.**

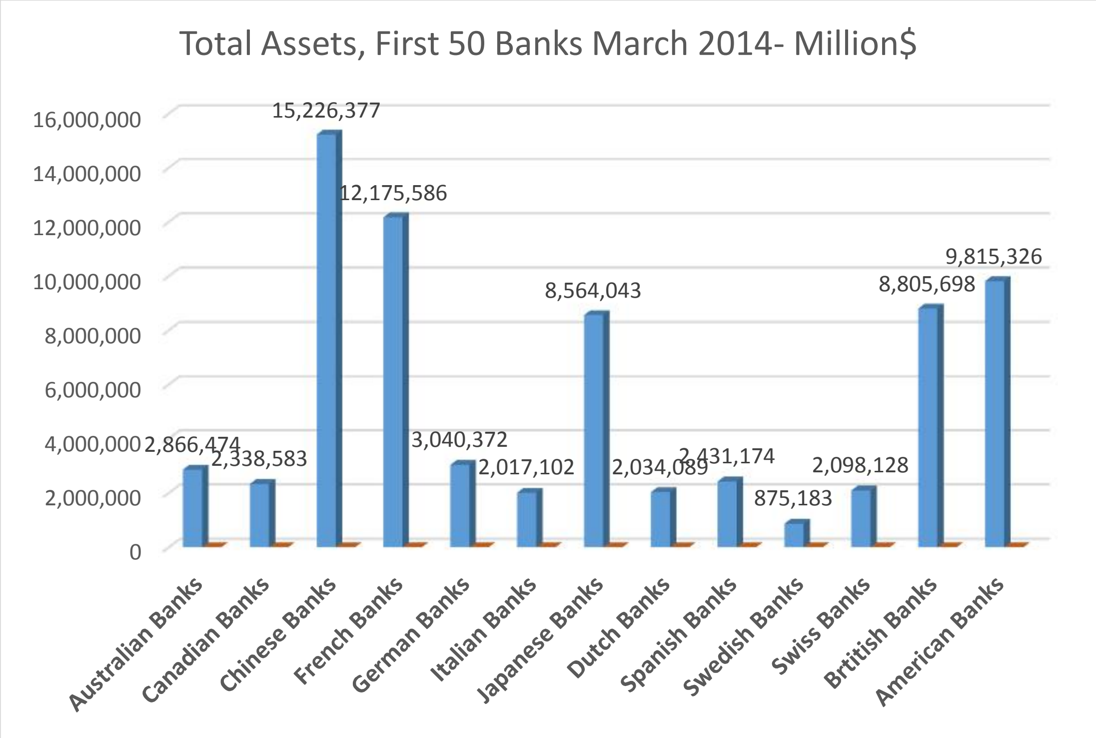


Figure 99: Total Assets of First 50 Banks March 2014 $ Millions
Source: author's own figure

As the Chinese banks have a huge market due to the population size, with over $15 trillion. French, US, British and Japanese banks come closely behind and the global participation of these country bank make them market leaders.

6.7 Conclusion

This chapter contributes to the existent literature by providing some insights within a framework that explains how the structure of the banking network and interdependencies between banks at country's level could contribute to systemic risk of the network. We study bilateral exposures cascades in a network setting and in-degree concentration index over selected networks. To obtain a realistic representation of interbank exposures relative to key variables, we exploit a unique dataset of bilateral exposures of banks at country level, balance sheet data of the banks, as well as economic data ending up with a concentration index. Research data was able to consolidate the following key findings:

(i) European banks with the most exposures were also those with the highest cross border activities and the highest interactions (out-degree) were in relation to US banks

(ii) Despite the size of participation and interlinkage from US banks, the US economy was least 'burdened' in comparison to other larger players in Switzerland, Germany and the UK, using the relative banking size index

(iii) The growth in cross-border activities in the largest banks was also traceable in the period leading to the financial crisis 07/08

(iv) Relatively smaller nations such as Irish, Italian and Swedish banks were able to interact with bigger players by conducting mainly cross-border transactions

Based on the above analysis we can suggest that there are a number of areas for further work that could help strengthen banking network vulnerability assessments:

1. Economic exposure to cross border lending could be used as guidelines by global regulators, such as the European Central Bank for monitoring banking system risk.
2. Incorporating explicit assessment of in-degree concentration index as part of evaluation of banking network vulnerabilities.
3. Elevating attention to an audit of incentive structures in assessing banking network vulnerability. An understanding of incentive structures under which the banking structure operates is likely to be a critical determinant of the robustness and potential vulnerability of the banking network.
4. Developing methodologies for linking risk exposures with macroeconomic performance. It would be desirable to research how banking sector risk can be linked to macro-economic performance and thereby a flagging mechanism can be in place not just from the banking system but the whole economic activity.

These results can help better connect global surveillance with country-level specificities. The data also shows that banks' exposure to the current hotspots seems to be limited if measured against total bank assets. This does not rule out contagion risk due to relatively large exposures of individual banks or non-bank financial institutions. After all, market perceptions of debt sustainability remain an important factor that may affect the banking sector's stability. The main benefit of this approach is the highlighting of the inconsistencies between banks connectivity in relation to country's GDP and cross border activity. The interconnected global picture in contrast with the individual banks' countries' economies, analysed in a multi-tier method displays the obvious vulnerabilities missed by either a micro-only (See (Bhansali, et al., 2008)), or macro-only, (Adrian and Brunnermeier, 2008), (or flat *macro*- plus *micro*-) investigative approach. For instance, the study analysed different EU countries in terms of their banking status and provided greater insights to banking sectors at country level. As an example it was indicated that economic exposure to cross border lending in 2014 shows Swiss Banks still have a high degree of relative size of banking sector and foreign lending ratio together, almost unchanged compared to 2007-Q4, followed by Swedish banks and Dutch banks. However, in 2007-Q4 Belgian Banks and Dutch Banks had second and third position accordingly. US, UK and Germany together achieved over 70% of the network exposures, as the in-degree concentration index in 2014 indicates. This being said, the same group gained over 70% of the network exposures in 2007-Q4, however the UK acquired a more important role in 2014 generally.

7 Chapter 7: New Global Financial Architecture & Systemic Risk

7.1 Introduction

Macro-prudential supervision, supposed to detect systemic risk and propose remedial action, has been devised because in a highly integrated and complex financial system, micro-prudential supervision alone can no longer guarantee financial stability, as seen so far. An astonishing feature of the 2007-8 financial crisis was how quickly and extensively the relatively small write-downs in US sub-prime mortgages spread, developing a situation where a few years later governments worldwide had to provide massive support to their banking systems. International banks played a key role in transmitting contagion through their claims on each other. A number of studies during the last five years examined how the interconnectedness of the international banking system impacts the threat of systemic risk in the international banking network (see, for example, Garratt, 2011), Ogawa and Thacker (2013), Basel (2012) and EMEA (2013), report on the risks posed by systemically important banks, but the studies and policy responses mainly were focused on non-structural changes. We believe financial structure and architecture should merit the same attention in a comprehensive consideration of systemic risk, and make a case for that in this chapter.

Although Danielsson et al. (2012) pointed out that the risks impacting financial markets were attributable (at least in part) to the actions of market participants, I would like to add that it might be attributable to the structure and topology of financial market networks too. In this chapter we want to review the financial market in terms of structure and architecture to see what the impact of the structure on systemic risk is.

7.2 Financial System and the Real Economy

One way the financial sector's impact on the overall economy has been measured in the past is through its direct contribution to employment and GDP. For example, in 2006 there were 6.19 million people employed in the finance and insurance sector of the American economy representing 5.4 percent of total non-finance private sector payrolls according to data from the Bureau of Labor Statistics (Baily and Elliot, 2013). By 2010 employment in the financial sector had dropped to 5.76 million, by 2012 employment in the sector had risen only to 5.83 million and the sector's share of employment was down to 5.2 percent (Baily and Elliot, op. cit.). However, our purpose is not discussing the direct employment or GDP impact of the sector but instead to emphasize the role it plays in the real economy. What is the impact of modern financial system on the real economy? By the 'real economy', we mean the sector that produces real goods and services. In this part we will discuss conceptually how the financial system can be more efficient in serving the real economy. Based on finance literature, the financial market is the intermediator to fund the real economy. The financial sector is a critical component of the economy. How well it works is a key factor in determining how the rest of the economy functions, as we will demonstrate in this chapter to manage the inherent systemic risk in the financial market, the structure of the financial sector should be under great scrutiny. We believe it to be crucial for any major changes to be based on a careful analysis of the financial sector and its relationship to the '"real economy'."

7.2 Financial System in the Economy, Where do financial Intermediaries fit in?

For orthodox economists the main function of markets is the efficient allocation of scarce resources to the unhindered relationship of supply and demand. Thus the main function of a free market financial system is to allocate scarce capital to those who can commit it to the most productive and profitable uses (Carvalho and Kregel, 2010).The financial system is an important part of the economy. It ensures that savings are channelled to the most productive investment opportunities and it allows for inter-temporal and cross-sectional risk sharing (see Allen and Gale, 2000). In classical finance literature, intermediaries serve a useful purpose in helping channel funds from savers to borrowers. One purpose of intermediaries is then to pool savers' funds and invest them in financial market securities. Borrowers, however, desire to invest in risky projects for longer time periods. This gap in demand and supply creates a market for intermediaries to repackage claims to savers. The difference in risk and maturity of the claims allows the middle man (the bank, for example) to make a profit.

Economists believe that the most important role of the financial sector in facilitating growth is to reduce information, enforcement, and transaction costs. This is achieved through a number of specific functions that the financial sector performs. The basic functions of the financial sector are: (i) to provide efficient payments mechanism for the whole economy; and (ii) intermediate between lenders and borrowers (Antony and Broer, 2010). These basic functions are the domain of banking institutions.

Financial intermediaries perform five basic functions that affect the real economy. Levine (2004) and Zhuang et al. (2009) identified and summarized five key functions that a financial system could provide in facilitating growth:

1.1. Monitoring investments and exerting corporate governance.
1.2. Facilitating the trading, diversification and management of risks.
1.3. Facilitating the exchange of goods and services.
1.4. Mobilizing and pooling savings.
1.5. Producing information and ex-ante about possible investments and allocating

In view of the Baily and Elliot (2013) contribution, financial markets serve three main purposes: Credit provision, Liquidity provision, Risk management services. However there are concerns that banks are not performing as intermediaries of loanable funds. In the intermediation of loanable funds model of banking, banks accept deposits of pre-existing real resources from savers and then lend them to borrowers. In the real world, banks provide financing through money creation Jakab and Kumhof (2015). In the event of lending still the system of financial intermediation as it stands is not allocating resources to economically useful, real economy activities but mainly to the financial sector. In the year to end August 2013, 45% of bank lending went to other banks in the financial system, 38% went to the property sector, while only 3% went to manufacturing Turner (2014). Bank loans outstanding to UK non-financial corporations fell by nearly 30% from Q4 2008 to end 2013 Financial Stability Board (2014).

7.3 Systemic Risk and New Financial Architecture

"There's nothing like a major crisis to focus people's minds on why it is important to improve the international financial architecture" (Morris, 1998, p. 67).

Searching for an optimum structure of financial system or regulation is not a new attempt. The globalisation of financial markets and increasing emphasis on systemic stability as a regulatory objective has prompted policy-makers to search for an ‘optimum’ regulatory structure that is adapted to the new market environment. (Dale and Wolfe, 1998). The design of the global financial architecture that is appropriate for promoting economic growth while ensuring financial stability has been a subject of intense debate worldwide. Despite frequent modifications to adapt to the changing needs of national economies and emerging complexities of the globalisation process, the global financial architecture has, arguably, had only a limited success in ensuring global monetary and financial stability. While the weaknesses of global financial architecture had been exposed in various economic crises occurring in the world economy from time to time, it was perhaps the wide sweep 2007 financial crisis that triggered a renewed debate on the need to revamp the architecture for the global monetary and financial system.

Fifteen years ago, in response to the East Asian crisis, there was much talk of creating a 'new international financial architecture' (NIFA), including stronger global governance. It did not happen; and as Wade (2009) asserted, once it became clear the East Asian crisis would not rebound from the periphery into the Atlantic heartland, the normal 'issue-attention' cycle of politics reasserted itself and talk of major change evaporated. Instead, we got the Financial Stability Forum (FSF) and a lot of standards and codes of best practice in banking, accounting and data dissemination. In Wade's (2009) point of view this did not constitute a 'new regime' as promised.

Throughout the 90's, the number of crises that had international repercussions increased. This increase brings the fact more to our attention that the global financial market is significantly fragile and needs a serious revision.

After the 90s, the crisis at the beginning of 2000 and slightly before, many reports have been written about the financial crises in a normative perspective (Bergsten et al., 1999); Eichengreen, 1999); Hills, Peterson and Goldstein, 1999; Metzler, 2000; and Goldstein, 2001). The interesting point of these reports was the fact that most of them focused on governance of international monetary and financial Institutions as an important issue in international financial architecture. What about the actual structure of financial system, does it ring any bells? In early 2000, faced with the gravity of the financial crises which occurred in Mexico in 1994 followed by the Asian crisis in 1997, before spreading to all the international capital markets, the question of the new structure for financial architecture was at the focal point. However, the governance of international monetary institutions and the role of international institutions were more highlighted rather than the financial market structure and backbone. In a radical reform call, Wyplosz (1999) suggested reform of the articles of the IMF in order to give it greater accountability and autonomy in relation to governments. Concerning the matter of the international lender of last resort, IMF experts, first and foremost Fischer (1999), had drawn up the conditions required for the IMF, on behalf of governments, to carry out this function in accordance with these conditions, whereas Aglietta and Boissieu (1999) consider that the BIS and the central banks are in a better position to carry out this role, together with supervising the international banking system and payment systems. In a more radical way, some post-Keynesian economists such as Eatwell and Taylor (1998) proposed the replacement of all the current Institutions (IMF, World

Bank, BIS etc) with a single World Financial Authority. These were all part of the efforts to change the new financial architecture but the propositions were less focused on the financial market structure, but on yet more regulatory conditions. So financial architecture was addressed on different occasions but in all above, firstly the new global financial architecture was seen mainly as the role of international monetary fund and institutions and secondly the global financial architecture was seen as a pragmatic solution to the global financial instability and not as an institutional advancement regarding the mode of monetary and financial governance on a global scale. But at the same time there were other thoughts, that the new global financial structure could not meet its goals to secure better stability for the economy. We will discuss later that even the name did not properly reflect the content, as the approach to new global financial architecture did not change the substance enough. Taking to account the debates and discussion of many experts it was highly unlikely that the new architecture would adopt the form of a series of rules leading to a new system that would impose itself on the international community as a whole (Cartapanis and Herland, 2002).

7.4 Systemic Risk and Market Structure, Global Financial Crisis Triggered by Market Failure

Professor Steven L. Schwarcz[35] in his lecture examines the causes of the global financial crisis, showing it was triggered by market failures, not by financial institution failures, and arguing that any regulatory framework for managing systemic risk must address markets as well as institutions. The lecture also analyses how regulation should be designed under that broader framework to mitigate systemic risk and its consequences. Acharya et al. (2011) analyse the financial crisis through the lens of market failures and regulatory failures. They present a case that there were four primary failures contributing to the crisis, of which one of the important ones was regulatory focus on individual institution risk rather than systemic risk. Helmer (2010) indicating the conventional wisdom was that the current financial crisis marks the failure of markets, possibly the end of capitalism. Our point is, market structure and architecture deserve the same attention as individual and interlinkage of individual participants in the market.

[35] Professor Steven L. Schwarcz Stanly's lecture is available at: http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=2974&context=faculty_scholarship

7.5 New Global Financial Architecture

7.5.1 The Basic Principles of the New Global Financial Architecture (NGFA)

Panitch and Leys (2002) in their article argue that the NGFA constitutes a transnational class-based strategy to reproduce the power of financial capital in the world economy and, in effect, the structural power of the United States. More specifically, the NGFA may be seen as a novel attempt to refurbish the political and ideological elements of the existing international financial architecture — the so-called Washington consensus — by way of what they call 'imposed leadership' Soederberg (2002). On the basis of the technical reports submitted in October 1998 by the three working groups, the Finance Ministers of the G-7 agreed on a common declaration at the Cologne summit in June 1999. This declaration lays out in detail the principles which could improve and reform the architecture of the global financial system. We will use the text of this declaration to describe the options which have been the object of a political compromise among the most developed countries. In spite of the formal and sometimes rather unconventional nature of this type of declaration, the basic options adopted by the G7 can be grouped under four main principles

.

(i) It is necessary to reinforce the transparency and the quality of information in order to improve the working of the international financial markets.

(ii) Whilst reaffirming, the superiority of the liberalization of the money markets, in order to optimize the international allocation of savings, the financing of growth and the creation of jobs, some twisting of the rules and some temporary control measures are considered as legitimate for developing countries given the dysfunctions observed on the markets in recent years. Controlling the outflow of capital is considered counterproductive and should be used only in exceptional circumstances.

(iii) It is not a question of reconstructing a new monetary and financial system, but rather of introducing in a practical way a series of incentives, codes of conduct or standards that must be respected, in order to ensure better practices among the countries in the areas of international cooperation and exchange regimes and above all among investors and financial intermediaries operating throughout the world.

(iv) Contrary to what the supporters of the efficiency of the financial markets claimed, the probability of the outbreak of international financial crises is not all that low.

Cartapanis and Herland (2002) stated that a close examination of the theoretical foundations implicitly underlying the G-7's position reveals a clear shift in the official doctrine which was favourable to the liberalisation of capital movements. They argue that can anyone see post mortem, the revenge of Keynes who spoke out clearly in favour of stricter rules for international markets, notably at the Bretton Woods Conference? It goes without saying that a common declaration of the Finance Ministers of the G-7 cannot refer to a theoretical basis in order to justify its proposals. One can, however, make out a series of implicit foundations which underlie the options that have been chosen and which reply, implicitly, to a Keynesian reading of the sources of international financial instability.

But it is by no means sure that the measures proposed by the G-7 take this reading into account. To what extent, therefore, is it legitimate to refer to Keynesrevenge concerning the architecture project? Certainly not in the sense of a return to the precise terms of a Clearing Union as envisaged in the Keynes Plan written in 1941 (REFERENCE?). It is rather in terms of the principles of international monetary and financial governance that a link with Keynes (op. cit.) can be asserted.

There are plenty of papers stating need of fundamental reforms in financial market architecture and principle of new architecture. For instance, the report of the Task Force of the Executive Committee on Economic and Social Affairs of the United Nations summarising that **i**n the longer term, fundamental reforms of the international financial architecture are needed. (Task Force of the Executive Committee Report, 1999)**.**

In Stiglitz (2009) viewpoint financial markets are not an end in themselves, but a means: they are supposed to perform certain vital functions which enable the real economy to be more productive:

a. Mobilizing savings
b. Allocating capital;
c. Managing risk, transferring it from those less able to bear it to those more able

It is hard to have a well-performing modern economy without a good financial system. Meanwhile Stiglitz (op. cit.) indicates that in America, and some other countries, financial markets have not performed these functions well and:

a. They encouraged spendthrift patterns, which led to near-zero savings
b. They misallocated capital
c. They created risk, they did not manage it well, and they left huge risks with ordinary Americans, who are now bearing huge costs because of these failures

These problems have occurred repeatedly and are pervasive, evidence that the problems are systemic and systematic. And failures in financial markets have effects that spread out to the entire economy. Stiglitz (op. cit.) points out that well-functioning markets require a balance between government and markets. Markets often fail, and financial markets have, on their own, failed in ways that have large systemic consequences. The deregulatory philosophy that has prevailed in many western countries during the past quarter century has no grounding in economic theory or historical experience; quite the contrary, modern economic theory explains why the government must take an active role, especially in regulating financial markets.

Government regulation is especially important because inevitably, when the problems are serious enough, there will be bail-outs; thus, government is, implicitly or explicitly, providing insurance. However the regulatory structure did not keep up with changes in the financial structure. The international banking regulatory structures (Basle II and III) were based on the notion of self-regulation, an oxymoron. Bail-outs have been a pervasive aspect of modern financial capitalism. Financial markets have repeatedly mismanaged risk, at great cost to taxpayers and society.

The report of the Task Force of the Executive Committee on Economic and Social Affairs of the United Nations (U. N. report, 1999) is indicating that **w**orld events since mid-1997, and its precedents in the 1980s and 1990s, have made painfully clear that the current international financial system is unable to safeguard the world economy from financial crises of high intensity and frequency and devastating real effects (U. N. report, op. cit.).

In the foreign affairs report (Foreign Affairs Report on The Future of the International Financial Architecture, 1999) and some other reports (see for example: Radelet and Sachs, 1998; Summers,2000), Stiglitz,1999) addressing that the new international financial architecture should:

1. encourage emerging economies to intensify their crisis prevention efforts
2. permit savings to flow to the countries and the uses where they have the best return
3. promote fair burden-sharing among private creditors, official debtors, and official creditors when a crisis does occur
4. increase the role of market-based incentives in crisis prevention and resolution
5. make reform of the architecture a two-way street, with the major industrial countries also doing their part
6. refocus the mandates of the international monetary fund and the world bank on areas they are best equipped to address

Edwards (1999), and a few others, on the way of new global financial architecture to prevent any future crisis focused on capital control and sequence of liberalisation. (see for example: Bhagwati,1998; Edwards 1999B; Krugman 1998;Guillermo and Reinhart, 1999;Eichengreen,et al., 1999; Takatoshi 1999;Johnston and Echeverria, 1999; Obstfeld,1998; Rodrik and Velasco,1999) Edwards (1999) highlighted the following points:

a. Capital controls may foster a false sense of security, encouraging complacent and careless behaviour by policymakers and investors alike.
b. After much talk about a new architecture, we will probably end up with a slightly embellished IMF that will continue to miss crises, throw good money after bad, and ultimately try to rationalize why currency crises persist.
c. We must understand what capital controls can and cannot do. The historical record shows convincingly that, despite their new popularity, controls on capital outflows and inflows are ineffective. The best prescriptions to combat financial turmoil, now as then, are sound macroeconomic policies, sufficiently flexible exchange rates, and banking reforms that introduce effective prudential regulations and reduce moral hazard and corruption.

On the new financial architecture some shedding lights on Tobin tax[36] describing its role as "Throw sands on the wheels" (see for example: Haq and Grunberg, 1996; Outlook,1999;Buiter and Sibert, 1999Eichengreen, 1999) .

7.6 Features of New Global Financial Architecture

We argue here that the 2007-8 global crisis, with serious future financial risks, marks a structural break in long-run development since the early 1980s. This development has been dominated by the neo-liberal model of deregulated labour markets, reduction of government intervention and social policies, redistribution of income from (lower) wages to profits and high management salaries, and deregulated international financial markets. In US and UK this model, in combination with expansive monetary and partly fiscal policies, has been able to generate sustained periods of high growth rates and low unemployment, and these economies performed far better than the Euro area. See Hein and Niechoj, 2007;Hein and Truger, 2005a;Hein and Truger, 2005b;Hein and Niechoj, 2007;Hein and Truger, 2007b;Hein and Truger, 2007c;Hein ,2009) for comparisons of the more restrictive German and Euro area macroeconomic policies, with the more expansive versions pursued in the US and the UK.

The neo-liberal model has also been consistent with a long period of growth of the world economy, with the US as the demand locomotive until recently. However, as the crisis has made clear, this model has been built on considerable imbalances, both at the national and the international level. In the following pages of this chapter we will analyse features of the new global financial architecture.

7.6.1 Rise of Inequality in Light of Increasing Systemic Risk

The recent global crisis has sparked interest in the relationship between income inequality, credit booms, and financial crises. Rajan (2010) and Kumhof and Rancière (2011) propose that rising inequality led to a credit boom and eventually to a financial crisis in the US in the first decade of the 21st century as it did in the 1920s. This is one of the most important factors prior to the financial crisis 2007-8. Morrow (2011) explains the main structural causes of the global financial crisis

[36] A Tobin tax, suggested by Nobel Laureate economist James Tobin, was originally defined as a tax on all spot conversions of one currency into another. The tax is intended to put a penalty on short-term financial round-trip excursions into another currency. Tobin suggested his currency transaction tax in 1972 in his Janeway Lectures at Princeton, shortly after the Bretton Woods system of monetary management ended in 1971 (Eun, 2015, p. 92).

2007-2008 as a low rate of profit in the US economy, wide economic inequalities**,** which led to increasing capital flow to the financial sector and the increasing provision of credit to US workers whose real incomes had declined. Financial innovations enabled debt to be sold in complex new financial products to investors. Cheap and apparently riskless lending drove the rising leverage of investments. 'Securitisation' helped to spread the risks to global financial markets and deficient government regulation facilitated these developments. Morrow (op. cit.) concludes his argument of complex set of global financial crisis (2007-2008) were connected to underlying features of the US capitalist economy where the crisis began. A low rate of profit and large economic inequalities led to increasing capital flow into the financial sector and increasing recourse to credit by US workers whose real incomes were in decline from the early 1970s. New financial innovations, which developed in the wake of financial deregulation and floating exchange rates, enabled debt to be parcelled into complex and opaque new financial products. However he believes one of the main underlying causes of the US financial crisis was the wide and growing inequalities of income and wealth between households in US society and between capital and labour Kotz (2009). He thought this is an important aspect of the global financial crisis, which has, at best, been under-explored (see for example, Faber, 2009; and Garnaut, 2009). In terms of income inequality, the Economic Policy Institute (2009b) estimates that between 1979-2006, about 91 percent of all income growth in the country went to the top 10 percent of income groups. At the same time, the highest paid 1 percent of the population more than doubled their share of total income from about 10 percent to almost 23 percent. By contrast, between "1973 and 2002, average real incomes for the bottom 90 percent of Americans fell by 9 per cent" (McNally, 2009, p. 60). Over a quarter of all workers in the US (26.4 percent) in 2007 were, in fact, earning poverty-level wages (Economic Policy Institute, 2009).

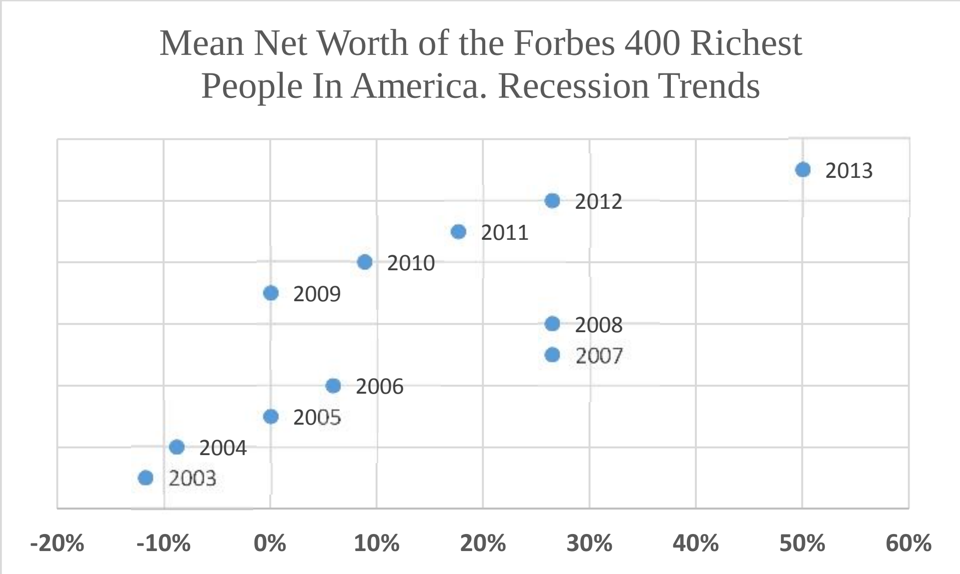
The situation is even more unequal when it comes to wealth. Between 1991 and 2003, the wealthiest 1 percent of Americans increased their share of corporate wealth from 38.7 percent to 57.5 percent (McNally, 2009, p. 60). In 2004, the wealthiest 1 percent of households owned more of the national wealth than the bottom 90 percent of households combined (Economic Policy Institute 2009) p.10. The concentration of wealth at the top has also increased over time. Between 1962-2004, the wealth of the bottom 80 percent of the population decreased from 19.1 percent to 15.3 percent and this wealth was shifted to the wealthiest 5 percent of the population. About one in six households have no net wealth at all and nearly one-third of households (30 percent) have a net worth under $10,000 (Economic Policy Institute 2009) p.10-11. There has also been widening inequality between wages and profits in the US economy. Between 1979-2007, real output per hour increased by 1.91 percent while the real average hourly earnings of non-supervisory workers fell by 0.04 percent. This suggests a transfer of income from labour to capital. Similarly, productivity growth for the same period was 4.6 percent while real compensation per hour (including fringe benefits) for all employees including managers increased by only 1.1 percent. Finally, real profits in the corporate sector over the same time period increased by 4.6 percent while real employee compensation grew by only 2 percent (Kotz, 2009). The recent figures showing that the situation is getting more unequal after the financial crisis 2007-8. The recent data indicating one of the winner of US Quantities Easing policy is the richest people in the country as from 2009 through 2013, the inflation-adjusted mean net worth of Forbes 400 Richest People in America increased from $3.4 to $5.1 billion, or by 50%. (Figure 101).

Table 12 the inflation-adjusted mean net worth of Forbes 400 Richest People in America

Year	All (CPI-adjusted billion $)	Change from 2009
2003	3	-12%
2004	3.1	-9%
2005	3.4	0%
2006	3.6	6%
2007	4.3	26%
2008	4.3	26%
2009	3.4	0%
2010	3.7	9%
2011	4	18%
2012	4.3	26%
2013	5.1	50%

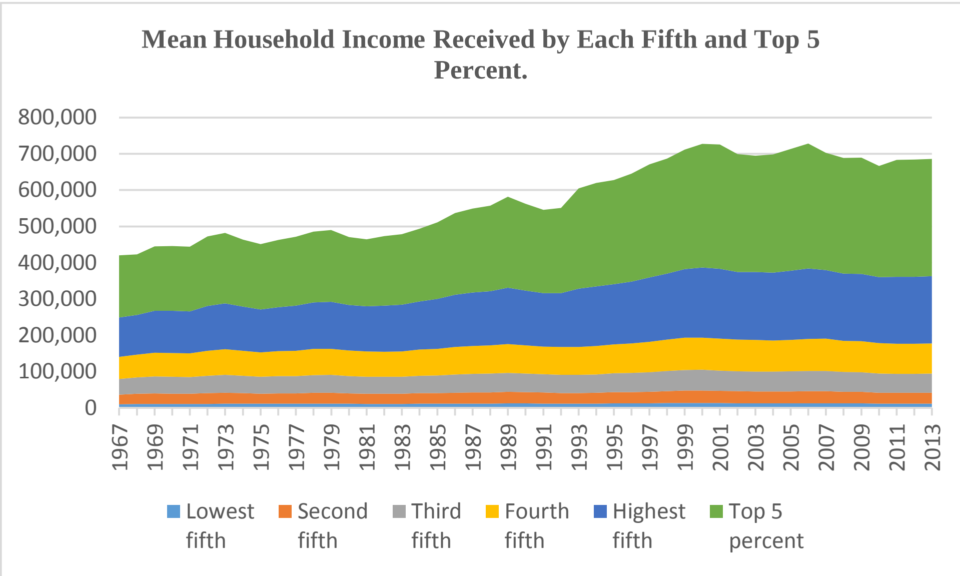
Source: Stanford CPI (using data from Forbes.com)

Table 12 is a case in point, proving the true benefactors of QE.



Source: Author's own calculation

Figure 100: Mean Net worth of the Forbes 400 richest people in America. Recession trends



Source: US Census Bureau, September 2014.

Figure 101: Mean household income received by each fifth and top 5 percent

Figure 101 shows the correlation between income band and relative income increase, showing the top fifth band receive the highest gross household increase.

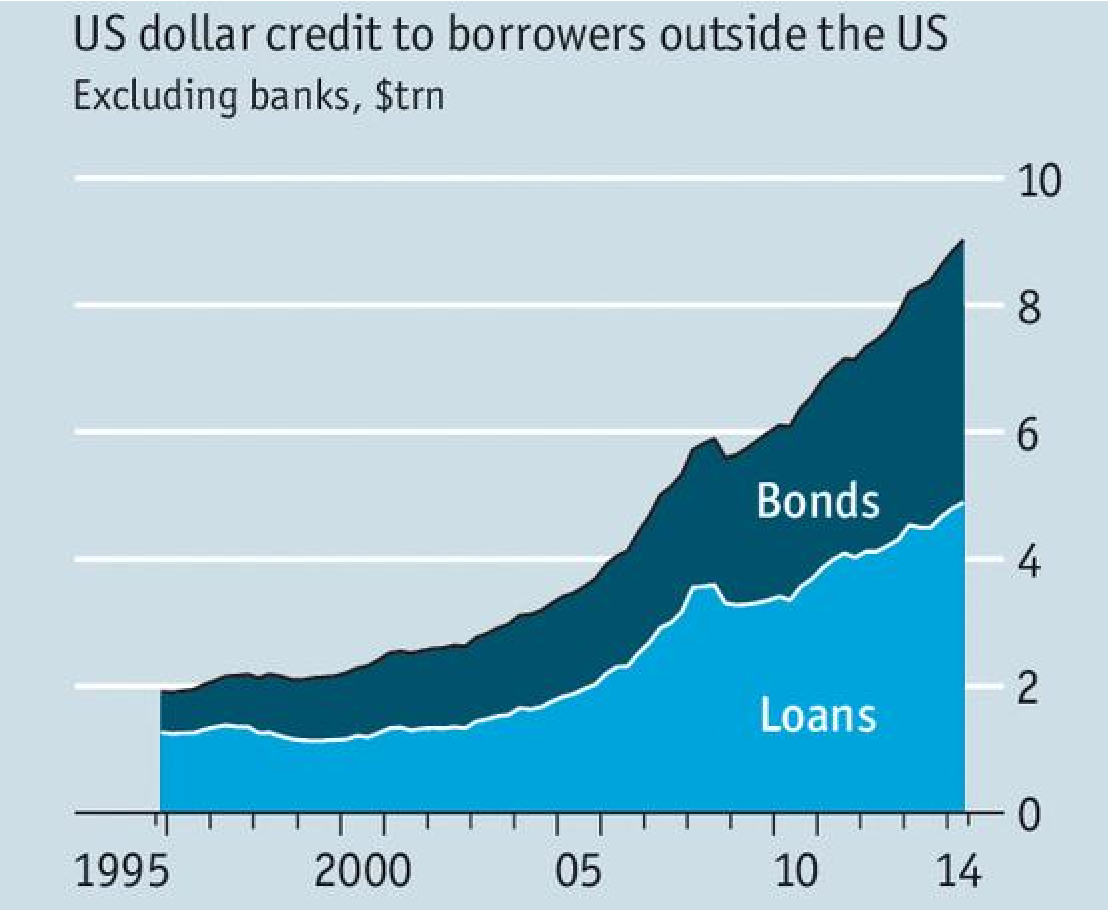
Did Increasing Income Gaps set the stage for rising systemic risk in financial system?

The share of income received by the top 1 percent of earners varied markedly between 1900 and 2008 in 24 developed and developing economies. Moreover, the biggest earners changed as well. When the century began, the top 1 percent was dominated by capital owners. By the end of the century the hired hands—the top executives—shared with capital owners the highest part of the income distribution (Alvaredo 2011). In order to find the source of inequality we could highlight before 1945, the decrease in the share of income garnered by the top 1 percent in the developed world was caused mostly by a fall in income from investment (capital income). That decline took place during wartime and the Great Depression, suggesting that income inequality dropped because capital owners were hurt by major shocks to their holdings. However, the dramatic increase in recent decades in the share of income going to the top 1 percent in many countries is due to a partial restoration of capital incomes and, more significantly, to very large increases in compensation for top executives. In the United States, as a result, the working rich have joined capital owners at the top of the income hierarchy (Alvaredo, 2011).

According to a study by world economic forum in 2013 severe income inequality is the biggest risk facing the world (World Economic Forum Risk Report, 2013). In a landscape of 50 global risks facing the world over the next 10 years, respondents rated severe income inequality as the most likely global risk. On a scale of 1 to 5, with 5 being ‘almost certain’ to occur, severe income disparity was given a risk rating of 4.14 by the experts, ranking above chronic fiscal imbalances (3.99), greenhouse emissions (3.91), water supply crisis (3.85) and mismanagement of population aging (3.83). In the report it was the second year in a row that income inequality has reached first place as the most likely global risk. Major financial systemic failure gained the top spot for the biggest global risk in terms of impact. (See (World Economic Forum Risk Report, 2012). However, in world economic forum report for 2014 worsening wealth gap seen as biggest risk facing the world in 2014. The report finds income disparity the most likely risk to cause an impact on a global scale in the next decade (World Economic Forum Risk Report, 2014). Moss (2010) investigated the possible connection between economic inequality and financial crises after financial crisis 2007-8. He studied the overlay two different graphs - one plotting financial regulation and bank failures, and the other charting trends in income inequality. He found the timelines danced in sync with each other. Income disparities between rich and poor widened as government regulations eased and bank failures rose.

7.6.2 *Dollar Dominance Market* - Return of Emperor

The dollar has been the preeminent global reserve currency for most of the past century. Its status as the dominant world currency was cemented by the perception of international investors, including foreign central banks, that US financial markets are a safe haven. That perception has ostensibly driven a significant portion of US capital inflows, which have surged in the past two decades. On top of this, the dollar's global role means it has a huge impact abroad, influencing more than $9 trillion in borrowing in dollars by non-financial companies outside America—more than enough to buy all the firms listed on the stock exchanges of Shanghai and Tokyo (see the following chart).



Source: (Economist 2015)

Figure 102 US dollar Credit to borrowers outside of US

According to Bank for International Settlement data (Economist, 2015) between 2009 and 2014 the dollar-denominated debts of the developing world, in the form of both bank loans and bonds, more than doubled, from around $2 trillion to some $4.5 trillion.

According to September 2014 BIS : (Economist, 2015) data about international money market instruments, analysis of international debt securities, commercial paper from September 1989 till June 2014 indicating that although the amount outstanding in Euro was always higher than Dollar since December 2002 but on December 2012 dollar replaced Euro to be the first currency in outstanding amount of commercial paper (Figure 103).

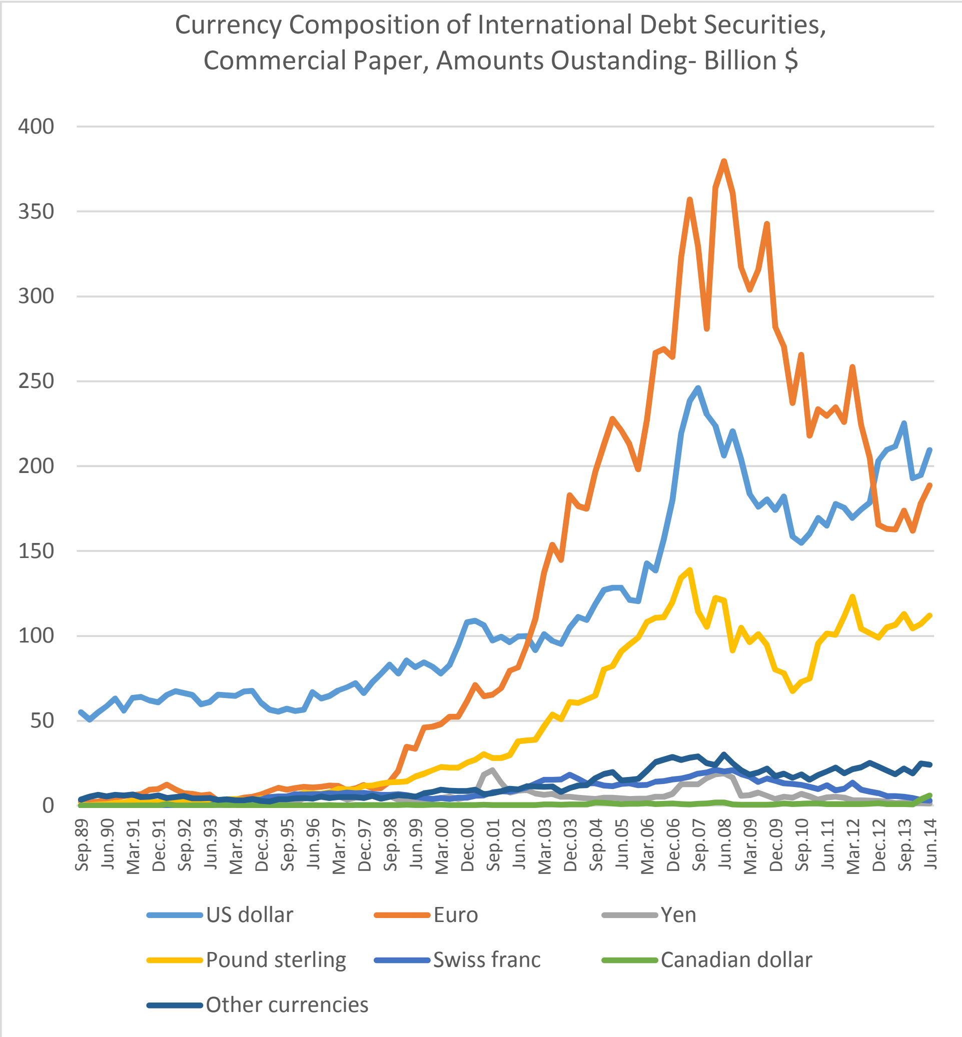


Figure 103: Currency composition of International Debt Securities, commercial paper
Source: author’s own figure

The same trend happened to outstanding amount of other instruments that Euro was the highest currency since March 2000 but it was replaced by dollar on March 2014.

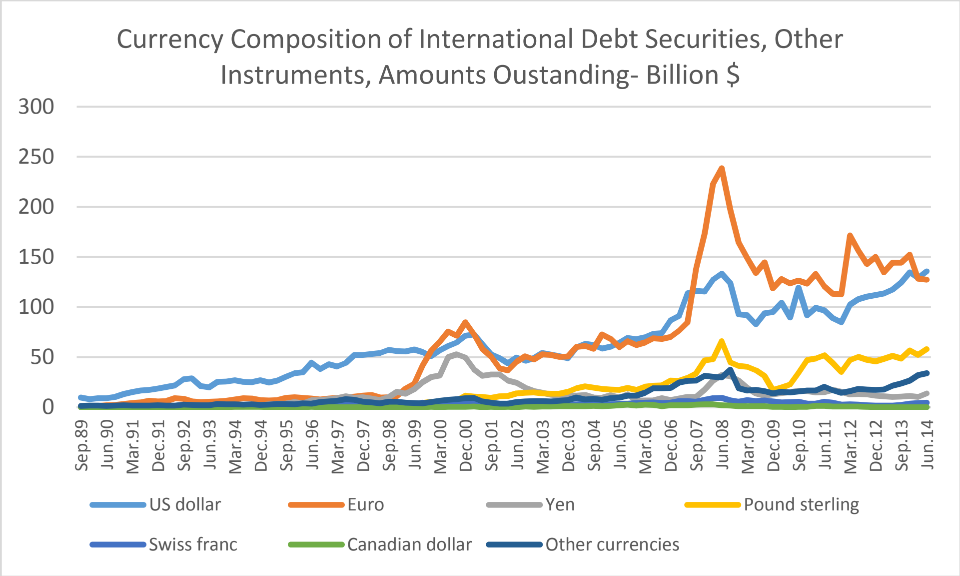


Figure 104: Currency Composition of International Debt Securities, Other Instruments
Source: author's own figure

In Figure 104, the trend for Euro occupying the largest share of 'other instruments' debt securities only starts in the period of the financial crises (pre-September, 2007), and understandably so. In an environment characterised by low and declining interest rates in the euro area, the euro was increasingly used as a funding currency by international borrowers. The share of the euro in international debt securities almost doubled at the end of the third quarter of 2007, compared with the beginning of the same quarter.

Moreover, the fact that a rich country like the United States has been a net importer of capital from middle-income countries like China has come to be seen as a prime example of global current account imbalances. The 2008–09 global financial crisis, whose aftershocks continue to reverberate through the world economy, led to heightened speculation about the dollar's looming, if not imminent, displacement as the world's leading currency. Indeed, there are indications that the dollar's status should be in peril. The United States is beset by a high and rising level of public debt. Gross public (federal government) debt has risen to $16.8 trillion. roughly equal to the nation's annual output of goods and services (Prasad, 2014).

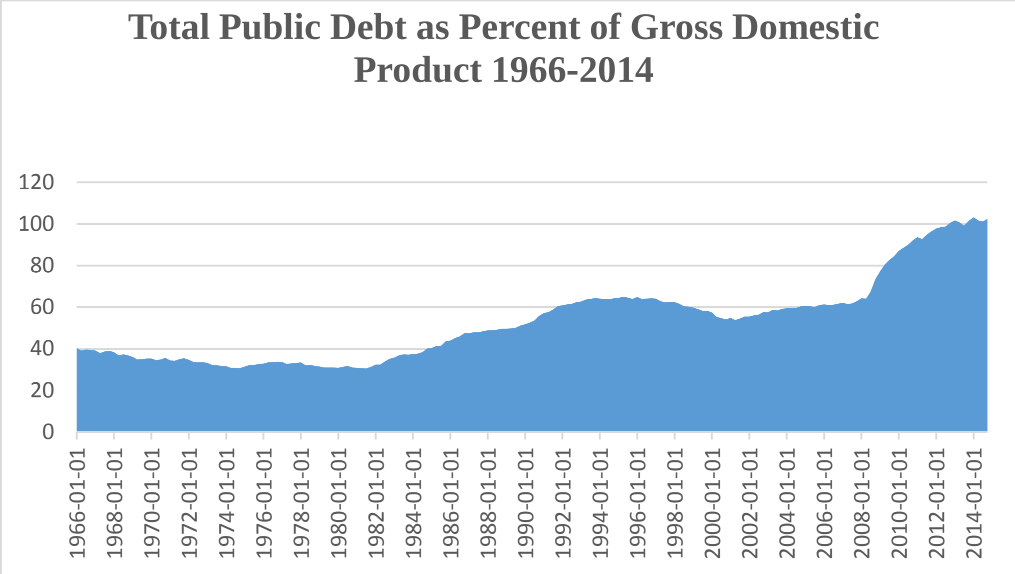
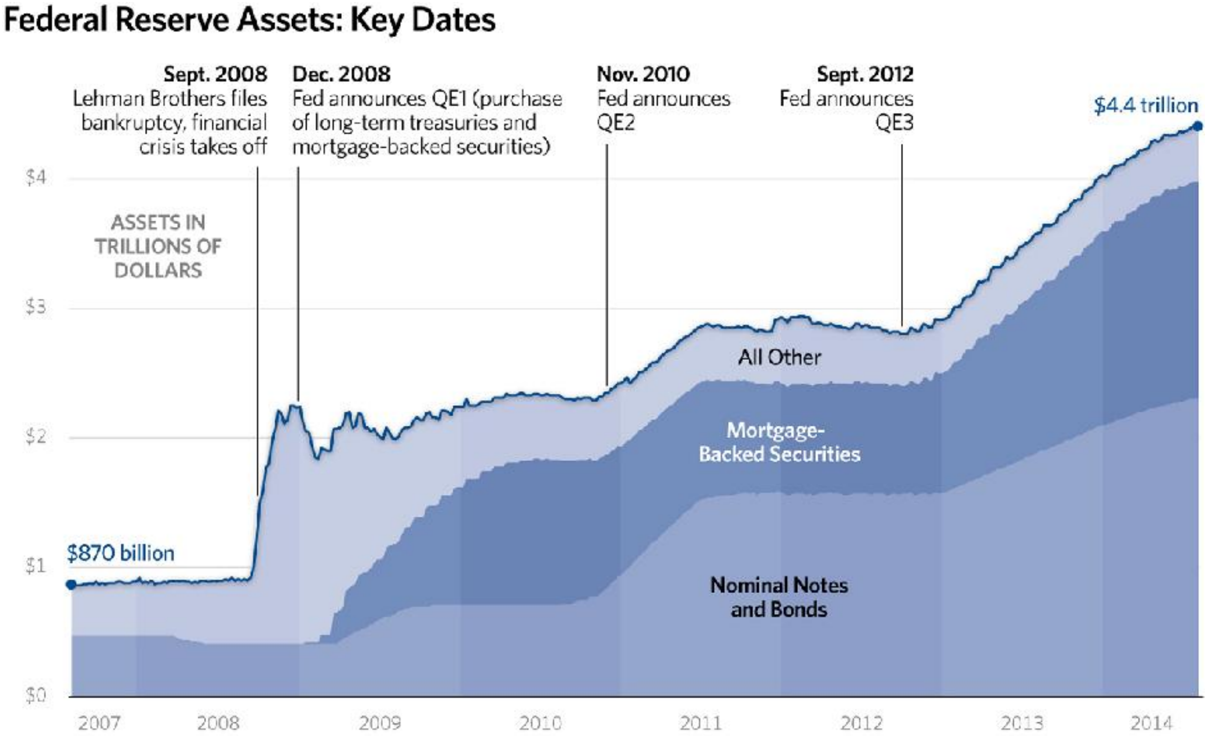


Figure 105: Total Public Debt as Percent of Gross Domestic Product 1966-2014
Source: author's own figure.

Government debt as a percent of GDP helps investors measure sovereign risk of default, and the ability to make future payments on its debt, thus affecting the country borrowing costs and government bond yields. The steady rise in this value as seen in Figure 105, from the late 90s and almost doubling by 2012 (where it reaches its peak) can be attributed to several factors from an aging population, accumulated interest rates on T-Bills and high investment during the late 1990s, low national saving, as well as continuous expenditure for social and political crises (wars, natural disasters and financial crises). The expectation is that if this percentage continues to grow, then another financial crisis is imminent (IMF, 2010).

The aggressive use of unconventional monetary policies by the Federal Reserve, the US central bank, has increased the supply of dollars and created risks in the financial system. The Fed on 2014 holds more than five times the amount of securities it had prior to the 2008 crisis. The Fed's balance sheet expanded from about $850 billion to more than $4.4 trillion (Norbert and Moore, 2014).
(See below chart)



Source: (Norbert and Moore 2014)

Figure 106: Federal Reserve assets: key dates

All these factors should have set off an economic decline in the United States and hastened erosion of the dollar's importance. But the reality is completely different. The dominance of the dollar as a global reserve currency has been barely affected by the global financial crisis.

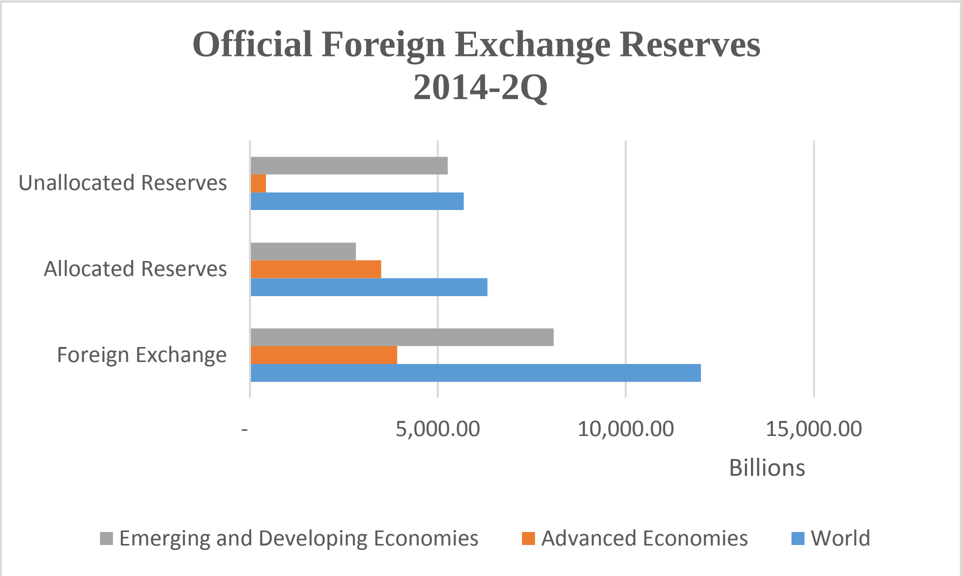


Figure 107: Official Foreign Exchange Reserves 2014-Q2
Source: author's own figure

Figure 107 illustrates data for 2014-Q2, where counter-intuitively it seems, advanced economies have the lowest share of foreign reserves. But further inspection will soon establish that these same economies are the largest borrowers, first due to higher credit rating and on the converse they exhibit an inflow tendency due to the attractiveness of investments in advanced economies. Thus, you would expect to see net lending from rich countries to poor countries, however it is the other way around.

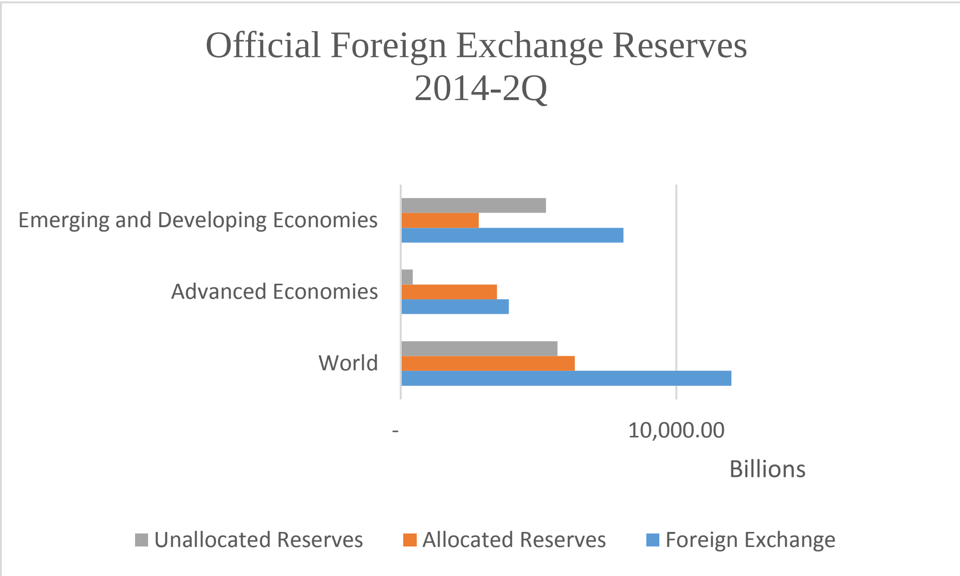


Figure 108: Official Foreign Exchange Reserves 2014- Q2
Source: author's own figure.

Furthermore, Figure 108 provides an in-depth dissection in support of the above analysis for Figure 107. The advanced economy (e.g. the US, UK and Swiss economies) elements with the largest share of wealth by definition have the lowest share of reserves. Despite high current account deficits and strong capital inflows, US net foreign liabilities have remained stable in recent years for example. Similarly, low interest rates have continued to make the Euro attractive hence the trend.

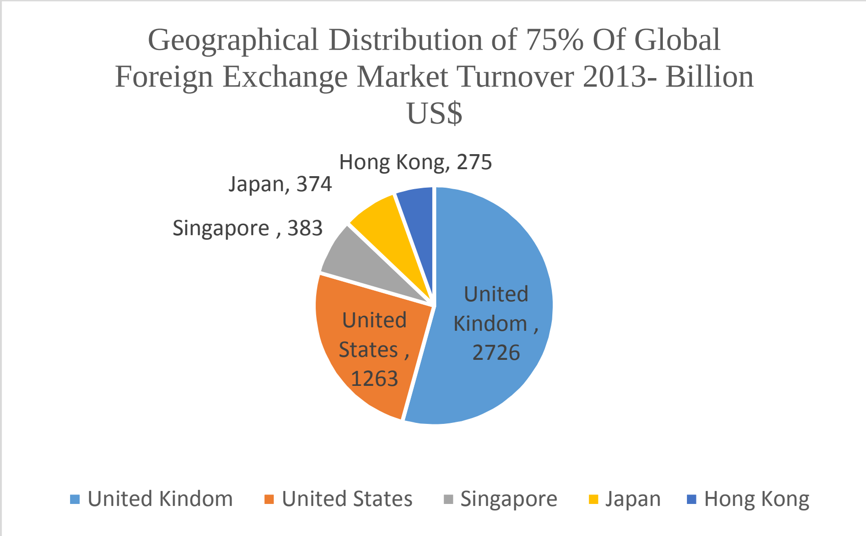


Figure 109: Geographical Distribution of 75% Of Global Foreign Exchange Market Turnover
Source: author's own figure**.**

Not only did the Dollar's share in global foreign currency reserves change only modestly in the decade before the crisis, according to BIS data, in September 2014 (the following chart) the Dollar claims 61 percent of world currency composition of official foreign exchange reserves in the second quarter of 2014. Charts 110 and 111 show the Dollar's share compared to other currencies.

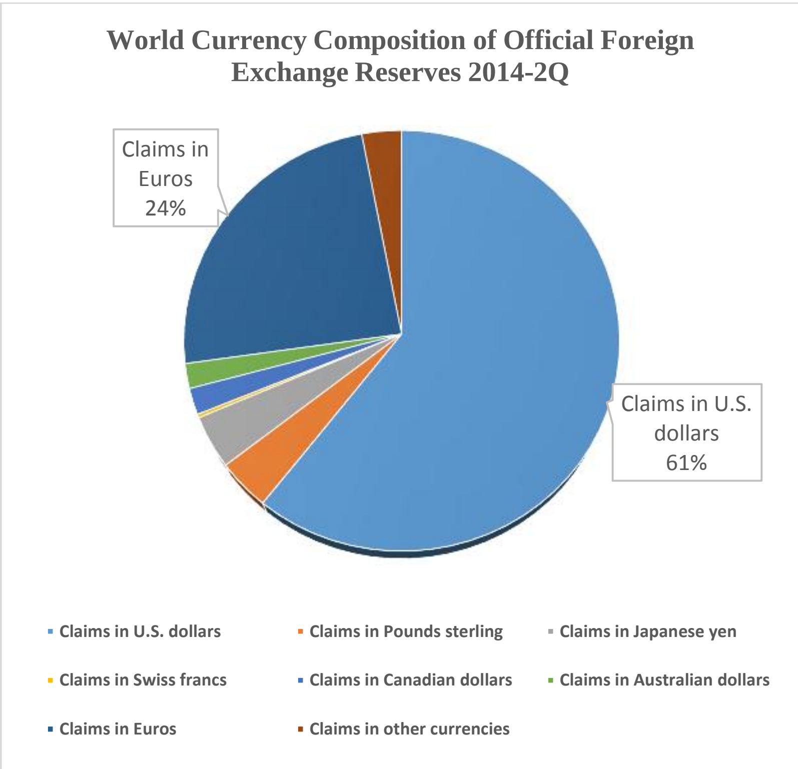


Figure 110: World Currency Composition of Official Foreign Exchange Reserves
Source: author's own figure.

Chart 110 also shows a steady decline over the years of the preference the Dollar enjoys, and over time the Euro is shown to eat up the area lost.

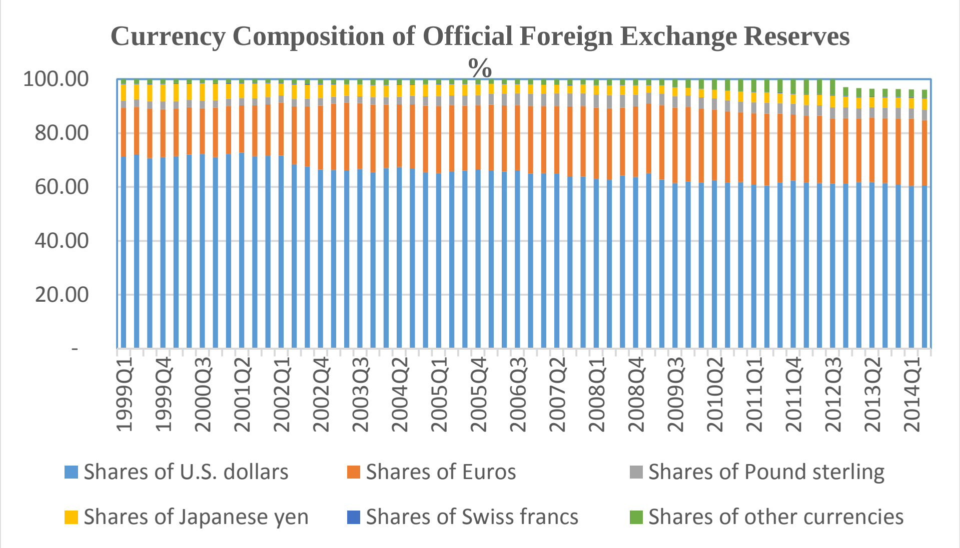


Figure 111 Currency Composition of Official Foreign Exchange Reserves %
Source: author's own figure.

Dollar dominance is not limited to currency reserve but according to SWIFT data 47% of world payments in value, is in dollar. According to data from SWIFT and the author's personal calculations, around 85% of Global Trade finance value on January 2012 was in dollar however this figure is reduced to 81% on October 2013, following the trend.

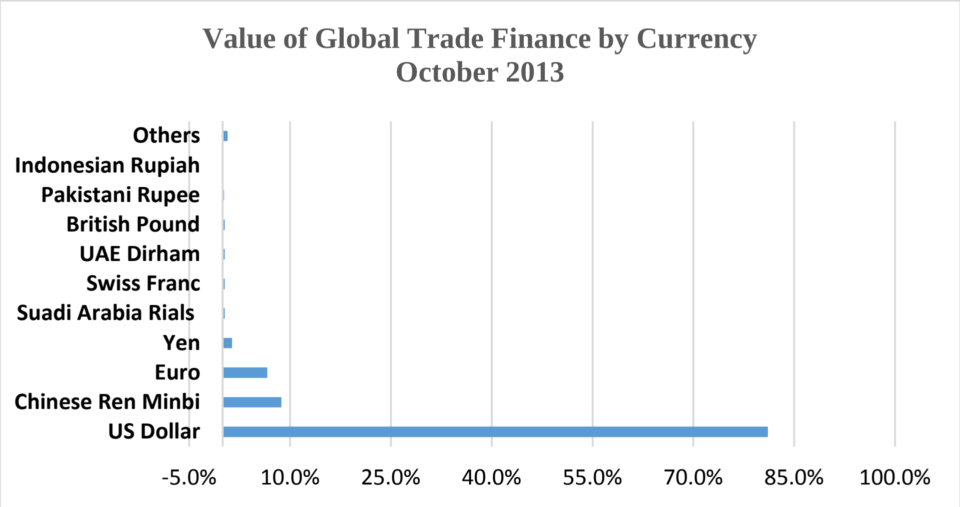


Figure 112: Value of Global Trade Finance by Currency
Source: author's own figure.

Trade finance seems to be even more dollar denominated than global trade, with close to 80% market share recorded here in 2013-Q4 (Figure 112). A curtailment in dollar funding lines however appears to be the biggest threat to this trend as will be illustrated in June 2014 data (Figure 113).

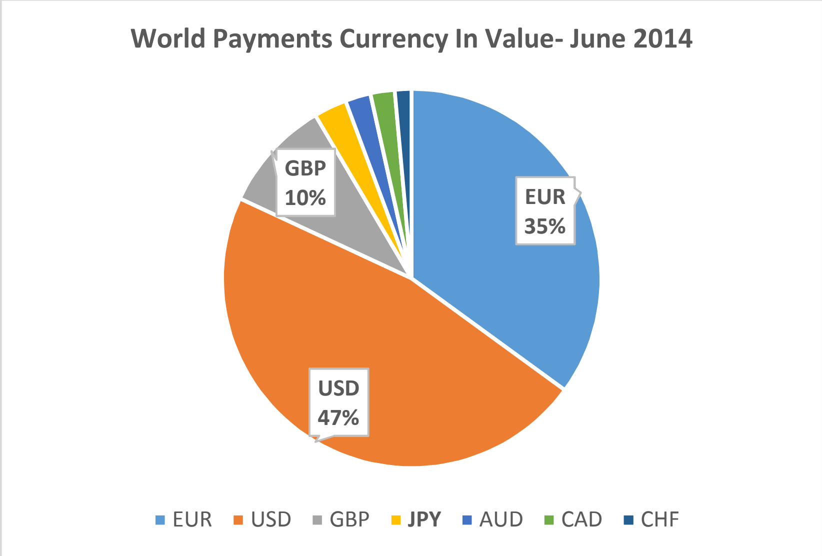


Figure 113: World Payments Currency in Value
Source: author's own figu.re

Increasingly, the dollar's hegemony on world payments currency dominance is being dented as more and more market share moves to local currencies. Over the years, the lion's share of commercial settlements worldwide have cleared in US dollars – even if the parties involved have nothing to do with the States, and this can be linked to the prevalence of US dollars in foreign reserves. The chart in Figure 113 is consistent with the US dollar's predominant role as the currency of denomination for invoicing trade outside Europe, it is also the dominant currency of denomination for international payments (by international banks, large corporations and SME's) with over 40% settled in US dollars. The euro is the second most important currency with a 35% share mostly due to domestic trade within the European Union.

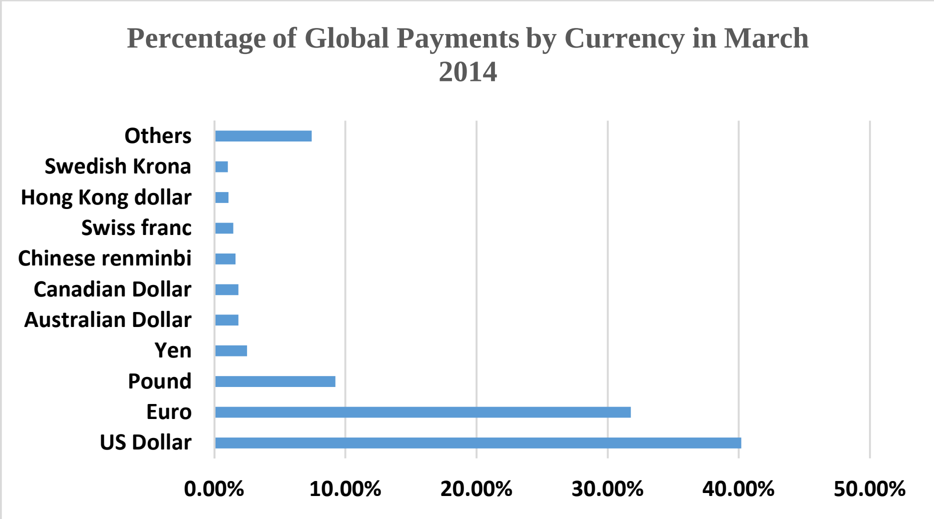


Figure 114: Percentage of Global Payments by Currency
Source: author's own figure.

Closer inspection reveals that payments volume in 2014 was in excess of equivalent to 1.7 trillion USDs. The full capacity of global payments covers cross-border supplier payments, global e-commerce, global pay outs and international remittances. Large banking foreign exchange platforms with advances in technology make it possible for the multi-currency spread seen in the chart above (Figure 114).

The reason the dollar keeps its position in currency distribution of global foreign exchange market turnover has been cited as monetary policies that favour interest accumulation and net profits for the last few decades (see figure 115)

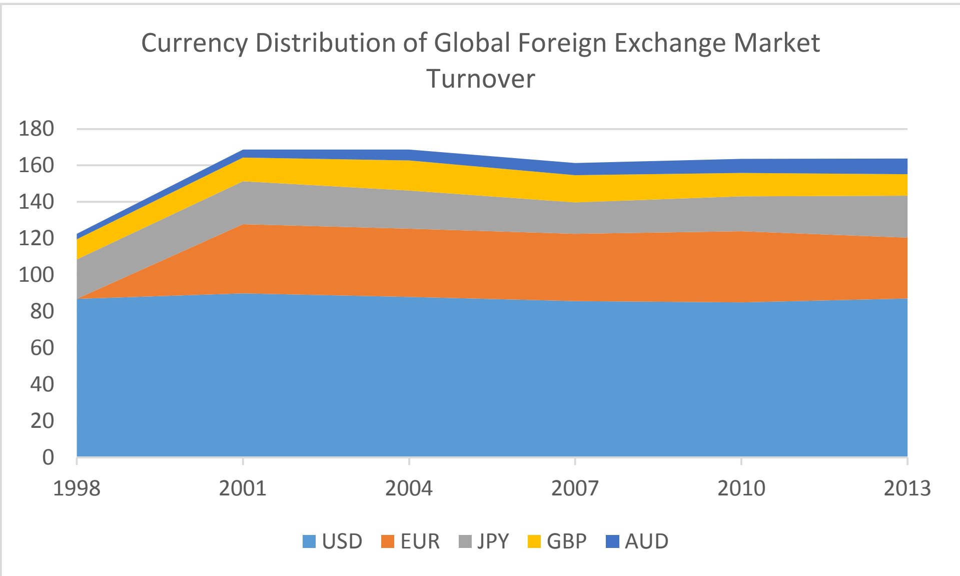


Figure 115 Currency Distribution of Global Foreign Exchange Market Turnover
Source: author's own figure.

In the area graph below, figures show that more than twice as many transactions between 2004 and 2013, trade volume climbed from $1.9 trillion to $5.3 trillion. This upward trend should remain intact, seeing the growing importance of FX as an asset class, as well as its increased use in global fund management assets use of financial derivatives. In addition, FX execution venues can be performed on diverse electronic platforms giving a wider access to the market. Turnover increased across all FX instruments, as illustrated in the chart, Figure 116. FX instruments showed the largest increase in absolute amounts, up over 120% and remain the most traded, accounting for 61% of all FX transactions. Spot transactions increased in a similar fashion, albeit by smaller margins, remarkably between 2007 and 2013. Turnover in FX swaps experienced a serious decline from the high values between 2007 until 2011, compared to 2013.

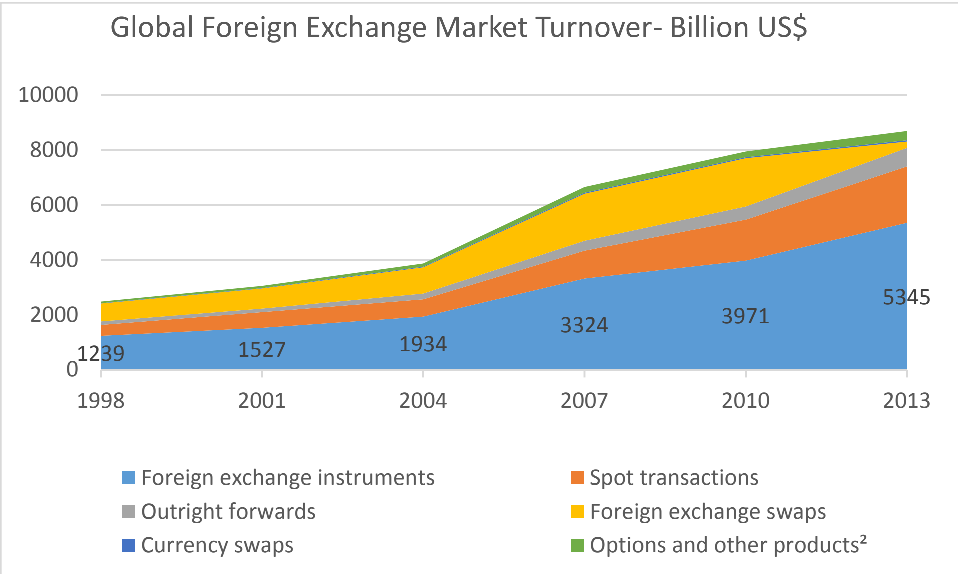


Figure 116: Global Foreign Exchange Market Turnover
Source: author's own figure.

Data shows the US dollar dominance will continue, although the global financial crisis has put a dent in market confidence, and thus shattered conventional views about the amount of reserves an economy needs to protect itself from the spillover effects of global crises.

7.6.3 Neglecting Public Interest

Some critics argue that policymakers have bent to the interests of financial firms while neglecting their duty to safeguard the general public. From the early 1980s until the financial crisis, financial sector regulation in particular the US and UK were slowly but steadily eroded by acts of Congress or decisions from administrative regulators (see also, Moss, 2010). For instance, in the US during the bubble years of 2000-2006, congressional bills that sought to tighten regulation were three times less likely to pass Congress than those that called for reduced regulation (Deniz and Mishra, 2011) Most notably many considered the repeal of the Glass-Steagall Act in 1999 to be one of the more critical regulatory changes that played a role in the financial crisis.

Policymakers' increasing adherence to the theory of self-regulating finance can help explain some of this trajectory, but the potential role of bank lobbying, campaign contributions, and quid-pro-quo favours should also be examined. Empirical studies have found that lobbying by the finance industry has had a significant effect on the outcome of regulatory legislation. From 2000-2006, the probability that a given congressional representative would vote "no" on a pro-regulation bill or "yes" on an anti-regulation bill increased with the amount of money that financial firms spent to lobby that individual.(Deniz and Mishra, 2011).

7.6.4 Rise of Neoliberalism in Economy

Since the 1930s the non-communist world has experienced two shifts in international economic norms and rules substantial enough to be called 'regime changes' (Wade, 208). They were separated by an interval of roughly thirty years: the first regime, characterized by Keynesianism and governed by the international Bretton Woods arrangements, lasted from about 1945 to 1975; the second began after the breakdown of Bretton Woods, and prevailed until the First World debt crisis of 2007–08. This latter regime, known variously as neoliberalism, the 'Washington Consensus'[37] or the globalization consensus, centred on the notion that all governments should liberalize, privatize, deregulate—prescriptions that have been so dominant at the level of global

[37] The term 'Washington Consensus' devised in 1989 by Williamson to refer to a set of ten policy recommendations, came to be used in a much broader sense, encompassing financial deregulation, free capital mobility, unrestricted purchase of local companies by foreign companies and unrestricted establishment of subsidiaries.

economic policy as to constitute, in John Stuart Mill's phrase, 'the deep slumber of a decided opinion'.

7.6.5 Rise of global Shadow Banking System

Financial Stability Board in its annual report has described shadow banking system as credit intermediation involving entities and activities outside of the regular banking system Financial Stability Board (2015). Intermediating credit through non-bank channels can have important advantages and contributes to the financing of the real economy, but such channels can also become a source of systemic risk, especially when they are structured to perform bank-like functions (e.g. maturity and liquidity transformation, and leverage) and when their interconnectedness with the regular banking system is strong Financial Stability Board (2015). The rapid growth of the market-based financial system since the mid-1980s changed the nature of financial intermediation. Within the market-based financial system, 'shadow banks' have served a critical role (Pozsar et al., 2012). Shadow banks are financial intermediaries that conduct maturity, credit, and liquidity transformation without explicit access to central bank liquidity or public sector credit guarantees. Examples of shadow banks include finance companies, asset-backed commercial paper (ABCP) conduits, structured investment vehicles (SIVs), credit hedge funds, money market mutual funds, securities lenders, limited-purpose finance companies (LPFCs), and the government-sponsored enterprises (GSEs). The financial crisis 2007-8 has highlighted the growing importance of the 'shadow banking system', which grew out of the securitization of assets and the integration of banking with capital market developments (Adrian and Shin, 2009). This trend has been most pronounced in the United States, but it has had a profound influence on the global financial system.

According to Financial Stability Board (2015) global shadow banking monitoring report 2015 global assets of financial entities classified as shadow banking under the economic functions approach in 26 jurisdictions continued their upward trend, increasing $1.1 trillion in 2014 and reaching $36 trillion Based on this measure, aggregate global shadow banking assets in these jurisdictions have increased on average by $1.3 trillion each year since 2011.

	Size in 2014 ($ trillion)	Growth in 2014 (year over year, percent)	Average annual growth (2011-2014, percent)
Banks	135	6.4	5.6
OFIs	68	9	6.3
Shadow Banking	36	10.1	6.3

Sources: National financial accounts; other national sources; FSB calculations (Financial Stability Board, 2015).

In a market-based financial system, banking and capital market developments are inseparable: Funding conditions are closely tied to fluctuations in the leverage of market-based financial intermediaries. Growth in the balance sheets of these intermediaries provides a sense of the availability of credit, while contractions of their balance sheets have tended to precede the onset of financial crises. Securitization was intended as a way to transfer credit risk to those better able to absorb losses, but instead it increased the fragility of the entire financial system by allowing banks and other intermediaries to "leverage up" by buying one another's securities. In the new, post-crisis financial system, the role of securitization will likely be held in check by more stringent financial regulation and by the recognition that it is important to prevent excessive leverage and maturity mismatch, both of which can undermine financial stability.

7.6.6 Highlighting Efficient Market Hypothesis (EMH) in light of Neoliberalism

In the realm of finance, neoliberal prescriptions were justified by the 'efficient markets hypothesis', which claimed that market prices convey all relevant information and that markets clear continuously—rendering sustained disequilibria, such as bubbles, unlikely; and making policy action to stop them inadvisable, due to their redundancy, since this would constitute 'financial repression'.

We would like to highlight the efficiency is neither a derived nor an observable property of financial markets. It is an assumption or assertion required to construct optimal asset pricing models that conclude that risk and return are properly priced. Fama (1991), one of the creators of efficient financial market theory, argues that "models of market equilibrium start with the presumption that markets are efficient" (p. 1575). The assumption is that all agents use all relevant information about securities correctly in the price setting process in financial markets. In neoclassical models, this information is the correct expectation of the distributions of future cash flows associated with each security – or 'rational' expectations. These are the vaunted knowable future 'fundamentals' of the theory. The efficient financial market assumption "is not empirically testable unless some equilibrium model of security returns is specified" (Beaver, 1981, p. 28). The canonical models of capital asset pricing insert this assumption into a theory of optimal equilibrium price formation based on agent utility maximization in perfectly competitive markets.[38]

The models of optimal asset pricing might be best understood as intellectual exercises in which the theorist asks the question: 'What is the minimum set of assumptions needed to generate the desired conclusion that capital markets price risk and return correctly?'' Let us assume in the absence of the Efficient Market Hypothesis, an alternative method of analysis would be to begin with a set of realistic assumptions about the financial markets and then ask: "What theory of the behaviour of financial markets can be derived from these assumptions?" This is the method associated with the work of Keynes and Minsky as Crotty (1985, p. 563) notes. Crotty (op. cit.) argues that the realism of assumptions matters greatly.

However, the efficient markets hypothesis is simple in principle, but remains elusive, as *ceteris paribus* a key economic concept, is near impossible to implement. Evolving from an initially puzzling set of observations about the random character of security prices, it became the dominant paradigm in finance since 1970s.

7.6.7 Credit Based Economy or Living on Thin Air

We have all heard about how the economy is like a car. It's the most popular analogy in financial reporting and political discourse. Some notable economists including Nobel-laureate Joseph Stiglitz, claim that our economy is stuck in 'first gear' due to inequality: too much income is concentrated among too few rich people who tend to save a larger share of their income and thus have a lower 'marginal propensity to consume'. The key Keynesian message is, if you want to put the economic pedal to the metal, you should consume. But we need to produce before consuming, we should not

[38] These models assume that financial markets are never out of equilibrium because they cannot deal with disequilibrium dynamics.

put the shopping cart before the horse. Where do these ‘consumers’ get their money to spend? Where does money come from? It is the main question in a published guide to the UK monetary and banking system Werner et al. (2012). According to the latter contributors there is widespread misunderstanding of how new money is created. The book examines the workings of the UK monetary system and concludes that the most useful description is that new money is created by commercial banks when they extend or create credit, either through making loans or buying existing assets. I think the more important issue the book raised is the misunderstanding of how new money is created is a problem for two main reasons. First, in the absence of this understanding, attempts at banking reform are more likely to fail. Second, the creation of new money and the allocation of purchasing power are a vital economic function and highly profitable. They conclude that it is therefore a matter of significant public interest and not an obscure technocratic debate. They argue that physical cash accounts for less than 3 per cent of the total stock of money in the economy. Commercial bank money – credit and coexistent deposits – makes up the remaining 97 per cent of the money supply.

The main question is if the banks have this power to create new money so what is the foundation of the economy? Are we creating the economy on thin air?

> To answer this question, I start with the basic question, which Leadbeater (1999) raised: “What do you make to earn your living?” (p. 101). Do you make anything tangible that can be weighed, measured or touched? For most people the answer is no. More and more of us make our livings from thin air. In old capitalism, the critical assets were raw materials, land, labour and machinery. In the new capitalism, the raw materials are know-how, creativity, ingenuity and imagination. As a result, the opportunities for growth are boundless. But this new economy is perilous as well as powerful. An economy driven by creativity should be more humane. Instead, most of us feel our economic lives are out of control, dominated by soulless financial markets and clouded by the insecurities bred by corporate downsizing. He explains that living on thin air is about how we can create an environment that is both innovative and inclusive. Our societies should be organized around the creation of knowledge capital and social capital, rather than being dominated by the power of financial capital (Leadbeater, 1999). Ingham (2008) defines capitalism in terms first used by

> Keynes: as a ‘monetary production economy’. He explains that “bank credit-money and financial asset markets give the capitalist system its dynamism, flexibility and adaptability; on the other hand, they inevitably generate asset price ‘bubbles’ financed by debt and the inevitable defaults that sooner or later burst them” (p. 230). Ingham’s (op. cit.) understanding of capitalism as a monetary production economy makes a refreshing change from more typical characterisations of capitalism.

This neglect by economists but also policy-makers of commercial bank balance sheets, should not come as a surprise. Pettifor (2013) argues that while economists and many bank regulators turned a blind eye, what happened next, and as Haldane (2012) notes, was extraordinary. Commercial banks' balance sheets grew by the largest amount in human history.

7.6.7.1 Credit Creating

To have a better picture of how we are living on thin air, we review very briefly credit creating during last decades.

A sustainable credit report (Sustainable Credit Report 2011) study released by the World Economic Forum (WEF), finds that while global credit stock doubled from $57 trillion to $109 trillion in just 10 years (from 2000 to 2010), it will need to double again to an incredible $210 trillion by 2020 in order to provide the necessary credit-driven growth (in a recursive way, whereby credit feeds growth, and growth requires additional credit issuance) for world GDP to retain its current growth rate. The report indicating that expansion was spread fairly evenly between the government, wholesale and retail segments until 2009, when government lending rose sharply to fund the banking bailout and to support economic stimulus programmes (below Figure 117).

Figure 117 Global Credit Stock Volume 2000-2009

Source: World Economic Forum, Sustainable Credit Report (2011).

Furthermore, Figure 117 displays patterns in average global credit growth also covering the past economic and financial crisis.

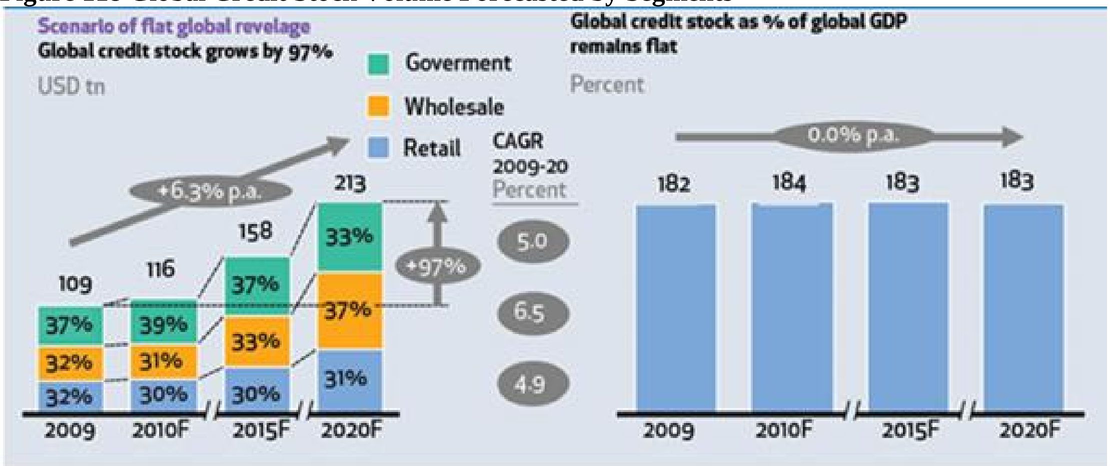
The study also forecast the global stock of loans outstanding from 2010 to 2020, assuming a consensus projection of global economic growth at 6.3% (nominal) per annum based on IMF staff's analysis and projections of economic developments at the global level, in major country groups as implemented by the *World Economic Outlook* report. [39] Three scenarios of credit growth for 2009-2020 were modelled:

1. Global leverage decrease. Global credit stock would grow at 5.5% per annum, reaching US$ 196 trillion in 2020. To meet consensus economic growth under this scenario, equity would need to grow almost twice as fast as GDP.
2. Global leverage increase. Global credit stock would grow at 6.6% per annum, reaching US$ 220 trillion in 2020. Likely deleveraging in currently overheated segments militates against this scenario.
3. Flat global leverage. Global credit stock would grow at 6.3% per annum to 2020, tracking GDP growth and reaching US$ 213 trillion in 2020 – almost double the total in 2009 (below Exhibit A, Figure 118). This scenario, which assumes that modest deleveraging in developed markets

[39] International Monetary Fund, World Economic Outlook. Tensions from the Two-Speed Recovery: Unemployment, Commodities, and Capital Flows. April 2011. Available at: https://www.imf.org/external/pubs/ft/weo/2011/01/

will be offset by credit growth in developing markets, provides the primary credit growth forecast used in this report.

Figure 118 Global Credit Stock Volume Forecasted by Segments



Source: World Economic Forum, Sustainable Credit Report (2011).

Rapid credit growth is forecast in developing markets, which will add almost US$ 50 trillion to their credit stock by 2020.

7.6.7.2 Economy Engine

Gordon (2012) in answering he question ‘Is US economic growth over?’ addressing that prior to 1750, there was little or no economic growth. It took around 500 years from 1300 to 1800 for the standard of living to double. Between 1800 and 1900, it doubled again.

The 20th century saw rapid improvements in living standards, which increased by five or six times. Living standards doubled between 1929 and 1957, and again between 1957 and 1988.

Between 1500 and 1820, economic production increased by less than 2% per century. Between 1820 and 1900, economic production roughly doubled. Between 1901 and 2000, economic production increased by a factor of something like four times. Gordon (op. cit.) questions the assumption, nearly universal since Solow’s (1956) seminal contributions of the 1950s, that economic growth is a continuous process, he argues that growth and improvements in living standards will slow significantly. He speculates that future growth rates may be 0.2%, well below even the modest 1.8% between 1987 and 2007.

Low or no growth is not necessarily a problem. But the current economic, political and social system is predicated on endless economic expansion and improvements in living standards. Boulding (1966) warned that "Anyone who believes exponential growth can go on forever in a finite world is either a madman or an economist" (p. 3).

7.7 Reforming International Financial Architecture

Eichengreen (1999) suggests that there is no shortage of proposals for reforming the international financial architecture. Many of these proposals are contradictory and mutually incompatible. The recommendations in his book follow from six assumptions for the operation of the international financial system. His recommendations for reforming the international financial architecture flow from these assumptions. They may seem unambitious in comparison, but they at least have a chance of being implemented. In effect, he stakes out a middle ground between the overly ambitious and politically unrealistic schemes of independent commentators and the excessively timid and ambiguous reports of international bodies and organizations. In his view point academics should be bolder than bureaucrats, but their recommendations should take the political realities into account.

Financial crises have always come in different flavors; this will be true in the future as it has been in the past. Macroeconomic imbalances can play a part in second class of financial crises, but theirs is not the leading role. First, some countries will continue to suffer crises purely because their governments follow reckless macroeconomic policies, but there old-fashioned balance of payments crises will become more the exception and less the rule. Second, there is relatively little confusion about how to treat crises caused by macroeconomic excesses. Finally Eichengreen (1999) indicating in his book that his goal instead is to suggest some practical reforms that will improve the trade off between financial liberalization and financial stability. He summarise the following recommendations:

1. UK: Creating permanent Standing Committee for Global Financial Regulation bringing together the IMF, the World Bank, the Basle Committee, and other

regulatory groups, and to establish and implement international standards for financial regulation and supervision.

2. French proposal: transforming the Interim Committee into a council that would serve as the ultimate decision-making body for the IMF.
3. US: creation of a contingency-finance mechanism
4. Canadian: six-point plan: vigilance on the part of G-7 central banks, the pursuit of strong policies by emerging-market economies, attention to the needs of the poorest countries, steps to strengthen national financial systems and international oversight, development of a specific strategy for prudent liberalization of the capital account, and mechanisms for involving private investors in the resolution of crises.

The proposals for the New Global Financial Architecture were focusing on bank supervision and regulation, auditing and accounting, bankruptcy procedures, and corporate governance. The IMF has sought to encourage the authorities to improve prudential supervision, root out corruption, eliminate subsidies, break up monopolies, and strengthen competition policy---intrusiveness. Capital is so mobile internationally, stabilizing the balance of payments means stabilizing the capital account, which requires restoring investor confidence. And restoring investor confidence means restoring confidence in the stability of the domestic financial system. (see for example: Dornbusch,1998;Eichengreen and Sussman , 2000;Eichengreen and Hausmann, 1999; Frankel 1999; Goldstein 1998; Rogoff ,1999).

7.8 New Global Financial Architecture, is it really a New Architecture?

17 years ago the East Asian, Russian and Brazilian crises of 1997–98 struck panic in the High Command of world finance, and were followed by vigorous discussion around a ‘new global financial architecture’. Robert wade for example indicated that after the financial crisis during 90s and early 2000 when it became clear that the Atlantic heartland would not be affected, the radical talk quickly subsided. (Wade. 2008) The upshot was a raft of new or reinvigorated public and private international bodies tasked with formulating standards of good practice in corporate governance, bank supervision, financial accounting, data dissemination and the like. For further details see Wade (2007A), and Arestis and Eatwell (2008). Such efforts diverted attention from the issue of re-regulation, and the financial sector in the West was able to ensure that

governmental initiatives did not include new constraints, such as limits on leverage or on new financial products.

Eichengreen (2011) indicating that the term architecture conveys a rather misleading sense; this is in terms of the nature of the process. By addressing the annual research conference of the Bank of Korea Eichengreen (op. cit.) suggests that "If US President Clinton's treasury secretary Robert Rubin is responsible for coining the phrase "international financial architecture" in a speech at the Brookings Institution in 1998, I deserve some of the blame for popularizing it" (p. 2). He continues that he used it in the title of his 1999 book, "I say blame because the term architecture conveys a rather misleading sense of the nature of the process" (p. 1). Mirriam-Webster's on-line dictionary defines architecture as "a unifying or coherent form or structure" (as in "this novel displays an admirable architecture").[40] In other words, the term implies a unity and coherence that financial markets, institutions and policies do not possess. Alternatively, Mirriam-Webster defines "architecture" as "a formation or construction resulting from or as if from a conscious act." But many of our international arrangements have, in fact, evolved as unintended consequences of past actions rather than as the result of anyone's conscious act, "as if" or otherwise.

The international financial system lacks the bodies that set standards and establish rules at the national level (Wade, 2007A). But rather than implementing institutional reforms that might help to stave off further instabilities, the West has sought to build a comprehensive regime of global economic standardization, surveillance and correction. Such areas as data dissemination, bank supervision, corporate governance and financial accounting have been subjected to greater scrutiny, through the concerted efforts of a range of actors: the IMF, the Basel Committee on Banking Supervision, the Financial Stability Forum, the G20 of finance ministers and a gamut of non-official bodies. Enforcement is to come largely through peer pressure and market reactions to information about compliance, so that countries, banks and firms which comply more closely with the standards gain better access to finance than those which comply less. These rules—what Wade (2007A) called them 'standards-surveillance-compliance' system have been drafted by a US-led institutional complex, including Western governments and multilateral organizations such as the IMF, as well as financial firms and think-tanks from the advanced capitalist states; the global South, of course, has had

[40] Available at: http://www.merriam-webster.com/dictionary/architecture

almost no say. The resulting regime is only one part of a larger set of international arrangements which have the effect of redistributing income upwards—to wealthy industrialized countries, the financial sector, and the top percentile of world income distribution. But its impact has been far-reaching, pushing a range of national economies towards one particular kind of capitalism, and shrinking the scope of 'policy space' for these countries still further than did the prescriptions of the Washington Consensus. Where the latter insisted on liberalizing the market, deregulation and fiscal austerity, the Post-Washington Consensus could be summed up by the commandment: 'standardize the market'.

7.9 Systemic flaws in new global financial architecture

7.9.1 Key structural flaws of the new global financial architecture

The objective of the new financial architecture as defined by the G7 and the IMF is to control international financial instability (see Cartapanis and Herland, 2002; Soederberg,2002)
Some commentators were still arguing that the crisis was a blip, analogous to a muscle strain in a champion athlete which could be healed with some rest and physiotherapy—as opposed to a heart attack in a 60-a-day smoker whose cure would require surgery and major changes in lifestyle.

There is a burgeoning literature on the global financial crisis and its causes, which is characterised by a 'vast disagreement about its main causes' (CARMASS et al., 2009). This section is an attempt to go beyond speculative, one-sided and individualistic explanations of the crisis which portray it as an 'act of God', or the result of greed and stupidity, herd behaviour, a blip, the construction of too many houses, analogous to a muscle strain in a champion athlete which could be healed with some rest and physiotherapy, the over-regulation of free markets, neoliberalism or regulatory failure.(see for example Butler,2008; Dobson,2008; Fine,2008; Stiglitz,2008; Faber, 2009; Garnaut,2009)

This section highlights the root causes of the global financial crisis rather than symptoms. We attempt to show the crisis was a heart attack in body of world economy whose cure would require possible surgery and major changes in lifestyle, and this is inherent systemic risk (embedded systemic risk) of the financial system. Without changing lifestyle, strategy and approach there is no guarantee of avoiding another attack.

The problem is much more that policy makers forget the lessons of the past and are easily seduced by the idea that the economic system could care for itself. It also attempts to go beyond official versions of the crisis which portray it as a 'financial crisis' divorced from a 'real economy' with 'sound fundamentals'. This view was favoured and promulgated by politicians and government officials, such as US President George W. Bush, Republican Senator John McCain, Federal Reserve Chair Ben Bernanke and Treasury Secretary Henry Paulson. Henderson,2005;Xinhua ,2008; Stein,2008)

In this section we try to use Marx's (2007, 1858) methodological advice for studying crises to examine the potential for crisis in both the spheres of production and finance, and how these are interrelated. Crotty (2009) addressed the key structural flaws of the New Financial Architecture (NFA) as follows:

A. The NFA is built on a very weak theoretical foundation.

The NFA is based on light regulation of commercial banks, even lighter regulation of investment banks and little, if any, regulation of the 'shadow banking system'—hedge and private equity funds and bank-created Structured Investment Vehicles (SIVs). As one bond trader described the current situation as 'the financial equivalent of the Reign of Terror during the French Revolution'. (Jansen, 2008). In these circumstances, the efficient markets hypothesis and the prescriptions derived from it have been thoroughly discredited.

B. The NFA has widespread perverse incentives that create excessive risk, exacerbate booms and generate crises.

The current financial system is riddled with perverse incentives that induce key personnel in virtually all important financial institutions—including commercial and investment banks, hedge and private equity funds, insurance companies and mutual and pension funds—to take excessive risk when financial markets are buoyant.[41]

C. Innovation created important financial products so complex and opaque they could not be priced correctly; they therefore lost liquidity when the boom ended.

Financial innovation has proceeded to the point where important structured financial products are so complex that they are inherently non-transparent. They cannot be priced correctly, are not sold on markets and are illiquid. According to the Securities Industry and Financial Markets Association (SIFMA), there was 500 billion dollars in Collateralised Debt Obligation (CDOs) were issued in both 2006 and 2007, up from 680 trillion worth of derivatives are sold over-the-counter in private deals negotiated between an investment bank and one or more customers. Thus, the claim that competitive capital markets price risk optimally, which is the foundation of the NFA, does not apply even in principle *to* these securities.

D. The claim that commercial banks distributed almost all risky assets to capital markets and hedged whatever risk remained was false.

Crotty (2008) argues that the conventional view was that banks were not risky because, in contrast to the previous era when they held the loans they made, they now sold their loans to capital markets through securitisation in the new 'originate and distribute' banking model. Moreover, it was believed that banks hedged whatever risk remained through CDSs. Both these propositions turned out to be false. Banks kept risky products such as Mortgaged Backed Securities (MBSs) and Collateralised Debt Obligations (CDOs) for five reasons, none of which were considered in the NFA narrative about efficient capital markets.

E. Regulators allowed banks to hold assets off balance sheet with no capital required to support them.

In the late 1990s, banks were allowed to hold risky securities off their balance sheets in SIVs with no capital required to support them.

Regulators allowed giant banks to measure their own risk and set their own capital requirements. Given perverse incentives, this inevitably led to excessive risk-taking.

[41] An analysis of the effects of perverse incentives in different market segments is presented in Crotty (2008).

Deregulation allowed financial conglomerates to become so large and complex that neither insiders nor outsiders could accurately evaluate their risk. The Bank for International Settlement told national regulators to allow banks to evaluate their own risk—and thus set their own capital requirements—through a statistical exercise based on historical data called Value at Risk (VAR). Government officials thus ceded to banks, as they had to ratings agencies, crucial aspects of regulatory power. VAR is an estimate of the highest possible loss in the value of a portfolio of securities over a fixed time interval with a specific statistical confidence level. The standard exercise calculates VAR under negative conditions likely to occur less than 5% of the time.

F. Heavy reliance on complex financial products in a tightly integrated global financial system created channels of contagion that raised systemic risk.

It was claimed that in the NFA, complex derivatives would allow the risk associated with securities to be divided into its component parts, such as interest rate and counter-party risk. Investors could buy only those risk segments they felt comfortable holding. And rather than concentrate in banks as in the 'Golden Age' financial system, it was argued, risk would be lightly sprinkled on agents all across the globe. Since markets price risk correctly, no one would be fooled into holding excessive risk, so systemic risk would be minimised. Then New York Fed Chairman, and current Secretary of the Treasury, Timothy Geithner stated in 2006: 'In the financial system we have today, with less risk concentrated in banks, the probability of systemic financial crises may be lower than in traditional bank-centred financial systems' (Geithner, 2008).

G. The NFA facilitated the growth of dangerously high system-wide leverage.

In Crotty's (2008) argument, the structural flaws in the NFA created dangerous leverage throughout the financial system. Annual borrowing by US financial institutions as a percent of gross domestic product (GDP) jumped from 6.9% in 1997 to 12.8% a decade later.

Panitch and Leys (2002) argue that the New International Financial Architecture (NIFA) is an attempt to strike a balance between financial deregulation and stability by encouraging governments of emerging markets to adopt only 'prudent' policies to restrain the inflow of speculative capital and to encourage more productive, long-term capital formation. Top officials from the IFIs have argued that certain limited capital controls (as opposed to universal controls, such as the Tobin tax) in emerging markets are acceptable as temporary, second-best options — that is, next to the first-best option of complete liberalization, which allows the magical self-corrective forces of the market to do their trick through open capital accounts. Panitch and Leys (2002) were arguing that there is also the problem that 'peripheral' political elites woo foreign capital by making significant concessions to global players. Governments have to address and subdue the escalating social conflicts to which these concessions give rise in ways that will not lead to capital flight or investment strikes — but, under the NIFA rules, with one hand tied behind their backs. They conclude that governments must also depoliticize these struggles in order to maintain their own legitimacy.

Another key structural flaws of the New Financial Architecture is the lack of Keynes's (1943) International Clearing Union. The International Clearing Union (ICU) would be a global bank whose job would be the clearance of trade between nations. All international trade would be denominated in its own unit of account, the proposed bancor. The bancor was to have had a fixed exchange rate with national currencies, and would have been used to measure the balance of trade between nations. Keynes (op. cit.) argued that international financial imbalances are not always due to the profligacy of debtor countries; creditor nations also play their part in that they withdraw money (gold) from circulation and hoard it as reserves. Refusing to spend this income on either domestic consumption or overseas investment reduces the international supply of money, leading to global unemployment and a stagnating industrial system. Under the non-politicized ICU, every member state's central bank would exchange their currency for an initial reserve of Bancor and a corresponding quota of overdraft facilities based on loose calculations of the previous three-five years' trade volume. Upon accession to the ICU, member states would agree on the values of their currencies in terms of bancors, maintaining their national currencies for domestic use. While this value could later be altered with the permission of the Governing Board, Keynes envisioned a system of relatively fixed exchange rates. International trade between countries would be done in bancors, deposited or debited to a country's ICU account.

As Keynes (1943) recognised, there is not much the debtor nations can do. Only the countries that maintain a trade surplus have real agency, so it is they who must be obliged to change their policies. His solution was an ingenious system for persuading the creditor nations to spend their surplus money back into the economies of the debtor nations. On 2008 G20 leaders admitted that "the Bretton Woods institutions must be comprehensively reformed" (G20, 2008, p. 2). But the only concrete suggestions they made were that the IMF should be given more money and that poorer nations 'should have greater voice and representation. Hess (2012, p. 27) assesses Keynes' (1943) 'Proposals for an International Clearing Union', presented at the 1944 Bretton Woods conference, that would have created a universal currency valid for trade transactions with all member countries via a supranational bank-like clearing union. He argues that Keynes' 1944 proposals could potentially provide a more solid alternative to the European monetary system for regional monetary integration.

7.10 Role of deregulation in Global Financial Architecture

Silvers (2012, chapter 21, p. 480) indicated that technology and innovation were significant contributors to the transformation of the global financial architecture. He thinks regulatory change in the form of deregulation was at the heart of the particular shape that the world's financial markets took in the post – cold war era. Silvers continues his address that the United States had the most developed regulatory structure in the post-war era, and it led the way in dismantling that structure, though in a sense the first move was the collapse of the post-war currency regulation system in 1971 Silvers (2012, chapter 21, p. 430). Other countries undertook similar efforts, ranging from the privatization of financial institutions in a range of countries, to establishment of equity markets in former Communist countries, to the liberalization of securities markets in the United Kingdom's Big Bang in the 1980s. But the United States set the tone, and ultimately, the consequences in the United States triggered the global financial and economic crisis. Silvers (2012) believes that the story of policy change is central to understanding the financial crisis. That is the story of how, following 1970 global labor-market deregulation, 'structural adjustment', the global trading regime, and national tax policies combined to repress workers' incomes and to increase economic insecurity and economic inequality. The mirage that finance could create income was a response to the lack of income itself among the working majorities of the world, particularly in the United States.

Although Silvers (2012) focuses on deregulation role in financial crisis, he, nonetheless, looks at the deregulation in light of development of financial economics. At a more technical level, the development of financial economics undermined the logic behind the efforts of the New Deal regulatory regime to create separate, solid capital markets. Two key papers in financial economics, Modigliani and Miller (1958) on the equivalency of debt and equity, and Black and Scholars' (1973) paper on valuing options, together with the equation that allowed puts—or options to sell securities, calls—options to buy securities, and risk-free debt to be related to each other, together had the effect of encouraging the idea that all capital markets, and all capital-market instruments, were intimately connected to each other (Silvers, 2012, chapter 21, p. 432). Silvers (op. cit.) explains the role of financial market theory in intellectual roots of deregulation. However Silvers (op. cit.) sees the fnancial-market deregulation in the late twentieth century beginning with currency-market deregulation in the context of the collapse of the Bretton Woods accord. This new world of market-based exchange rates was the backdrop to the deregulation of national capital markets and the rise of a global market in currency derivatives dwarfing in notional amounts any financial market the world had ever seen. Silvers (2012) continues his argument by indicating that two features of deregulated currency markets ultimately were important contributors to the financial crisis of 2008. The first was the incentive that countries like China that were pursuing export-led growth strategies had to stockpile the currencies of their trading partners, rather than convert those currencies into their own domestic currency, thus increasing the value of their domestic currency and hurting the competitiveness of their exports. The second was the practical need, in a world where any country's currency was vulnerable to raids by financial actors, for all countries to hold significant amounts of reserves in dollars, so as to be able to use those dollars to manage the value of their own currency. Together these two structural features of a deregulated global currency regime were to help fuel a glut of dollar-denominated credit in the context of both global trade imbalances and US economic policy in the first decade of the twenty-first century.

7.10.1 Deregulation and increasing systemic risk

Silvers (2012) indicates that the repeal of the Glass-Steagall Act is an important move to deregulation. Silvers (op. cit., chapter 21, p. 439) addresses the End of Glass-Steagall act with Rise of Too Big to Fail banks and financial institutions. In his view one of the key New Deal regulatory reforms was the separation of the business of taking insured deposits and making loans from the business of underwriting and trading securities.

Most important, for the story of the financial crisis, these developments lifted the regulatory barriers for the metastasization of private-label mortgage finance. Universal banks could originate mortgages, capitalize nominally independent mortgage companies to originate the really embarrassing ones, underwrite the securitizations of those mortgages, and then do the servicing of the same. They could pick and choose where to commit their capital in the process, laying off the riskier steps on less well informed parties. This part is not in an expansive-enough stage to get into the role played in these issues by the Basel Committee on Bank Supervision. However, it is worth noting that the Basel process was another area where the banking crises of the late 1980s and the early 1990s appeared to give rise to a more serious regulatory framework, only to give way before concepts of self-regulation and notions that the new financial architecture had ended risk as we know it by spreading it around. This approach culminated in the approach taken in Basel II, analysed by the Federal Reserve Governor Daniel Tarullo (2008), where bank regulators looked to bank management themselves to assess through computer models that they themselves designed the safety and soundness of their own institutions. Finally, a point about funding sources and systemic risk. Regulated banks in the New Deal era largely had three sources of capital: insured deposits, long-term debt, and long-term equity. They were carefully regulated to ensure that none of their capital was susceptible to bank runs. But the new deregulated megabanks had additional, significant sources of capital that were quite susceptible to runs. These sources included commercial paper and the uninsured money market funds that invested in it, overnight lending from other financial institutions, largely organized in the London Interbank Market, and asset-backed short-term credit deals with a wide variety of financial actors called repos. These new, unregulated sources of capital were key to the ability of megabanks to grow and to finance new businesses such as derivatives dealing and mortgage securitization, and they were key sources of instability when trouble came. It is important to note here that up until this point the story of deregulation is the story of financial activity being liberated from substantive constraints within a general framework of regulatory oversight.

One of the key contributions of Silvers (2012, chapter 21, p. 444) is the point that by the first years of the new millennium, deregulation, technology, and globalization had produced a new capital-markets architecture, one where banks were increasingly the organizer of transactions and the servicer of customers, not the provider of capital. To the extent that banks needed capital, they no longer sought to grow their deposit base, which was expensive and time-consuming. Instead, they sought funding in the commercial paper, interbank lending, and repo markets.

The consequences of deregulation were free-floating currency markets, the dominance of securitization, the originate to distribute model of mortgage finance, the ability of banks to capitalize the originate to distribute model and derive revenue from the capital market side while convincing themselves they were not bearing the risk, the consolidation of commercial banking, the existence of mortgage insurance without the cost of capital to support it, and the lack of accountability for financial intermediaries or their highly paid employees. These all set the stage for the economic devastation to come.

A 2009 report by the United Nations Conference on Trade and Development (UNCTAD, 2009), called for a new system of global financial regulations to curb the indiscriminate speculation and finance that caused the 2008 Recession. The report indicating that global financial crisis arose amidst the failure of the international community to give the globalized economy credible global rules, especially with regard to international financial relations and macroeconomic policies. The speculative bubbles, were made possible by an active policy of deregulating financial markets on a global scale, widely endorsed by governments around the world. The spreading of risk and the severing of risk – and the information about it – were promoted by the use of 'securitization' through instruments such as residential mortgages-backed securities that seemed to satisfy investors' hunger for double-digit profits. It is only at this point that greed and profligacy enter the stage. In the presence of more appropriate regulation, expectations on returns of purely financial instruments in the double-digit range would not have been possible.

7.11 Financial regulatory reform

The financial crisis 2007-8, created the perfect storm for new financial regulation. On 21 July 2010 the US enacted the Dodd-Frank Wall Street Reform and Consumer Protection Act (the Dodd-Frank Act).

The Act resulted in several changes to the shape and scope of US financial regulation, summarised in the table below (Guynn and Polk, 2010):

Key reforms in the Dodd-Frank Act	
Systemic Risk Regulation	Securitisation – Credit Risk Retention
Financial Stability Oversight Council	Financial Stability Oversight Council
Office of Financial Research	Elimination of the OTS
Enhanced Prudential Standards	Deposit Insurance Reforms
Living Wills	Enhanced Regulation of Banking Entities
Orderly Liquidation Authority	Payment, Clearing and Settlement Systems
Volcker Rule	Consumer Financial Protection
Swaps Pushout rule	Restrictions on Emergency Stabilisation
Bank Capital (Collins Amendment)	Federal Reserve Governance
Derivatives	Pay it Back Act
Hedge Funds	Insurance
Investor Protection	International Sovereign Assistance
Enhanced Regulation of Securities Markets	Mortgage Market Reforms
Credit Rating Agencies	

Source: Guynn and Polk, 2010

Guynn and Polk (2010) argue the Dodd-Frank Act is the most extensive revision of US financial regulation since the 1930s, although it has left some important issues unresolved. Barth, Prabha and Wihlbor (2015) put Dodd-Frank into a historical perspective, identify its key features, discuss the implementation progress, and assess whether the law will accomplish its objectives. In their view Dodd-Frank reforms that strengthen market discipline on bank risk-taking and enhance competition would reduce the regulatory burden and enhance the efficiency and stability of the financial system. However it is more about market discipline rather than a structural reform, so these reforms couldn’t change the status of structural causes of systemic risk after the financial crisis 2007-8**.**

In the UK after the financial crisis 2007 a new legislation in the form of the Financial Services Act 2012 has been passed. This established the new regulatory framework for the financial services industry. In parallel with the passage of that legislation was the publication of the Report of the Independent Commission on Banking headed by Sir John Vickers. Vickers looked at solutions to the 'too big to fail' banking conundrum, as well as at issues connected with competition in banking. The main features proposed by the Vickers Commission were intended, with government approval to go forward to form the basis of a further financial services Bill (Edmonds 2013). The Vickers report focussed largely on the proposals surrounding the ring-fencing of British retail banks; i.e. separating deposit and lending functions from investment banking. John Vickers summarised his proposals in the following way: "Structural reform, in sharp form, would end universal banking and require retail banking and wholesale and investment banking to be carried out by separate banks. This would aim to isolate retail banking services and taxpayers from the risks of global wholesale and investment banking. The Commission's focus is on a combination of these capital and structural approaches, in moderate form. First, we estimate that systemically important banks should have an equity ratio of at least 10% provided that they also have genuinely loss-absorbing debt. We believe this should be agreed internationally".((Vickers 2011, p. 3).

As we discussed the Vickers report focussed largely on the proposals surrounding the ring-fencing of British retail banks; i.e. separating deposit and lending functions from investment banking not the structural issues of the financial market. Even recently writing in the Financial Times, Sir John Vickers argues that recent Bank of England plans for the largest lenders to build an extra buffer of capital do not go far enough. His criticism comes as financial markets are once again being roiled, sparking fears of a fresh global crisis (Vickers, 2016).

7.12 Structural causes of systemic risk still exist

The Financial Crisis Inquiry Report (Financial Crisis Inquiry Report 2011) makes a strong case that the global financial crisis was foreseeable and avoidable. It did not 'just happen' and it had nothing to do with 'black swans with fat tails'. It was created by the biggest banks under the noses of our 'public stewards'. The global financial crisis represents a dramatic failure of corporate governance and risk management, in large part a result of an unwarranted and unwise focus on trading (actually, gambling) and rapid growth (a good indication of fraud, as Black, 2005, argues).

However main question is, whether structural causes of the 2007-8 financial crisis still exist or not? There are many changes in financial market since financial crisis 2007/8, IMF report (IMF Report 2015) highlights a shift from direct cross-border lending to local lending by foreign banks' affiliates. The decline in cross-border lending can be explained by a combination of regulatory changes, weaknesses in bank balance sheets, and macroeconomic factors. The report concludes that this change can positively affect the financial stability of host countries. Cross-border lending tends to compound adverse domestic and global shocks; in contrast, foreign-owned subsidiaries behave less pro-cyclically than domestic banks during domestic crises. However the same report reveal that global financial stability risks have risen and these risks have also been pivoting away from banks to shadow banks, from solvency to market liquidity risks, and from advanced economies to emerging markets so it is shifting to other part of structure. It is in line with fear of economists from the International Monetary Fund (IMF) who indicate that many of the structural causes of the 2007-2008 financial crises still exist, including too big to fail banks. The seven economists expressed their concerns in a paper published on August 2012 that does not represent the official view of the organization but is intended to stimulate debate among its members (Claessens, et al. 2012). "Many of the structural characteristics that contributed to the build-up of systemic risks in financial sectors are still in place today, and moral hazard has increased" (p. 20). Claessens et al. (2012) suggest that "In most countries, the structure of the financial system has changed little. In fact, as large banks acquired failing institutions, concentration has increased on average" (p. 20). they argue that in 12 countries that had suffered recent crises the assets of the five largest banks have risen from 307 percent of GDP before the crisis to 335 percent in 2009, complicating recovery efforts. Our analysis in chapter 4, 5 and 6 of this research also showing the same result as the structure of the banking system has changed little during 2007-2014.

We might say that global financial crisis was not strictly inevitable, but we could say the financial structure made a crisis highly probable. The interesting point is in many important respects, we had produced conditions similar to those that existed on the eve of the 'Great Crash' and we experienced a similar crisis. The most important difference, however, was the response. While we emerged from the Great Depression with a robust financial system, strict regulation, and strong safety nets, as of spring 2012 we have only managed to prop up the financial institutions that caused the crisis and have left the economy in a much weaker state than it had been in either 2006 or 1940.

Governments need to rethink how to reduce the threat posed by large financial institutions, "including through reduced complexity, better capital structures, and possibly restrictions on their scope and activities," (Financial Crisis Inquiry Report, 2011p.125).

We could go further than The Financial Crisis Inquiry Report and note that in all this, the biggest banks were aided and abetted by government ‘regulators’ and ’supervisors’ who not only did they refuse to do their jobs, but indeed continually pushed for deregulation and de-supervision in favour of ‘self regulation’ and ’self supervision’. While many want to blame the crisis on ‘liquidity’ problems, the liquidity crisis bore no relation to an ’irrational’ bank run, but instead reflected an accurate appraisal of financial institution insolvency. That, in turn, can be attributed to catastrophic reductions of lending standards and to pervasive fraud.

Wray (2012) indicates that while The Financial Crisis Inquiry Report does ‘name names’ and accurately identifies practices and even individuals that are culpable, he could find some merit in the complaint made by the Republican minority report as well as by some reviewers (most notably Nocera, 2011) that there is some danger in focusing on “bad actors, bad financial practices and bad events” (p. 3); see, also, Nocera, 2011; and Morgenson, 2011).

All above data give us a picture about the global economy and its foundation. Taking all facts in account, in line with the existing financial system architecture and its inherent associated systemic another financial crisis is a matter of ‘when’, not ’if’. Still, it is important to understand longer term trends. We need to put the crisis in the context of the long-term post war transformation of the financial system to understand the deep cause of financial crisis and origin its systemic risk. This conclusion is in comply with Wray (2012) deviation from The Financial Crisis Inquiry Report’s conclusion: financial fragility had grown on trend, making ‘it’ likely to ‘happen again’.

7.13 Need for a new global financial architecture

Sustainable development must spring from macroeconomic and financial stability, which in turn paves the way for robust growth and a productive economy. This is the first key step of the journey. We need a right strategy in financial system. Over the past few years, we have been mired in the worst economic crisis since the Great Depression. Great uncertainty hangs over global prospects. Too many regions today are still stuck in a trap of low growth and high unemployment. We need to get economic growth going again but on a different track than before the crisis. We have tried to illustrate that financial markets can potentially harm the economy and economic performance. We need to get the financial markets right.

Perhaps we can help with a simple concept of financial market that everybody can understand. As Christine Lagarde managing director of IMF mentioned in her speech on June 2012 said, “We need a strategy that is good for stability and good for growth—where stability is conducive to growth and growth facilitates stability” [42].

7.14 Need for a new framework of systemic risk

There is a connection between systemic risk and global financial architecture, so systemic risk framework should be expanded and modified to explicitly incorporate financial architecture and financial structure in addition to stability. Haldane(2014) argues that, the rules of the road for this system have failed to keep pace with the growing scale and complexity of global financial flows. It is for this reason that some have called the international monetary system a ‘non-system’ or ’anti-system’ (Truman, 2012;Larosiere,2014) - a system whose shape and scale has outgrown its architecture.

7.15 Conclusion

The global financial system as a critical component of the economy, is an organic whole and requires a comprehensive approach. How well it works is a key factor in

[42] Christine Lagarde, Managing Director, International Monetary. Fund Back to Rio—the Road to a Sustainable Economic Future Washington DC, June 12, 2012. available at : http://www.imf.org/external/np/speeches/2012/061212.htm

determining how the rest of the economy functions, as was clearly demonstrated when the recent financial crisis plunged economies into recession around the globe.

The structure of the financial sector is under great scrutiny as a result of the crisis and some significant changes are being mandated. But still the financial system architecture needs to be revised carefully. The post financial crisis reforms could not change the status of structural causes of systemic risk financial market. The reform must therefore encompass a number of interrelated aspects of structural issues, global consistency of macroeconomic policies and financial regulation. Financial market reform has so far understandably focused on financial stability, prudential regulation, and conduct of business issues.

One of the conclusions of this chapter is to highlight that the reform should now turn to architecture of the market to ensure that the wholesale and institutional markets perform this critical financial intermediation function more efficiently in the interests of the real economy. We might say that global financial crisis was not strictly inevitable, but we could say the financial structure made a crisis highly probable. Wray (2012) argues that while we emerged from the great depression with a robust financial system, strict regulation, and strong safety nets, as of spring 2012 we have only managed to prop up the financial institutions that caused the crisis—and have left the economy in a much weaker state than it had been in either 2006 or 1940.. We argue in a similar way that the main cause of systemic risk in financial system still remain. In line with what Schwarcz's[43] argument, we agree that global financial crisis was triggered by market failures, not by financial institution failures. As a result, we suggest that any regulatory framework for managing systemic risk must address markets as well as institutions.

Stiglitz (2008) explains, financial markets have not performed their primary functions well. These problems have occurred repeatedly and are pervasive, evidence that the problems are systemic and systematic. This chapter has illustrated that it would be crucial for any major changes to be based on a careful analysis of the financial market structure and its relationship to the 'real economy'. It is highlighted that financial markets are not an end in themselves, but a means: they are supposed to perform certain

[43] Levehulm lectures 2010; available at: http://scholarship.law.duke.edu/cgi/viewcontent.cgi?article=2974&context=faculty_scholarship

vital functions, which enable the real economy to be more productive (in line with Stiglitz, 2008).

There is a connection between systemic risk and global financial architecture and so systemic risk framework should substantially expanded and evolved to fully encompass financial architecture and financial structure. Another key point to highlight is the quote by Financial Times (2 January,2009) that "although financial markets are bad, they are, nevertheless, a necessary evil"." So as a result this necessary evil needs appropriate surveillance. As Arestis and Singh (2010) argue, the world economy works best when international financial markets function under appropriate regulation. This regulation should consist of re-structuring of the financial market and monitoring the structure. Finally, some studies highlighted that the risks impacting financial markets are attributable to the actions of market participants (see, for example, Laeven, 2014, and Davies, 2010). We would like to add that it might be attributable to the structure of financial market too.

8 Chapter 8 Summary, Conclusions and Recommendations

One of the aspects of systemic risk which has been highlighted in the recent financial crisis has been the interconnectedness of financial institutions, which increases the probability of contagion of financial distress. However, the financial network systemic risk depends on the interplay of the network topology with the nature of financial transactions over the network, assets and buffer stemming from bank size, correlations, and the nature of the shocks to the financial system. This study concludes that in addition to being too big to fail, banks could be too interconnected, too central, and too correlated to fail. The study presents the growing roles of financial linkages and complexity in injecting latent instability into the global financial system. By doing so, it underscores the value of a global financial architecture design that is effective in forestalling the risk that a localized shock propagates through the global financial network turning into a large-scale systemic crisis.

The importance of contagion was dismissed in a large number of the empirical studies on systemic risk and default contagion in interbank networks (Mistrulli,2007;Furfine ,2003;Sheldon and Maurer, 1998;Upper and Worms, 2004;Wells, 2004).

This study finds that contagion significantly contributes to systemic risk in the banking system with focusing on the European banking data. Our results do not contradict previous findings but present them in a different light: while most of the aforementioned studies use indicators averaged across institutions, we argue that given the heterogeneity of the systemic importance across institutions, the property of network, topology of financial system, size of the economy which the banks operating in are important factors to be considered. With some exception eg Elsinger, Lehar and Summer (2006b) most previous studies measure the impact of the idiosyncratic default of a single bank, whereas we focus on interlinked consolidated cross border mutual exposures on ultimate risk basis at country level as a different level of research.

The study answers the research questions within six chapters. The main questions of the research are (i) what is the definition of systemic risk? (ii) How could systemic risk in the banking network be measured? (iii) What is a suitable analytical tool for assessing and monitoring systemic risk in EU banks, which enable us to visualise the relationship between the financial network topology and systemic risk? (iv) Does the banking network follow a core-periphery structure? (v) What are the effects of microeconomic shocks on banking structure? Does the banking structure network affect stability of the system? What is the role of aggregate fluctuations and its dependency on network structure? (vi) To what extent were EU banks exposed to systemic risk at the country level during and after the financial crisis of 2007/8? (vii) What is the impact of global financial architecture on systemic risk?

In answering the first question of the research the study collects together *various definitions* and descriptions of systemic risk that have been offered in the different studies. We analysed them and came up with the following definition. 'System wide risk, as probability of breakdowns in an entire financial system, triggered by failure of a participant or structure due to interconnecting nature of financial system (architecture), with adverse effect on real economy'**.**

The measurement methods of systemic risk in banking network were discussed in detail with pros and cons to answer the second question of the research. Network approach was discussed in more detail and the various methodologies were compared together.

Chapter 4 of the study answers questions iii and iv of the research. The research provides an analytical tool for assessing and monitoring systemic risk in EU banks whilst elaborating on the relationship between the financial network topology and systemic risk, using network methodology. We develop a framework starting from the best equations linking each node to its neighbours where some studies like Cabrales et al. (2015) where unified treatment starts with the fixed point equation resulting from the interactions in the different financial network models. In our network structure formation, we have analysed the network interactions through first and second order connectivity and highlight the role of interactions and aggregation functions in shock transmission. We analyse how our measures relate to the size of the economy, the size of the banking sector, and the borrower concentration ratio.

Elsinger et al. (2006) argue that the risk of contagion is not well explained by accounting data. Hence regulators are not able to assess the contribution of an individual bank to the overall risk of the banking system on accounting data alone. However, our study uses wide range of data in risk assessment at international level, such as size of the economy, size of the banking sector, and borrower concentration ratio. Clearly the result of our study is a first step in the analysis of banking systemic risk at a consolidated country level. The attractive feature of our approach is that we didn't simulate a model but we take real cross border exposures of the banks with ultimate risk approach and apply the measuring to the level of the banking system by looking at whole banking system as a portfolio, and each country as a contingent claims on the whole banks' assets.

In Chapter 4 the framework for studying and visualising relationship between the financial network topology and systemic risk due to contagion of bilateral exposures is presented. We have highlighted through the study that interconnectedness in the financial system was part of the problem in the financial crisis 2007/8. We are introducing and implementing a quantitative methodology for analysing the potential for contagion and systemic risk in a network of interlinked financial institutions. We do this by using a metric for the systemic importance of country in terms of banking institutions -the Contagion Index. On the contrary to indicators of systemic risk purely based on market data (Acharya, et al, 2010;Adrian and Brunnermeier, 2008;Zhou, et al., 2009) metric of the study is a forward-looking measure of systemic risk and aggregate volatility is based on banking system exposures, which represent potential losses in case of default.

Chapter 4 employs the network approach to analyse interconnectdness and provide some insights to monitor systemic risk. The chapter suggests a potentially fruitful road of forming policies reducing systemic risk. This chapter contributes to the existent literature by developing a framework that explains how interdependencies between banks at country level emerge endogenously. We have carried out empirical study to show banking network follow core-periphery structure. The systemic risk in a network of interlinked financial institutions in selected countries, is analysed using a metric for the systemic importance players. By applying the methodology to a data set of consolidated cross border mutual exposures on ultimate risk basis, relative to size of the economy, size of the banks and concentration index the role of balance sheet size and network property in each country's banks, contribution to systemic risk is analysed in more details. One of the contribution of Chapter 4 is highlighting the role of proactively tracking potential systemic linkage by regulators worldwide. In absence of this approach due to financial interconnections during stress events even actions geared to enhance soundness of a particular bank or institution may undermine the stability of other banks or the whole network.

Chapter 5 of the study answers question (v) of the research. Chapter 5 deals with the effects of microeconomic shocks on banking structure and whether the banking structure network affect stability of the system or not. The role of aggregate fluctuations and its dependency on network structure is analysed in this chapter. It highlights whether the effects of microeconomic shocks remain locally and the banking structure network such as regional banking affect stability or not. The chapter argues how idiosyncratic shocks could be filtered by the network structure and how financial system structure may exacerbate contagion during a crisis. We highlight that ignoring the structure can lead to an underestimation of the extent of contagion in the network. Another finding of the chapter is that different network structures, which entail different aggregate volatilities due to the fact that the presence of direct relations averages out the idiosyncrasies across establishments.

Within the discussion of Chapter 5 we have illustrated that in selected networks we have four core countries banking sections that supply to many other sectors; banks in the periphery achieved a low degree so not very important but banks in the middle of network (Core banks) obtained a high out-degrees. The topology of selected network is star and the core sectors are: German banks, British banks, French banks, and American banks. Within the network we have inequality of out-degrees and as a result when the middle of the network (German banks, British banks, French banks or American banks) is hit, then the network will suffer significantly. Most of the time the network is robust because most of the shocks could be absorbed in the structure, but the network is also very fragile when the specific shock hits the middle of the structure.

In demonstrating the structure of the interconnected network of selected banks and its defining effect on aggregate fluctuations it was pointed out that the banking network interconnections may imply that aggregate fluctuation concentrates around its mean at a speed rate slower than$\sqrt{n}$. The study explains that by applying this to selected networks, slower rates of decay means shocks to core selected countries banks (British banks, American banks, French banks and German banks) would have a more significant role in creating aggregate fluctuations, even at high levels of disaggregation. We provide a framework for studying the relationship between the financial network architecture and systemic risk due to contagion of bilateral exposures. (Acemoglu, et al., 2013) explained that financial contagion exhibits a form of phase transition as interbank connections increase: as long as the magnitude and the number of negative shocks affecting financial institutions are sufficiently small, more ‘complete’ interbank claims enhance the stability of the system. However, beyond a certain point, such interconnections start to serve as a mechanism for propagation of shocks and lead to a more fragile financial system. Within this analytical framework we provide more analysis about structure of bilateral exposure in selected network and define the core and peripheries countries in network. We explained how such interconnections might start to serve as a mechanism for propagation of shocks and lead to a more fragile financial system.

The chapter suggests, regulators with limited resources might concentrate their efforts not on the largest banks in the network but on the most important ones in terms of significant linkages.

Chapter 6 deals with question (vi) of the research. This chapter analyses the extent to which EU banks were exposed to systemic risk at the country level during and after the financial crisis of 2007/8. The chapter contributes to the existing literature by providing some insights within a framework that explains how interdependencies between banks at country level could contribute to systemic risk of the network. The study explores structural vulnerabilities at the country level, but also reviews bilateral exposures within a network context. Using a framework of bilateral exposures cascades in a network setting, we analyse cross border contagion patterns of exposure propagation from 2005 until 2014 quarterly, and study the In-degree concentration index over selected network. Economic exposure to cross border lending at 2014 shows Swiss banks still have a high degree of relative size of banking sector and foreign lending ratio together, almost unchanged compared to 2007 (Q4) , followed by Swedish banks and Dutch banks. However in 2007(Q4) Belgian banks and Dutch banks had the second and third position accordingly. The In-degree concentration index on 2014 indicates that USA, UK and Germany together, achieved over 70% of the network exposures. The result of comparing the in-degree concentration index with 2007(4Q), illustrates the same group obtained over 70% of the network exposure; however the UK obtained a more important role. For the purpose of better illustration for the first three countries (US, UK and Germany) detailed in-degree concentration index was analysed on 2014 compared to 2007.

The global financial system is at the focal point of Chapter 7 to answer the last question of the research. The chapter analyses the impact of global financial architecture on systemic risk. The financial system architecture is analysed as an organic whole and concludes that it requires a comprehensive approach. The chapter argues that there is a substantial connection between systemic risk and global financial architecture and concludes that systemic risk framework should be expanded and modified to explicitly incorporate financial architecture and financial structure in addition to stability. We demonstrate that it would be crucial for any major changes to be based on a careful analysis of the financial market structure and its relationship to the ‘real economy’. In many cases, there is a need for considerably more research and analysis and in other cases the existing state of knowledge is too frequently ignored or inconvenient realities played down. The chapter has argued that the global financial crisis of 2007/8 had a complex set of systemic causes. These were connected to underlying features of the finance dominated capitalist economy where the crisis began. The chapter has looked at issues of systemic risk in global financial architecture through financial stability and development. It is highlighted that in any framework for systemic risk the global financial architecture merit further attention. While financial stability is a central goal, financial structure and architecture should merit the same attention.

Our study reveals several interesting features of the structure of the European Banking system and the nature of systemic risk and default contagion in this system. What follows are some important findings of the study:

Many of the structural characteristics that contributed to the build-up of systemic risks in banking sectors are still in place today, this verifies the concerns of seven economists in August 2012 (Claessens, et al, 2012). The latter wrote that "In most countries, the structure of the financial system has changed little. In fact, as large banks acquired failing institutions, concentration has increased on average" (p.3). Our analysis in Chapter 4, 5and 6 also reflects the same result as the structure of the banking system has changed little during 2007-2014.

A. We argue that an increase in global financial integration, like increasing integration of any network, can be double-edged from a stability perspective we argue how within the limits, connectivity acts as a shock-absorber. Links in the system act as a mutual insurance device, helping distribute and disperse risk. These systems are then ‘robust’ to shocks. But when shocks are sufficiently large, connectivity may instead serve as a shock-transmitter. Risk-sharing becomes risk-spreading. Links in the system act as a mutual incendiary device, amplifying risk. These systems are then also ‘fragile’.

B. We empirically test that interbank structure follow the core-periphery structure, a setting first proposed in sociology for networks of acquaintanceships. Among centrality measures the fit of Core with Betweeness is much better than others.

C. The composition of banks group within the core sector remains remarkably stable over time.

D. Interbank networks exhibit a complex heterogeneous structure, which resembles a directed scale-free network. The distributions of number of counterparties and exposure sizes are found to be heavy-tailed, with an asymmetry between incoming and outgoing links. Furthermore, while individual exposures are quite variable in time, these statistical regularities, which encode the large-scale statistical structure of the network are shown to be stable across time.

E. Systemic risk is concentrated on a few nodes in the financial network. Countries with shallow domestic financial markets and concentrated exposures to a few lenders are more prone to synchronized shifts in cross-border flows

F. Ignoring the effect of relative size of the economy in which banking system operates, the size of banking system (consolidated Banks' balance sheets) and borrower concentration ratio can lead to a serious underestimation of contagion risk. Specifically, banks' balance sheet size and size of the economy are found to increase the proportion of contagious exposures in the network.

G. The compounded effect of correlated market shocks and contagion via counterparty exposures are important variables of contagion risk. Specifically, market shocks are found to increase the proportion of contagious exposures in the network, i.e. exposures that transmit default in all shock scenarios. We are thus led to question the conclusions of previous studies which dismissed the importance of contagion by looking at pure balance sheet contagion in absence of market shocks.

H. Balance sheet size alone is not a good indicator for the systemic importance of financial institutions: network structure does matter when assessing systemic importance. Network-based measures of connectivity and concentration of exposures across counterparties-counterparty susceptibility and local network frailty- are shown to contribute significantly to the systemic importance of banking system.

I. From 2005 to 2014, American banks' positions in the banking network changed from fragile section to important and fragile; and more importantly common factors (such as global risk aversion) increasingly drive global financial markets and tend to intensify abruptly during periods of stress, amplifying shock transmission. These features point to potentially large costs of systemic shocks to crisis bystanders (countries with relatively strong fundamentals for which the likelihood of an idiosyncratic crisis is normally low), and reinforce the case for a global financial architecture that is designed to help ring-fence such countries from systemic shock contagion.

J. This study emphasizes the role of banking in the real economy. Arestis and Sawyer (2011) recommend that the banks should serve the needs of their customers rather than provide short term gains for shareholder and huge profit for themselves. We argue here that the core function of banking should be restated to reflect better the true connection to the real economy. We pointed out that banks are supposed to perform certain vital functions which enable the real economy to be more productive not only with existing money but also with creating new money. Werner (1993) addressed the issue that banks are recognised as not being financial intermediaries that lend existing money, but creators of new money through the process of lending.

K. The effects of microeconomic shocks may not remain confined to where they originate, and the study explains why regional banking structure might be more stable. The role of aggregate fluctuations depends on banking network structure, nature of interaction over the banking network between sectors and types of idiosyncratic shocks.

L. Our study highlights that the global financial crisis 2007-8 was triggered by market failures, not by financial institution failures. We argue that any regulatory framework for managing systemic risk must address markets architecture and structure as well as institutions.

M. We clearly analyse the financial crisis through the lens of market structure failures and regulatory failures. One of the most prominent failure contributing to financial crisis was regulatory focus on individual institution risk rather than systemic risk.

We highlight the role of systemic risk in financial market with focus on banking system.

N. One of our points in the study is that the market structure and architecture deserve the same attention as individual and interlinkage of individual participants in the market.

O. We conclude that, the new architecture is a working compromise, which brings together neo-Keynesian and neo-liberal principles but which cannot fully reply to the challenges of systemic risk.

P. In the study we have discussed that financial market reform has so far understandably focused on financial stability, prudential regulation, and conduct of business issues. We would like to highlight that the reform should now focus on architecture of the financial market to make sure that the wholesale and institutional markets perform this critical financial intermediation function more efficiently in the interests of the real economy.

Q. Most of the empirical studies on systemic risk and default contagion in interbank networks have dismissed the importance of contagion, (Sheldon and Maurer, 1998), (Furfine 2003), (Upper and Worms 2004), (Wells, 2004), we find that contagion significantly contributes to systemic risk in the European banking system.

8.1 Recommendations

1. A better regulation is at the focus of financial reform needs; this reform should be beyond of higher capital ratios or better liquidity ratios for instance. The new connected world needs a new financial architecture with a new approach to regulation. Supervising across border resolutions of banks and financial institutions should get more attention in the risk management approach of the financial system. More proactive global supervisory for financial system is needed, to capture and monitor proactively the interconnectedness between countries' financial system. This analysis can help better connect global surveillance with country-level specificities.
2. The same analytical framework, which is introduced in this study, could be used by regulators for instance the European Central Bank (ECB), and it would help to put the data into perspective and to uncover – sometimes not so

obviously – cross-country dependencies. Using the same analytical framework by the ECB and the network analysis, could produce a bird's eye view on interlinkages and structural changes in cross-border claims over time. This in turn would help the regulator to apply the right policy in monitoring the financial network. The presented framework could assists forward looking policy makers and regulators to monitor and rely on bilateral exposures of financial units (banks), and anticipate the possibility of system wide failure during network formation.

3. As we discussed in Chapter 5 we could say in case of $\varepsilon > \varepsilon(m)$ weakly connected structure in banks will be more stable. This structure is similar to old style unit banking or regional banking (the banks have links to the other regional banks but the link to the rest of economy is weak). One of the recommendations of the study for policy makers is that regional banking structure could be more stable in the banking network.
4. At the country level increasing cross border financial linkages may lead to reducing exposure to local originated shocks (diversification effect). However, increased interconnectedness, by facilitating shocks transmission internationally, makes financial network more prone to systemic risk accordingly. Enhancing the structural complexity of cross border financial linkages makes specific exposure traceability more difficult. In turn, this leads to systemic amplification effects from panic responses to shocks due to less certain information. In another word increasing cross border financial linkages with the purpose of diversification and reducing risks might lead to systemic instability in the network.
5. If the government intervene to solve the systemic risk, they can inadvertently be the cause for creation of the risk and there would be endogenous reason for banks to expose themselves to the same risk.
6. One of the suggestions of our analysis is that the rating agencies should take into account embedded interconnected systemic risk through network approach in rating the firms or sovereign. More connection or less connection within the network structure and economic interactions could have impact on firm or sovereign's rating. The banks' risk management approach to diversity away from more risky counterparties could connect them in more connected nodes in the network (with better credit rating) and increase the systemic risk consequently.

7. Further to Chapter 5's discussion, it is recommended that the monitoring system should have a more comprehensive approach not only on the topology of network in the financial market but also the nature of transactions over the network and also take into account the types of shocks as an important variable. Proactively tracking potential systemic linkage should be in the agenda of regulators worldwide and in absence of this approach due to financial interconnections during stress events even actions geared to enhance soundness of a particular bank or institution may undermine the stability of other banks or the whole network.

8. In order to avoid a huge systemic risk in the global financial system, it is recommended that any policy package of a global financial market new deal should consist of re-structuring of the financial market and build up a new global financial architecture based on role and connection of financial market to real economy.

9. As our study underlines, and since Erol and Vohra (2014) argue the same, it is important to specify the shock structure before investigating a given network as a particular network and shock structure could be incompatible.

More research needs to be done about systemic risk and financial market structure. Many studies are focused on financial stability, prudential regulation, and conduct of business issues. We suggest more studies should be conducted on financial market architecture and its role in systemic risk.

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Appendices

Appendix 1

Dependent Variable: CORE
2005-Q1 – 2014Q1

Regressors	1	2	3	4	5	6	7	8	9	10	11	12	13
Exposures	0.05**		0.00**	0.01**	0.03**				0.02**	0.00**	0.01**		0.02**
	(57.64)		(-3.70)	(23.91)	(36.25)				(34.82)	(-3.98)	(24.27)		(34.63)
Closeness			3.66			-0.16	3.44		-1.01	3.54		-0.21	-1.03**
			(95.04)			(-4.53)	(92.60)		(-24.87)	(78.86)		(-5.57)	(-24.49)
Betweenness		0.13**		0.12**		0.14**		0.13**	0.15**		0.13**	0.14**	0.15**
		(247.69)		(209.77)		(120.20)		(197.55)	133.84		187.71	120.05	133.52
PageRank					38.07**		4.19**	0.87**		4.36**	-2.04**	1.83**	0.76**
					39.76		5.06	1.91		5.26	-4.47	3.75	(1.67)
C	-0.28	0.02	-1.78	-0.05	-0.34	0.10	-1.71	0.01	0.41	-1.74	-0.04	0.11	0.42
	(-39.46)	(15.72)	(-107.95)	(-15.92)	(-50.59)	(5.56)	(-100.54)	(6.31)	(22.06)	(-94.21)	(-12.97)	(6.32)	(21.98)
R-squared	0.30	0.89	0.68	0.90	0.42	0.89	0.68	0.89	0.90	0.68	0.90	0.89	0.91
No of obs	7618	7618	7618	7618	7618	7618	7618	7618	7618	7618	7618	7618	7618

Appendix 2

Cob Douglass equation production function of different sections which is:
Equation 20

$$X_i = Z_i^{\propto} \ell_i^{\propto} \prod_{j=1}^{n} X_{ij}{}^{(1-\propto)W_{ij}}$$

where

ℓ_i: Labour employed by sector i
$\propto \in \; 0,1$: Labor Share
X_{ij}: amount of commodity j used in the production of good i
$W_{ij} \geq 0$: input share of sector j in sector i 's production

$\in_i = \log(Z_i) \sim F_i$ Productivity shock to sector i .

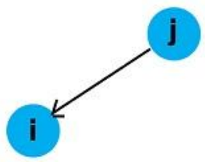
It depends on some random shock $\{Z_i\}$ where the shocks coming from (productivity shock, it could be demand shocks or anything else but I just put it as productivity shock). We assume that productivity shocks $\{Z_i\}$ are independent across sectors, and denote the distribution of $\in_i = \log(Z_i)$ by F_i. The exponent $W_{ij} \geq 0$ designates the share of good j in the total intermediate input use of firms in sector i. In particular, $W_{ij} \geq 0$ if sector i does not use good j as input for production. In view of the Cobb–Douglas technology in ….. and competitive factor markets, $W_{ij}'s$ also correspond to

the entries of input–output tables, measuring the value of spending on input j per dollar of production of good i.
It depends on labour ℓ_i. It depends on X_{ij} which denotes amount of input from sector j that sector i use in its products, W_{ij} is the input output structure of the economy, If W_{ij} is equal to zero there is not connection between these two sectors, I am not using your input, If W_{ij} is positive I use your input and more positive meaning your input is more important as an input supplier. The log Z_i is important we define $\mathcal{E}_i$= log Z_i and has a distribution function of {F_i} and $\sigma_i^2 < \infty$ with sum finite various sigma I saqure

We will assume:
$\sum_{j=1}^{n} W_{ij} = 1$ for each i, For all i=1,2,3,….,n, for a normalisation purpose.

a.

As we are studying domino effect , not correlated disaster, we will focus on case that all of these $\mathcal{E}_i$as idiosyncratic shocks are independent across sectors, even if they are dependant it would be fine there is some co movements across the sector that comes from the presence of aggregate shocks.
This is the description of environment in terms of network , but we could have slightly different representation of this environment in terms of network or graph in a way to have slightly more informative. This economy could be as graph directed weighted graph.



W_{ij}

There is a link between i and j, which means j is supplier to i but not necessarily at the opposite and there is weighted link It means there is an important or not important link between i and j.
We've mentioned the role of network topology in stability, structural properties of network , one of the key structure is degree distribution of network, how important are different sectors as suppliers to other sectors one way to measure that is the out degrees of network
Degree of sector j: (value) share of j output in the total production of the economy.
We use the notions of the intersectoral network and input–output matrix interchangeably as equivalent representations of the structure of intersectoral trades.
We also define the weighted outdegree, or simply the degree, of sector i as the share of sector i's output in the input supply of the entire economy normalized by constant 1−α; that is,

Equation 21

$$d_j = \sum_{i=1}^{n} Wij$$

Clearly, when all nonzero edge weights are identical, the outdegree of vertex i is proportional to the number of sectors to which it is a supplier. Finally, we refer to the collection $\{d_1, d_2, d_3, \ldots, d_n\}$ as the degree sequence of economy $\mathcal{E}$[44].

In the competitive equilibrium of economy $\mathcal{E}=(L, W, \{F_i\}_{i \in L})$ the logarithm of real value added is given by Constant return to scale:

$$\log\ GDP = V_n' \, \mathcal{E}$$

Before describing about systemic risk let's clarify the equilibrium's characters. Cob Douglass equation gives us log linearity input output economy , based on Leontief:

Equation 22

$$y_n = \log\ GDP = V_n' \, \mathcal{E}$$

y_n in the economy of size n is just given by $\mathcal{E}$ which is the vector of those $\mathcal{E}$ shocks (proportional shocks) that hit every sector, v is the vector which we called influence vector, y_n is the inter product of two vectors , or in another words every sectors get some shocks and those shocks are weighted according to the influence vector , if the first entry is very large for the influence vector it means the shock to the first sector is very important, in aggregate .

Where $\mathcal{E} \equiv [\varepsilon_1, \varepsilon_2, \varepsilon_3, \ldots, \varepsilon_n]$, and the n-dimensional vector v, called the influence vector, is defined as

Equation 23

$$V_n' \equiv \frac{\propto}{n} \left[I - (1-\propto) W_n' \right]^{-1} \mathbf{1}$$

Thus, the logarithm of real value added, which for simplicity we refer to as aggregate output, is a linear combination of log sectoral shocks with coefficients determined by the elements of the influence vector. Equation (4) shows that aggregate output depends on the intersectoral network of the economy through the Leontief inverse $\left[I - (1-\propto) W_n' \right]^{-1}$ (see (Burress 1994)). It also captures how sectoral productivity shocks propagate downstream to other sectors through the input–output matrix.[45] We note that the influence vector is closely related to the Bonacich centrality vector corresponding to the intersectoral network.[46] Thus, sectors that take more "central" positions in the network representation of the economy play a more important role in determining aggregate output. This observation is consistent with the intuition that productivity shocks to a sector with more direct or indirect downstream customers should have more significant aggregate effects. The vector v is also the "sales vector" of the economy. In particular the i_{th} element of the influence vector is equal to the equilibrium share of sales of sector i,

Equation 24

$$V_{in} = \frac{P_i X_i}{\sum_j^n P_i X_i}$$

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[44] Similarly, one can define an indegree for any given sector. However, in view of Assumption 1, the (weighted) indegrees of all sectors are equal to 1

[45] In general, sectoral shocks also affect upstream production through a price and a quantity effect. For instance, with a negative shock to a sector, (i) its output price increases, raising its demand for inputs; and (ii) its production decreases, reducing its demand for inputs. With Cobb–Douglas production technologies, however, these two effects cancel out.

[46] For more on the Bonacich centrality measure, see (Bonacich 1987).

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with P_i denoting the equilibrium price of good i. This is not surprising in view of the results in (Hulten 1978) and (Gabaix 2011), relating aggregate total factor productivity (TFP) to firm- or sector-level TFPs weighted by sales.[47] (Acemoglu, Carvalho, et al. 2012) argue that this observation also implies that there exists a close connection between their results on the network origins of output fluctuations and Gabaix's results on their granular origins. A major difference is that the distribution of sales shares across sectors (or other micro units) in their model is derived from input–output interactions. Meanwhile they argue that this not only provides microfoundations for such size differences, but also enables them to sharply characterize the role of important structural properties of the network in shaping aggregate volatility. Furthermore, unlike in (Gabaix 2011), the structure of interconnections also determines the co movements between different sectors, placing a range of additional restrictions on the interplay of aggregate and more micro-level data.
Finally, note that rather than deriving (3) and (4) as the equilibrium of a multisector economy, one could have started with a reduced form model

Equation 25

$$\tilde{y} = \tilde{w}\tilde{y} + \varepsilon$$

where:

b. $\tilde{y}$ is the vector consisting of the output levels, value added, or other actions (or the logarithms thereof) of n economic units,
c. $\tilde{w}$ is a matrix capturing the interactions between them,
d. ε is a vector of independent shocks to each unit or idiosyncratic shock

Appendix 3

Data:
To monitor cross border exposures of banks' in selected countries use banking data to compare banks' cross-border exposures, both at the individual country level and in a network context. In the first step 177,111 data was gathered. The data were purified for EU and Us banks as followings:

Table 13 Data table for selected banks

Banks	Period	Starting time	Ending Time	No of collected Data
Australian Banks	Quarterly	2005-1Q	2014-1Q	8103
Austrian Banks	Quarterly	2005-1Q	2014-1Q	8,103

[47] Note that, in contrast to Hulten (1978) formula, the logarithms of sectoral shocks (i.e., the ε's) are multiplied by sales shares, and not by sales divided by value added. This is due to the fact that shocks in our model correspond to Harrod-neutral changes in productivity ($z_i = \exp(\varepsilon_i)$ is raised to the power α), whereas Hulten considered Hicks-neutral changes in productivity.

Banks	Period	Starting time	Ending Time	No of collected Data
Belgian Banks	Quarterly	2005-1Q	2014-1Q	8,103
Canadian Banks	Quarterly	2005-2Q	2014-1Q	7,884
Chilean Banks	Quarterly	2005-2Q	2014-1Q	7,884
Finnish Banks	Quarterly	2010-2Q	2014-1Q	1,752
French Banks	Quarterly	2005-1Q	2014-1Q	8,103
German Banks	Quarterly	2005-1Q	2014-1Q	8,103
Greek Banks	Quarterly	2005-1Q	2014-1Q	8,103
Irish Banks	Quarterly	2006-1Q	2014-1Q	7,821
Indian Banks	Quarterly	2005-2Q	2014-1Q	7,884
Italian Banks	Quarterly	2005-1Q	2014-1Q	8,103
Japanese Banks	Quarterly	2005-2Q	2014-1Q	7,884
South Korean Banks	Quarterly	2013-4Q	2014-1Q	418
Dutch Banks	Quarterly	2005-1Q	2014-1Q	8,103
Portuguese Banks	Quarterly	2005-1Q	2014-1Q	8,103
Spanish Banks	Quarterly	2005-2Q	2014-1Q	7,884
Swedish Banks	Quarterly	2005-2Q	2014-1Q	7,884
Swiss Banks	Quarterly	2005-2Q	2014-1Q	7,884
British Banks	Quarterly	2005-1Q	2014-1Q	8,103
Turkish Banks	Quarterly	2005-2Q	2014-1Q	7,884
American Banks	Quarterly	2005-1Q	2014-1Q	8,103
Total				145,990

Appendix 4

Network Centrality Measure and connectedness 2014-1Q.

vertex_id	CheiRank	CheiRank-0	PageRank	PageRank-0	closeness	cvpcore	maxclique	newman
Afghanistan	0.0007	0.0000	0.0040	0.0036	0.489	FALSE	0	4
Albania	0.0007	0.0000	0.0041	0.0037	0.498	FALSE	0	1
Algeria	0.0007	0.0000	0.0040	0.0037	0.509	FALSE	0	3
Andorra	0.0007	0.0000	0.0040	0.0036	0.507	FALSE	0	1
Angola	0.0007	0.0000	0.0044	0.0041	0.510	FALSE	0	3
Argentina	0.0007	0.0000	0.0042	0.0039	0.516	FALSE	0	2
Armenia	0.0007	0.0000	0.0040	0.0036	0.504	FALSE	0	1
Aruba	0.0007	0.0000	0.0040	0.0036	0.494	FALSE	0	1
Australia	0.0194	0.0181	0.0070	0.0081	0.697	TRUE	1	5
Austria	0.0106	0.0095	0.0051	0.0052	0.617	TRUE	1	2
Azerbaijan	0.0007	0.0000	0.0040	0.0037	0.514	FALSE	0	0
Bahamas	0.0007	0.0000	0.0042	0.0039	0.515	FALSE	0	2
Bahrain	0.0007	0.0000	0.0042	0.0039	0.518	FALSE	0	0
Bangladesh	0.0007	0.0000	0.0041	0.0038	0.511	FALSE	0	3
Barbados	0.0007	0.0000	0.0040	0.0037	0.507	FALSE	0	1
Belarus	0.0007	0.0000	0.0040	0.0036	0.509	FALSE	0	0
Belgium	0.0104	0.0105	0.0072	0.0081	0.722	TRUE	1	0
Belize	0.0007	0.0000	0.0040	0.0036	0.502	FALSE	0	1
Benin	0.0007	0.0000	0.0040	0.0036	0.496	FALSE	0	1
Bermuda	0.0007	0.0000	0.0044	0.0042	0.522	FALSE	0	2
Bhutan	0.0007	0.0000	0.0040	0.0036	0.442	FALSE	0	0
Bolivia	0.0007	0.0000	0.0040	0.0036	0.505	FALSE	0	3
Bonaire, Saint Eustatius and Saba	0.0007	0.0000	0.0040	0.0036	0.465	FALSE	0	4
Bosnia and Herzegovina	0.0007	0.0000	0.0041	0.0038	0.506	FALSE	0	1
Botswana	0.0007	0.0000	0.0040	0.0036	0.498	FALSE	0	1
Brazil	0.0007	0.0000	0.0073	0.0083	0.519	FALSE	0	2
Brunei	0.0007	0.0000	0.0040	0.0037	0.488	FALSE	0	1
Bulgaria	0.0007	0.0000	0.0046	0.0043	0.518	FALSE	0	0
Burkina Faso	0.0007	0.0000	0.0040	0.0036	0.500	FALSE	0	1
Burundi	0.0007	0.0000	0.0040	0.0036	0.470	FALSE	0	4
Cambodia	0.0007	0.0000	0.0040	0.0036	0.501	FALSE	0	1
Cameroon	0.0007	0.0000	0.0040	0.0036	0.506	FALSE	0	3
Canada	0.0327	0.0383	0.0072	0.0084	0.563	TRUE	1	2
Cape Verde	0.0007	0.0000	0.0040	0.0037	0.481	FALSE	0	4
Cayman Islands	0.0007	0.0000	0.0082	0.0101	0.524	FALSE	0	2
Central African Republic	0.0007	0.0000	0.0040	0.0036	0.420	FALSE	0	0
Chad	0.0007	0.0000	0.0040	0.0036	0.468	FALSE	0	1
Chile	0.0009	0.0002	0.0045	0.0043	0.547	TRUE	0	2
China	0.0007	0.0000	0.0089	0.0107	0.524	FALSE	0	2
Chinese Taipei	0.0007	0.0000	0.0051	0.0053	0.516	FALSE	0	2
Colombia	0.0007	0.0000	0.0047	0.0045	0.515	FALSE	0	0
Comoros	0.0007	0.0000	0.0040	0.0036	0.468	FALSE	0	1
Costa Rica	0.0007	0.0000	0.0040	0.0037	0.505	FALSE	0	3
Cote d'Ivoire	0.0007	0.0000	0.0040	0.0036	0.502	FALSE	0	3
Croatia	0.0007	0.0000	0.0047	0.0046	0.518	FALSE	0	0

vertex_id	CheiRank	CheiRank-0	PageRank	PageRank-0	closeness	cvpcore	maxclique	newman
Cuba	0.0007	0.0000	0.0040	0.0036	0.483	FALSE	0	4
Curacao	0.0007	0.0000	0.0040	0.0036	0.506	FALSE	0	1
Cyprus	0.0007	0.0000	0.0045	0.0042	0.516	FALSE	0	0
Czech Republic	0.0007	0.0000	0.0065	0.0069	0.519	FALSE	0	2
Democratic Republic of Congo	0.0007	0.0000	0.0040	0.0036	0.500	FALSE	0	1
Denmark	0.0007	0.0000	0.0058	0.0059	0.527	FALSE	0	2
Djibouti	0.0007	0.0000	0.0040	0.0036	0.418	FALSE	0	0
Dominica	0.0007	0.0000	0.0040	0.0036	0.361	FALSE	0	2
Dominican Republic	0.0007	0.0000	0.0040	0.0036	0.509	FALSE	0	3
Ecuador	0.0007	0.0000	0.0040	0.0036	0.514	FALSE	0	3
Egypt	0.0007	0.0000	0.0042	0.0040	0.514	FALSE	0	0
El Salvador	0.0007	0.0000	0.0040	0.0037	0.506	FALSE	0	3
Equatorial Guinea	0.0007	0.0000	0.0040	0.0036	0.470	FALSE	0	4
Estonia	0.0007	0.0000	0.0041	0.0037	0.506	FALSE	0	3
Ethiopia	0.0007	0.0000	0.0040	0.0036	0.502	FALSE	0	1
Faeroe Islands	0.0007	0.0000	0.0040	0.0036	0.490	FALSE	0	1
Falkland Islands	0.0007	0.0000	0.0040	0.0036	0.492	FALSE	0	1
Fiji	0.0007	0.0000	0.0040	0.0036	0.494	FALSE	0	1
Finland	0.0022	0.0019	0.0051	0.0051	0.532	FALSE	1	2
France	0.1041	0.1389	0.0130	0.0167	0.547	TRUE	1	2
French Polynesia	0.0007	0.0000	0.0040	0.0036	0.493	FALSE	0	1
Gabon	0.0007	0.0000	0.0040	0.0036	0.502	FALSE	0	1
Georgia	0.0007	0.0000	0.0040	0.0036	0.510	FALSE	0	3
Germany	0.1043	0.1199	0.0160	0.0206	0.865	TRUE	1	4
Ghana	0.0007	0.0000	0.0040	0.0037	0.507	FALSE	0	3
Gibraltar	0.0007	0.0000	0.0040	0.0037	0.510	FALSE	0	1
Greece	0.0049	0.0014	0.0044	0.0042	0.629	TRUE	1	2
Greenland	0.0007	0.0000	0.0040	0.0036	0.479	FALSE	0	4
Grenada	0.0007	0.0000	0.0040	0.0036	0.445	FALSE	0	2
Guatemala	0.0007	0.0000	0.0040	0.0037	0.500	FALSE	0	3
Guernsey	0.0007	0.0000	0.0041	0.0038	0.513	FALSE	0	0
Guinea	0.0007	0.0000	0.0040	0.0036	0.500	FALSE	0	1
Guinea-Bissau	0.0007	0.0000	0.0040	0.0036	0.472	FALSE	0	1
Guyana	0.0007	0.0000	0.0040	0.0036	0.482	FALSE	0	1
Haiti	0.0007	0.0000	0.0040	0.0036	0.485	FALSE	0	1
Honduras	0.0007	0.0000	0.0040	0.0036	0.495	FALSE	0	1
Hong Kong SAR	0.0007	0.0000	0.0081	0.0097	0.527	FALSE	0	2
Hungary	0.0007	0.0000	0.0050	0.0050	0.519	FALSE	0	2
Iceland	0.0007	0.0000	0.0040	0.0037	0.515	FALSE	0	0
India	0.0057	0.0015	0.0057	0.0063	0.714	TRUE	1	0
Indonesia	0.0007	0.0000	0.0046	0.0045	0.516	FALSE	0	2
Iran	0.0007	0.0000	0.0040	0.0036	0.513	FALSE	0	0
Iraq	0.0007	0.0000	0.0041	0.0037	0.506	FALSE	0	3
Ireland	0.0059	0.0069	0.0067	0.0077	0.530	TRUE	0	2
Isle of Man	0.0007	0.0000	0.0041	0.0038	0.514	FALSE	0	0

vertex_id	CheiRank	CheiRank-0	PageRank	PageRank-0	closeness	cvpcore	maxclique	newman
Israel	0.0007	0.0000	0.0041	0.0038	0.522	FALSE	0	2
Italy	0.0302	0.0323	0.0084	0.0101	0.712	TRUE	1	0
Jamaica	0.0007	0.0000	0.0040	0.0036	0.500	FALSE	0	3
Japan	0.0877	0.1122	0.0096	0.0122	0.661	TRUE	1	2
Jersey	0.0007	0.0000	0.0044	0.0043	0.518	FALSE	0	2
Jordan	0.0007	0.0000	0.0040	0.0037	0.516	FALSE	0	0
Kazakhstan	0.0007	0.0000	0.0040	0.0037	0.515	FALSE	0	0
Kenya	0.0007	0.0000	0.0040	0.0037	0.509	FALSE	0	3
Kuwait	0.0007	0.0000	0.0041	0.0037	0.518	FALSE	0	0
Kyrgyz Republic	0.0007	0.0000	0.0040	0.0036	0.455	FALSE	0	2
Laos	0.0007	0.0000	0.0040	0.0036	0.470	FALSE	0	5
Latvia	0.0007	0.0000	0.0041	0.0037	0.514	FALSE	0	0
Lebanon	0.0007	0.0000	0.0040	0.0037	0.511	FALSE	0	0
Liberia	0.0007	0.0000	0.0042	0.0039	0.511	FALSE	0	0
Libya	0.0007	0.0000	0.0040	0.0036	0.509	FALSE	0	3
Liechtenstein	0.0007	0.0000	0.0040	0.0037	0.509	FALSE	0	0
Lithuania	0.0007	0.0000	0.0041	0.0038	0.509	FALSE	0	3
Luxembourg	0.0007	0.0000	0.0072	0.0082	0.527	FALSE	1	2
Macao SAR	0.0007	0.0000	0.0041	0.0037	0.511	FALSE	0	3
Macedonia	0.0007	0.0000	0.0041	0.0038	0.499	FALSE	0	1
Madagascar	0.0007	0.0000	0.0040	0.0036	0.499	FALSE	0	1
Malawi	0.0007	0.0000	0.0040	0.0036	0.494	FALSE	0	1
Malaysia	0.0007	0.0000	0.0046	0.0046	0.518	FALSE	0	0
Maldives	0.0007	0.0000	0.0040	0.0036	0.498	FALSE	0	1
Mali	0.0007	0.0000	0.0040	0.0036	0.479	FALSE	0	4
Malta	0.0007	0.0000	0.0043	0.0040	0.515	FALSE	0	2
Marshall Islands	0.0007	0.0000	0.0043	0.0041	0.509	FALSE	0	3
Mauritania	0.0007	0.0000	0.0040	0.0036	0.498	FALSE	0	1
Mauritius	0.0007	0.0000	0.0041	0.0038	0.509	FALSE	0	3
Mexico	0.0007	0.0000	0.0064	0.0072	0.518	FALSE	0	2
Moldova	0.0007	0.0000	0.0040	0.0036	0.500	FALSE	0	1
Mongolia	0.0007	0.0000	0.0040	0.0036	0.501	FALSE	0	3
Montenegro	0.0007	0.0000	0.0040	0.0036	0.499	FALSE	0	3
Morocco	0.0007	0.0000	0.0040	0.0037	0.518	FALSE	0	0
Mozambique	0.0007	0.0000	0.0042	0.0039	0.505	FALSE	0	3
Myanmar	0.0007	0.0000	0.0040	0.0036	0.499	FALSE	0	1
Namibia	0.0007	0.0000	0.0040	0.0036	0.506	FALSE	0	3
Nauru	0.0007	0.0000	0.0040	0.0036	0.488	FALSE	0	1
Nepal	0.0007	0.0000	0.0040	0.0036	0.501	FALSE	0	3
Netherlands	0.0475	0.0612	0.0098	0.0118	0.601	TRUE	1	2
New Caledonia	0.0007	0.0000	0.0040	0.0036	0.483	FALSE	0	1
New Zealand	0.0007	0.0000	0.0066	0.0072	0.523	FALSE	0	2
Nicaragua	0.0007	0.0000	0.0040	0.0036	0.499	FALSE	0	1
Niger	0.0007	0.0000	0.0040	0.0036	0.481	FALSE	0	1
Nigeria	0.0007	0.0000	0.0041	0.0037	0.514	FALSE	0	0

vertex_id	CheiRank	CheiRank-0	PageRank	PageRank-0	closeness	cvpcore	maxclique	newman
North Korea	0.0007	0.0000	0.0040	0.0036	0.487	FALSE	0	3
Norway	0.0007	0.0000	0.0056	0.0058	0.526	FALSE	0	2
Oman	0.0007	0.0000	0.0041	0.0038	0.509	FALSE	0	3
Pakistan	0.0007	0.0000	0.0041	0.0037	0.514	FALSE	0	0
Palau	0.0007	0.0000	0.0040	0.0036	0.468	FALSE	0	1
Palestinian Territory	0.0007	0.0000	0.0040	0.0036	0.465	FALSE	0	4
Panama	0.0007	0.0000	0.0045	0.0043	0.522	FALSE	0	2
Papua New Guinea	0.0007	0.0000	0.0040	0.0037	0.499	FALSE	0	3
Paraguay	0.0007	0.0000	0.0040	0.0036	0.507	FALSE	0	3
Peru	0.0007	0.0000	0.0043	0.0040	0.514	FALSE	0	3
Philippines	0.0007	0.0000	0.0042	0.0040	0.514	FALSE	0	2
Poland	0.0007	0.0000	0.0062	0.0066	0.519	FALSE	0	2
Portugal	0.0083	0.0045	0.0048	0.0048	0.681	TRUE	1	2
Qatar	0.0007	0.0000	0.0042	0.0039	0.519	FALSE	0	2
Republic of Congo	0.0007	0.0000	0.0040	0.0036	0.489	FALSE	0	4
Romania	0.0007	0.0000	0.0052	0.0051	0.518	FALSE	0	2
Russia	0.0007	0.0000	0.0054	0.0057	0.522	FALSE	0	2
Rwanda	0.0007	0.0000	0.0040	0.0036	0.499	FALSE	0	1
Samoa	0.0007	0.0000	0.0040	0.0036	0.482	FALSE	0	1
San Marino	0.0007	0.0000	0.0040	0.0036	0.489	FALSE	0	1
Sao Tome and Principe	0.0007	0.0000	0.0040	0.0036	0.406	FALSE	0	6
Saudi Arabia	0.0007	0.0000	0.0043	0.0041	0.519	FALSE	0	2
Senegal	0.0007	0.0000	0.0040	0.0036	0.510	FALSE	0	3
Serbia	0.0007	0.0000	0.0044	0.0041	0.515	FALSE	0	0
Seychelles	0.0007	0.0000	0.0040	0.0036	0.513	FALSE	0	3
Sierra Leone	0.0007	0.0000	0.0040	0.0036	0.483	FALSE	0	1
Singapore	0.0007	0.0000	0.0069	0.0080	0.522	FALSE	0	2
Sint Maarten	0.0007	0.0000	0.0040	0.0036	0.472	FALSE	0	1
Slovakia	0.0007	0.0000	0.0049	0.0049	0.513	FALSE	0	2
Slovenia	0.0007	0.0000	0.0042	0.0039	0.518	FALSE	0	0
Solomon Islands	0.0007	0.0000	0.0040	0.0036	0.451	FALSE	0	0
Somalia	0.0007	0.0000	0.0040	0.0036	0.468	FALSE	0	1
South Africa	0.0007	0.0000	0.0047	0.0047	0.522	FALSE	0	2
South Korea	0.0070	0.0025	0.0059	0.0065	0.768	TRUE	1	3
Spain	0.0428	0.0463	0.0082	0.0097	0.745	TRUE	1	0
Sri lanka	0.0007	0.0000	0.0041	0.0038	0.509	FALSE	0	3
St. Helena and Dependencies	0.0007	0.0000	0.0040	0.0036	0.387	FALSE	0	2
St. Vincent and the Grenadines	0.0007	0.0000	0.0040	0.0036	0.500	FALSE	0	1
St.Lucia	0.0007	0.0000	0.0040	0.0036	0.494	FALSE	0	1
Sudan	0.0007	0.0000	0.0040	0.0036	0.490	FALSE	0	3
Suriname	0.0007	0.0000	0.0040	0.0036	0.468	FALSE	0	1
Swaziland	0.0007	0.0000	0.0040	0.0036	0.487	FALSE	0	1
Sweden	0.0200	0.0197	0.0057	0.0059	0.719	TRUE	1	0
Switzerland	0.0438	0.0587	0.0066	0.0074	0.537	FALSE	1	2
Syria	0.0007	0.0000	0.0040	0.0036	0.467	FALSE	0	4

vertex_id	CheiRank	CheiRank-0	PageRank	PageRank-0	closeness	cvpcore	maxclique	newman
Tajikistan	0.0007	0.0000	0.0040	0.0036	0.480	FALSE	0	4
Tanzania	0.0007	0.0000	0.0040	0.0036	0.505	FALSE	0	3
Thailand	0.0007	0.0000	0.0044	0.0043	0.511	FALSE	0	0
The Gambia	0.0007	0.0000	0.0040	0.0036	0.472	FALSE	0	1
Timor Leste	0.0007	0.0000	0.0040	0.0036	0.406	FALSE	0	7
Togo	0.0007	0.0000	0.0040	0.0036	0.492	FALSE	0	1
Tonga	0.0007	0.0000	0.0040	0.0036	0.412	FALSE	0	5
Trinidad and Tobago	0.0007	0.0000	0.0041	0.0037	0.507	FALSE	0	3
Tunisia	0.0007	0.0000	0.0040	0.0036	0.511	FALSE	0	3
Turkey	0.0030	0.0011	0.0062	0.0065	0.599	TRUE	1	2
Turkmenistan	0.0007	0.0000	0.0040	0.0036	0.476	FALSE	0	4
Turks and Caicos Islands	0.0007	0.0000	0.0040	0.0036	0.495	FALSE	0	1
US Pacific Islands	0.0007	0.0000	0.0040	0.0036	0.482	FALSE	0	1
Uganda	0.0007	0.0000	0.0040	0.0036	0.500	FALSE	0	3
Ukraine	0.0007	0.0000	0.0041	0.0038	0.513	FALSE	0	3
United Arab Emirates	0.0007	0.0000	0.0051	0.0052	0.523	FALSE	0	2
United Kingdom	0.1244	0.1395	0.0268	0.0361	0.792	TRUE	1	3
United States	0.1502	0.1748	0.0355	0.0483	0.876	TRUE	1	1
Uruguay	0.0007	0.0000	0.0040	0.0037	0.513	FALSE	0	0
Uzbekistan	0.0007	0.0000	0.0040	0.0036	0.502	FALSE	0	3
Vanuatu	0.0007	0.0000	0.0040	0.0036	0.473	FALSE	0	4
Venezuela	0.0007	0.0000	0.0041	0.0038	0.510	FALSE	0	2
Vietnam	0.0007	0.0000	0.0044	0.0041	0.510	FALSE	0	3
Yemen	0.0007	0.0000	0.0040	0.0036	0.489	FALSE	0	3
Zambia	0.0007	0.0000	0.0040	0.0037	0.506	FALSE	0	3
Zimbabwe	0.0007	0.0000	0.0040	0.0036	0.502	FALSE	0	3

Appendix 5

First order interconnectivity table

	Austrian Banks	Belgian Banks	Swiss Banks	German Banks	Spanish Banks	French Banks	British Banks	Greek Banks	Irish Banks	Italian Banks	Dutch Banks	Portuguese Banks	Swedish Banks	American Banks
2005-1Q	0.0%	7.5%	0.0%	28.1%	0.0%	14.7%	21.9%	0.3%	0.0%	2.9%	14.9%	0.8%	0.0%	9.0%
2005-2Q	1.9%	5.3%	13.3%	21.1%	5.1%	12.0%	16.8%	0.3%	0.0%	2.1%	11.2%	0.6%	3.5%	7.0%
2005-3Q	2.0%	5.3%	13.2%	20.3%	5.2%	11.5%	17.9%	0.3%	0.0%	2.1%	11.3%	0.6%	3.4%	6.8%
2005-4Q	2.2%	5.6%	13.4%	18.4%	5.8%	11.9%	17.8%	0.2%	0.0%	2.1%	11.5%	0.6%	3.5%	6.9%

2006-1Q	2.1%	5.6%	12.8%	18.1%	5.3%	11.7%	17.4%	0.2%	2.8%	1.9%	11.3%	0.6%	3.2%	7.0%
2006-2Q	2.1%	5.7%	12.8%	17.9%	5.2%	12.1%	17.1%	0.2%	2.9%	1.8%	11.5%	0.6%	3.2%	7.1%
2006-3Q	2.1%	5.5%	12.9%	17.5%	5.0%	12.8%	17.4%	0.2%	2.9%	1.9%	11.1%	0.6%	3.1%	7.0%
2006-4Q	2.2%	5.7%	12.8%	17.6%	5.1%	13.3%	16.9%	0.3%	2.9%	1.8%	10.9%	0.7%	3.1%	6.7%
2007-1Q	2.1%	5.7%	12.4%	16.9%	4.9%	13.3%	16.5%	0.3%	2.6%	4.5%	10.6%	0.6%	2.9%	6.7%
2007-2Q	2.1%	5.7%	11.7%	17.2%	4.9%	13.6%	16.0%	0.3%	2.6%	4.6%	10.5%	0.6%	2.9%	7.3%
2007-3Q	2.2%	5.5%	11.2%	17.2%	5.0%	13.6%	17.1%	0.4%	2.6%	4.6%	10.4%	0.6%	2.8%	7.0%
2007-4Q	2.2%	5.6%	10.5%	17.6%	5.0%	14.7%	16.5%	0.4%	2.8%	4.6%	10.0%	0.6%	2.8%	6.8%
2008-1Q	2.3%	5.9%	10.0%	17.4%	4.7%	15.7%	16.9%	0.4%	2.8%	4.6%	9.4%	0.6%	2.9%	6.5%
2008-2Q	2.3%	6.3%	9.8%	17.4%	5.1%	15.7%	16.3%	0.4%	2.8%	4.8%	9.0%	0.6%	3.0%	6.5%
2008-3Q	2.3%	5.7%	9.9%	17.4%	5.2%	15.3%	18.1%	0.4%	2.7%	4.8%	8.1%	0.6%	3.0%	6.7%
2008-4Q	2.3%	4.5%	9.4%	16.8%	5.6%	17.0%	17.5%	0.5%	2.9%	4.9%	8.1%	0.7%	3.1%	6.8%
2009-1Q	2.2%	3.9%	8.3%	15.9%	5.7%	15.8%	17.1%	0.4%	2.7%	4.4%	7.5%	0.7%	3.0%	12.4%
2009-2Q	2.2%	3.8%	8.2%	15.7%	6.0%	15.9%	17.0%	0.4%	2.7%	4.5%	7.4%	0.7%	3.1%	12.2%
2009-3Q	2.3%	3.8%	8.1%	15.4%	5.9%	14.9%	16.7%	0.4%	2.6%	4.4%	7.3%	0.7%	3.1%	14.5%
2009-4Q	2.4%	2.0%	7.5%	15.1%	6.4%	17.1%	16.8%	0.7%	2.6%	4.4%	7.3%	0.7%	3.3%	13.8%
2010-1Q	2.4%	1.9%	7.5%	14.6%	6.0%	16.3%	18.0%	0.7%	2.4%	4.3%	7.2%	0.7%	3.2%	14.6%
2010-2Q	2.3%	1.9%	8.0%	14.9%	6.3%	14.5%	19.2%	0.7%	2.5%	4.3%	6.1%	0.7%	3.4%	15.4%
2010-3Q	2.3%	1.9%	8.0%	14.6%	6.5%	16.3%	18.9%	0.7%	2.5%	4.3%	6.4%	0.7%	3.5%	13.4%
2010-4Q	2.2%	1.9%	8.6%	14.5%	6.8%	15.1%	19.4%	0.7%	1.9%	4.4%	6.3%	0.7%	3.6%	14.0%
2011-1Q	2.4%	1.9%	8.4%	14.3%	7.0%	15.2%	19.0%	0.7%	1.7%	4.4%	6.4%	0.7%	3.8%	14.1%
2011-2Q	2.3%	1.8%	8.6%	14.3%	7.1%	14.9%	19.1%	0.6%	1.5%	4.4%	6.5%	0.6%	3.9%	14.3%
2011-3Q	2.3%	1.7%	8.4%	14.4%	6.9%	14.4%	19.5%	0.6%	1.5%	4.2%	6.4%	0.6%	4.0%	15.0%
2011-4Q	2.2%	1.6%	8.7%	13.9%	7.2%	13.8%	20.1%	0.6%	0.9%	4.3%	6.3%	0.6%	4.3%	15.3%
2012-1Q	2.1%	1.4%	8.9%	13.6%	7.4%	13.2%	20.8%	0.6%	0.8%	4.3%	6.2%	0.6%	4.4%	15.6%
2012-2Q	2.1%	1.4%	8.8%	13.5%	7.5%	13.0%	20.8%	0.6%	0.8%	4.3%	6.1%	0.6%	4.5%	16.0%
2012-3Q	2.1%	1.4%	8.6%	13.9%	7.5%	11.7%	20.6%	0.6%	0.7%	4.4%	6.5%	0.6%	4.7%	16.6%
2012-4Q	2.0%	1.3%	8.0%	13.4%	7.5%	12.5%	20.9%	0.6%	0.7%	4.4%	6.2%	0.6%	4.7%	17.1%
2013-1Q	2.0%	1.3%	8.0%	13.6%	7.6%	12.8%	20.3%	0.6%	0.6%	4.3%	6.3%	0.6%	4.7%	17.3%
2013-2Q	2.0%	1.3%	8.0%	13.6%	7.6%	12.8%	20.3%	0.6%	0.6%	4.3%	6.3%	0.6%	4.7%	17.3%
2013-3Q	2.1%	1.3%	7.7%	13.7%	7.6%	13.4%	20.2%	0.6%	0.6%	4.3%	6.5%	0.6%	4.8%	16.6%
2013-4Q	2.1%	1.2%	7.5%	12.9%	7.8%	14.6%	20.1%	0.6%	0.7%	4.5%	6.7%	0.6%	5.0%	15.7%
2014-1Q	2.0%	1.3%	7.1%	13.0%	7.9%	14.9%	19.9%	0.6%	0.6%	3.4%	6.7%	0.6%	5.1%	16.8%

Second order interconnectivity table (14 countries)

	Austrian Banks	Belgian Banks	Swiss Banks	German Banks	Spanish Banks	French Banks	British Banks	Greek Banks	Irish Banks	Italian Banks	Dutch Banks	Portuguese Banks	Swedish Banks	American Banks
2005-1Q	0.0%	3.9%	0.0%	39.3%	0.0%	10.6%	26.8%	0.2%	0.0%	1.2%	10.9%	0.2%	0.0%	7.0%
2005-2Q	1.4%	2.9%	13.1%	28.5%	5.0%	9.0%	20.5%	0.1%	0.0%	0.7%	7.6%	0.1%	6.4%	4.8%
2005-3Q	1.4%	3.0%	13.0%	26.4%	5.1%	8.4%	23.4%	0.1%	0.0%	0.7%	7.8%	0.1%	6.0%	4.5%
2005-4Q	1.9%	3.4%	13.4%	21.6%	6.0%	9.2%	24.0%	0.1%	0.0%	0.8%	8.3%	0.1%	6.4%	4.8%
2006-1Q	1.8%	3.3%	12.9%	22.3%	5.5%	9.2%	24.5%	0.1%	0.8%	0.7%	8.3%	0.1%	5.4%	5.1%
2006-2Q	1.9%	3.4%	12.8%	21.8%	5.2%	9.9%	23.6%	0.2%	0.8%	0.7%	8.7%	0.1%	5.7%	5.2%
2006-3Q	1.9%	3.2%	13.3%	20.5%	5.1%	11.5%	24.2%	0.1%	0.8%	0.7%	8.1%	0.1%	5.4%	5.1%
2006-4Q	2.5%	3.2%	13.1%	20.9%	5.2%	12.2%	22.9%	0.2%	0.8%	0.6%	7.9%	0.1%	5.5%	4.9%
2007-1Q	2.0%	3.3%	12.5%	19.6%	4.8%	12.7%	22.9%	0.2%	0.6%	4.2%	7.6%	0.1%	4.6%	4.9%
2007-2Q	2.0%	3.4%	11.1%	20.3%	4.9%	13.3%	21.7%	0.2%	0.7%	4.3%	7.6%	0.1%	4.6%	5.8%
2007-3Q	2.1%	3.0%	9.8%	19.9%	4.9%	13.2%	24.2%	0.3%	0.7%	4.2%	7.7%	0.1%	4.7%	5.2%
2007-4Q	2.0%	3.2%	8.6%	20.4%	5.1%	15.5%	22.8%	0.3%	0.8%	4.1%	7.2%	0.1%	5.0%	4.8%
2008-1Q	2.1%	3.5%	7.8%	20.3%	4.5%	17.4%	23.2%	0.3%	0.8%	4.1%	6.2%	0.1%	5.2%	4.3%
2008-2Q	1.9%	4.0%	7.4%	19.8%	5.0%	18.0%	22.2%	0.3%	0.8%	4.4%	5.9%	0.2%	5.7%	4.5%
2008-3Q	1.9%	3.3%	7.4%	19.0%	5.7%	16.7%	26.0%	0.3%	0.7%	4.4%	4.7%	0.2%	5.4%	4.5%
2008-4Q	2.1%	1.7%	6.7%	17.8%	6.3%	19.7%	24.6%	0.3%	0.8%	4.7%	4.9%	0.2%	5.6%	4.6%
2009-1Q	1.8%	1.4%	5.3%	16.1%	6.1%	17.5%	24.1%	0.3%	0.6%	3.4%	4.3%	0.2%	5.3%	13.5%
2009-2Q	1.8%	1.4%	5.1%	15.7%	6.6%	17.5%	24.2%	0.3%	0.7%	3.6%	4.3%	0.2%	5.8%	12.9%
2009-3Q	1.9%	1.4%	5.0%	15.3%	6.1%	15.8%	23.3%	0.3%	0.6%	3.4%	4.0%	0.2%	5.6%	17.3%
2009-4Q	2.2%	0.6%	4.2%	14.1%	6.5%	20.5%	22.8%	0.5%	0.6%	3.3%	3.5%	0.2%	6.1%	14.9%
2010-1Q	2.4%	0.6%	4.0%	13.1%	6.0%	18.8%	25.2%	0.5%	0.5%	3.2%	3.5%	0.2%	5.5%	16.5%
2010-2Q	2.2%	0.6%	4.4%	13.1%	6.4%	14.5%	27.1%	0.5%	0.5%	3.4%	3.1%	0.2%	5.9%	18.0%
2010-3Q	2.3%	0.6%	4.6%	13.0%	6.8%	18.6%	26.4%	0.5%	0.5%	3.3%	2.8%	0.2%	6.2%	14.3%
2010-4Q	2.1%	0.6%	5.2%	12.7%	7.5%	15.8%	27.2%	0.5%	0.4%	3.3%	2.9%	0.2%	6.7%	14.9%
2011-1Q	2.4%	0.6%	5.0%	12.6%	7.5%	16.1%	26.5%	0.5%	0.3%	3.3%	2.9%	0.2%	7.0%	15.3%
2011-2Q	2.4%	0.5%	5.1%	12.2%	7.5%	15.8%	26.4%	0.5%	0.3%	3.2%	3.0%	0.2%	7.3%	15.5%
2011-3Q	2.2%	0.5%	4.8%	12.2%	7.0%	15.3%	27.0%	0.5%	0.3%	3.0%	2.9%	0.2%	7.6%	16.7%
2011-4Q	2.1%	0.5%	5.2%	11.0%	7.3%	14.0%	27.5%	0.4%	0.2%	3.2%	2.9%	0.3%	8.3%	17.2%
2012-1Q	2.1%	0.4%	5.4%	10.5%	7.7%	12.9%	28.9%	0.5%	0.2%	3.2%	2.7%	0.3%	8.0%	17.3%
2012-2Q	2.0%	0.4%	5.3%	10.3%	7.7%	12.9%	28.9%	0.5%	0.1%	3.1%	2.6%	0.3%	8.1%	17.8%
2012-3Q	2.0%	0.4%	4.9%	11.0%	8.0%	10.7%	28.7%	0.4%	0.1%	3.3%	3.2%	0.3%	7.9%	19.2%
2012-4Q	1.9%	0.4%	4.3%	10.0%	7.9%	11.4%	28.9%	0.4%	0.1%	3.2%	3.0%	0.3%	8.1%	20.1%

2013-1Q	1.9%	0.4%	4.1%	10.3%	8.1%	12.0%	27.9%	0.5%	0.1%	3.1%	3.0%	0.4%	7.6%	20.6%
2013-2Q	1.9%	0.4%	3.8%	10.4%	8.0%	12.5%	28.5%	0.5%	0.1%	3.1%	2.9%	0.4%	7.5%	20.0%
2013-3Q	1.9%	0.4%	3.7%	10.5%	8.1%	12.8%	28.1%	0.5%	0.1%	3.2%	3.1%	0.3%	7.7%	19.7%
2013-4Q	2.0%	0.4%	4.4%	8.9%	8.7%	14.1%	27.8%	0.5%	0.1%	3.3%	3.2%	0.4%	8.9%	17.3%
2014-1Q	1.9%	0.4%	3.9%	9.3%	8.5%	14.5%	27.1%	0.5%	0.1%	2.2%	3.2%	0.4%	8.7%	19.2%