Analysis of impact of banking regulation on international financial network in 2001-2013

By

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Abstract

This thesis investigates the relation between the banking regulation and its underlying financial network. In particular, it tries to identify impact if there is any, of the regulatory framework on the structure of the financial industry. It is completed by means of comparing results of the financial network and regulatory evolution analysis. The literature up to date argues for significant lags in the regulatory changes preventing from effective supervision of financial network.

The data for network analysis comes from two datasets: cross-border banking claims and portfolio investments for the years 2001-2013. Assuming a direct impact of the regulation on interbank relations, the paper attempts to catch wider influence by means of mapping securities flows as well.

The analysis shows that indeed there were dramatic structural changes in both layers of the international financial network. However, the direct impact of the regulation is minor and arguably rather negative. Based on network mapping and regulatory research, I conclude with certain policy implications aiming to ensure a stability of the international financial system.

Acknowledgments

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Introduction

Banking industry once started as simply tool for access to finance of the real economy, transformed into one of the major ingredients of the real economy itself with corresponding implications. It contributed significantly to globalization spread, making international financial flows more available and convenient. At the same time, its feature of connecting financial markets globally proved to be a threat as well. Especially after the end of Bretton Woods's framework, international financial system had been exposed to more stability issues. With an aim to respond and forecast financial disruptions, a Committee on Banking Regulations and Supervisory Practices was established at the end of 1974.

"The Committee was designed as a forum for regular cooperation between its member countries on banking supervisory matters. Its aim was and is to enhance financial stability by improving supervisory knowhow and the quality of banking supervision worldwide " (BIS, A brief history of the Basel Committee, 2014)

During the 40 years as financial markets were getting more and more complex not only in the means of financial instruments, but also types and density of connections between the major players, regulations were being developed to capture these changes. Financial regulators around the world have given the most attention to ensuring financial stability and building a rigid regulatory framework based on global banking network. The international financial network was evolving in parallel with the rules making it more difficult for regulating agencies to capture and model all its layers.

Crisis of 2007 highlighted flaws of the banking network, especially importance of monitoring not only individual players, but also linkages between them as they may be source of contagion. For

this network analysis was long proven to be the most effective tool, as "it 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" (BIS, A brief history of the Basel Committee, 2014).

As international financial system has been changing rapidly for many years, it was always in the interest of various researchers to analyze its structural changes, possibilities of risk contagions and even estimate ability of the network topology to predict crises. Along the way there were attempts to analyze changes of the regulation to identify its drawbacks and steps for improvement. However, there were not many papers conducting cross-analysis of how well regulation actually reflects the network characteristics and whether they were moving along. This thesis looks at the changes of the international banking network between 2001 and 2013 and estimates the impact of the banking regulation on the topological changes of the network. Analysis is done based on mapping of two datasets: banking claims and international portfolio investments.

I start with mapping the international financial network, analyzing the trends in some typical network measures like density of network, degree distribution and clustering. These properties of the network provide an important insight for spotting how exactly risk contagion occurred and help to identify if there were signs in the structure or behavior of the network that would enable predicting the sub-prime bubble. I also conduct a detailed analysis of post-crisis structural changes and try to indicate to some emerging crisis warning signs.

Following chapter provides analysis of the regulatory framework, particularly the banking regulation developed and published by the Basel Committee on Banking Supervision. I analyze how the banking regulation was evolving from the simplest first accord of 26 pages to the most

complex one, covering all important aspects of the banks' behavior. Considering main and important difference between the accords, I summarize several surveys and tests conducted in order to estimate impact of the regulation on the industry.

As final part of analysis I conduct a contagion simulation for the most current dataset of 2013. It shows how resistant is the recent network to possible exogenous shocks and enables to evaluate impact of current regulation in stabilizing international financial system and particularly preventing risk spill overs. I use an algorithm used by (Elliott, 2014).

Conclusion presents a summary of the international financial network evolution for the past 14 years, outlines positive and negative impacts of the banking regulation, based on the results of network analysis and provides some policy implications.

Literature Review

After the recent financial crisis the importance of international financial system interconnectedness, particularly a high level of integration of the banks has been in the center of policy and academic discussions. It pushed a new wave of extensive researches to improve resistance of the financial system to shocks by means of network analysis. Networks enable the description of complex financial systems as a simplified set of nodes and links between them. Nodes can be financial institutions, countries or whole regions. Links might represent various connections between the nodes, from migration flows to interbank loans. Network analysis provides settings for policymakers to analyze channels of the crisis as well as test effectiveness of the macroprudential policies (Alves, The structure and resilience of the European interbank market., 2013). This chapter will provide a summary of researches done of applying network analysis tools to the field of finance.

Two most common approaches to network analysis are static and dynamic. Static approach is a descriptive one, using topological measures of the network to understand its structure and properties. Dynamic approach is rather applying algorithm of certain transmission mechanism and by this testing the network for resistance or the strength of the contagion channels.

Literature on network analysis: Static approach

S. Schiavo et al. presented the importance of topological issues in the analysis of international financial integration. They introduced such network indicators as node degree (measuring the number of node‘s links), average nearest neighbor degree (measuring how many links the neighbors of a node have on average),clustering coefficient (the percentage of pairs of node’s partners that are connected among themselves), node strength (the sum of weights associated

with the links maintained by any node), average nearest neighbor strength or random walk betweenness centrality (the position of each node relative to all other nodes) and showed that these indicators provide additional information of financial integration (Schiavo, 2010).

Due to data constraints, most of static approach works are done limited to a single market, either a country or type of the financial product. This data is more complete and allows full investigation of financial network's structural properties. Country level analysis examples include (Soramäki, 2007) on US, (Toivanen, 2009) on Finnish, (Fourel, 2013) on French, (Nobi, 2013) on Korean, (Affinito, 2014) on Italian, (van Lelyveld, 2014) on Netherland, and many others. Local banking networks' structure shares a common feature of distinct core-periphery structure and dramatic changes during stressed years.

Other researches are based on international consolidated level of the data, mostly cross countries flows of securities, bank lending or trade. Of course papers published by international organizations provide more comprehensive view on the network due to access to bigger and more complete datasets. IMF conducted mapping of cross-border financial linkages and identified main drivers of the structural changes. Main conclusions are that linkages have increased dramatically over time and become more complex. Cross-border networks also have a clearly defined core-periphery structure, where a few advanced economies and some financial centers dominate the web of linkages across asset classes and regions (IMF, 2011).

Lydeka presented another evidence of core-periphery structure of the network, using data on international securities holdings. Analyzing network of 76 countries over 2001-2011, authors concluded that core group of countries tightly connected among themselves shares the biggest part of the network value (Lydeka, 2013). The high clustering coefficient indicates that local ties are preferred over more distant ones. Similar structure exists in cross-border banking claims as

presented by McGuire and Tarashev. Authors mapped the data from Bank for International Settlements locational banking statistics database and found trends in rising importance of emerging markets starting from 2002 and continuing to the crisis of 2007 (McGuire P. T., 2005). This is another evidence of core-periphery structure of the network and its instability. It happens with a significant shift from equity to debt, particularly bond financing. Possible explanation can be changes of the credit risk of emerging market debt, following with the narrowing spread on lending and thus providing more beneficial terms for core creditors.

Dramatic structural changes in the network occurred after stress events of 2007 as highlighted in work of (Minoiu, 2013). Authors explore the properties of the global banking network applying network analysis techniques on the same set of BIS data over longer time range. They observed changes in the network from 1978 to 2009 and found an evidence of diminishing connectivity in stress years, like Asian crisis of 1997-1998 or subprime bubble of 2007.

Powerful evidence of how these structural changes impact real economy was presented by Bank of England. Garatt et al. divided banking groups from 21 countries into modules. Such a structure of the international banking network enabled to analyze the flow of financial stress through network and topological features influenced it over past 25 years. Authors tried to understand why defaults in US sub-prime mortgages had such large global implications, causing waves of crisis across the continents. They indicated several important financial centers forming a large supercluster and contributing dramatically to the stress transmission during crisis years (Garratt, 2011). Focusing rather on banking groups than on country gives a different perspective on importance of large international bank holding companies for the financial system.

Literature on network analysis: Dynamic approach

This approach uses a certain transmission algorithm to explore the resilience of a network during stress events. Algorithm usually includes simulation with introduction of external or internal shock which triggers the system. Shock can be applied to an individual node or to the system in general. The analysis of how shocks travel is important to get a sense of how a crisis may spread after the initial shock has taken place. Analysis of contagion can also help identifying institutions or countries that are most vulnerable to the systemic risk. With a full and adequate data results of analysis can be used to develop effective regulatory tools.

The most common approach used is simulating a domino effect. Bhattacharya and Gale built a model of interbank coordination focusing on a role of central banker in designing risk sharing across the banks (Bhattacharya, 1985). Authors introduced an idiosyncratic liquidity shock that may have resulted from banks' excessive appetite for long-term high yielding but relatively ill-liquid assets. They identify a need for adequate borrowing and lending mechanism to insure depositors against liquidity shocks. Capital requirements of Basel regulation, considered in my paper, exactly aimed to prevent from lack of liquidity that can be triggering for crisis spillovers. Espinosa-Vega and Sole introduced similar liquidity and credit shock to the international banking network. By focusing particularly on risk transfers, authors illustrate techniques to test financial surveillance. Including balance sheet analysis, they found that apart from liquidity, interconnectedness has proven to have an impact on financial stability (Espinosa, 2010).

Allan & Gale used network tools to model spreading of a financial crisis and found its dependence on the level of the banking network integration (Allen F. &., 2000). They concluded that a "complete" network, when every bank is connected to all other banks, due to higher diversification, is more resistant to crisis shocks. Thus, being connected is a good sign for the

network. Gai and Kapadia explored the probability of contagion triggered by idiosyncratic shock and found a robust-yet-fragile feature of networks. This implies that networks expected to have a small number, but extremely spread crises. While high connectivity may reduce the probability of contagion, it can also increase its spread when problems occur (Gai, 2010). Mapping the banking network after the crisis Allen & Babus showed how network theory can be used to explain freezes in the interbank market observed during the crisis. Furthermore, they examined how networks can explain investment decisions and distributions of debt and equity securities (Allen & Babus, 2008).

IMF working paper estimates a threshold of "allowed interconnectedness" after which probability of a banking crisis increases (Cihák, 2011). Authors find an M-shaped relationship between financial stability of the banking sector and level of its interconnectedness. Countries that are not significantly integrated into international financial network higher interconnectedness means less probability of a banking crisis as diversification brings more available funding and investment opportunities. However, after certain point greater financial linkages trigger local shocks of one country to be transmitted to other countries and cause dramatic consequences. Paper highlights an important point: there is a growing consensus that interconnectedness, together with size, should be a key variable in assessing the systemic importance of a jurisdiction from viewpoint of financial stability (Cihák, 2011).

Analysis of international financial network

Past fifteen years were marked by several major crises and as a result substantive changes in the international financial network. Years between "dot com" bubble burst and appearance of the housing market bubble are defined with high volatility of this network. Shifting centrality from banks to new players such as various funds, market of secondary derivatives experienced enormous growth leading to an increased complexity of the network. Post crisis condition of the network can be defined by significant structural changes occurring for different reasons. As a consequence of the crisis some of the major hubs reconsidered their investment flows especially to periphery countries.

Given a background of research done on applying network analysis in the field of finance, I provide results of my analysis of the international network. This chapter aims to analyze evolution of the international financial network through changes in topology. I start with presenting the datasets, assess their correlation and explain on which countries analysis is focused and why. Cross-analysis of the highly correlated datasets provides a unique opportunity to test whether banking regulation has an impact on the international financial network through the flows of securities (see Appendix A for correlation results). Then I introduce several topological measures of the network and observe how they are reflected in pre and post crisis years. Rich club and core-periphery analyses conducted later give an important insight to which countries play most roles in the network and therefore should be targeted by regulation.

Comparison of datasets

To better understand financial network's dynamics and to enable projecting future distortions one needs a comprehensive data. However, data availability for sound research and reasonable

conclusions is still one of the main problems. Data constraints restrict to two types: local and aggregated. Local data is based on exposures of the single markets. This data is more complete and allows full investigation of financial network's structural properties. Other datasets include aggregated information, considering networks comprised of countries as nodes.

One of the latest analyses is done using a unique dataset on interbank exposures between 53 large EU banks collected by the Bank of England. A group of prominent researchers (Alves, 2013) helped to understand European interbank network condition in 2013 by plotting a network, considering its topological structure and conducting default contagion simulation. They agree with previous researches that interconnectedness is a core component of systemic risk and it is therefore important to continue thorough monitoring financial links between large EU banks. Authors suggest, it requires data on exposures observed at sufficiently high frequency and with a granular set of instruments as well as capturing wider time dimension.

A similar approach to data is used by IMF economists in analyzing a banking network over 1983-2010. Camelia Minoiu (Minoiu, 2013) maps a global banking network based on the Bank for International Settlements (BIS) locational banking statistics data. They apply network analysis tools to test whether financial interconnectedness can predict financial crises and found that level of linkages within financial system can indeed serve as an early warning indicator for systemic banking crises. (Minoiu, 2013) concludes that network and data mining tools can be effectively used to explain past and predict future crises.

I would like to follow Minoiu's approach as this dataset is one of the most comprehensive banking statistics databases, presenting amounts of cross-border bank exposures between all participating countries. Central bank of a reporting country collects the data on claims of local banks towards cross-border counterparties and reports the data to the BIS. Committee compiles

these statistics in two broad categories, locational banking statistics and consolidated banking statistics.

Both datasets are designed to provide comprehensive and consistent quarterly data on international banking business conducted in the reporting countries. Locational statistics are reported with a full breakdown by either the residence of counterparty or nationality of reporting institution while consolidated data focuses on banks' nationality only (McGuire P. W., 2005). If one third of locational data comes from inter-office positions, consolidated data nets out those, allowing clear capturing linkages between unaffiliated counterparties, rather than countries' banking sectors in general. Advantage of using such data is that it includes all types of financial instruments as well as providing a detailed breakdowns based on currency, type of claims, sectors and maturity. However, due to public availability of the data, I use the BIS consolidated dataset.

Another dataset I use is the Coordinated Portfolio Investment Survey collected by IMF. The survey aimed to fill the gaps in global financial statistics and serve as an internationally coordinated benchmark survey of long-term portfolio investment holdings. It is a set of bilateral data on portfolio investments providing geographical details on the counterparties' country of residence. Data covers equity, debt with an original maturity of over one year (long-term) and one year or less (short-term) issued by nonresidents and owned by residents of the reporting country. In some instances, to reduce respondent burden, a threshold of holdings may be used so that any holdings below that threshold need not be reported separately. Since survey was fully implemented starting 2001, I use both datasets for the period of 2001-2013.

Reporting vs. Non-reporting countries

Both datasets are constructed by values submitted by reporting countries. Number of reporting countries in IMF - CPI dataset is more constant and with BIS's list of reporters gradually increasing, composition of cross analyzed countries overlap.

	CPI	CBS
Number of reporting countries	~70	~20
Years covered	1997, 2001-2013	1997-2013

Table 1. Summary of datasets

Reporting countries are considered as "core" as they complete a core network of bilateral financial flows and moreover, they represent most developed countries. Non-reporting countries are considered as "periphery" as they represent emerging markets, have limited number of links and only with reporting countries, with no links among themselves. As there are a high number of non-reporting countries that are reported as counterparties, they affect soundness of such network measures, like density, clustering and etc. For clear conclusions about the network I conduct main analysis only for the reporting countries.

Density

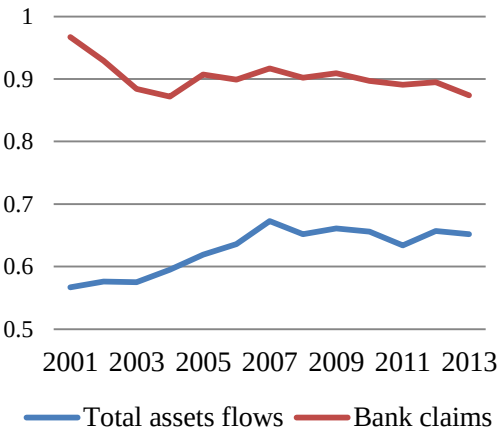
Network density describes the fraction of the potential interconnections of countries in a network that are actually observed. A potential connection is a connection that could potentially exist between two "nodes" – regardless of whether or not it actually does. With regards to the financial network, density shows what percentage of the potential channels of securities or banking claims are indeed present. Density is calculated by dividing the number of observed edges over the number of total connections that could potentially exist for

$$D = \frac{2E}{N(N-1)}$$

the observed number of nodes. Formula is as given on the left, where D is density, E is a number of existing edges and N is a number of nodes.

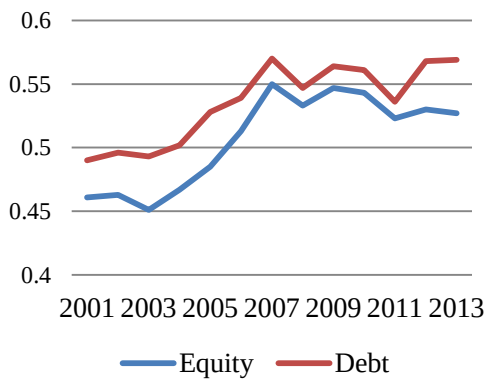
First of all, comparing density trends between flows of total assets and interbank claims, one can see that there is some convergence up to 2004 (see Figure 1). Density of the cross-border banking relations is similar to fluctuations in the Target Federal Reserve Funds rate. This would be reasonable as the federal funds rate is one of the most influential interest rates in the U.S. economy and consequently in the world. It affects monetary and financial conditions, which in turn have a bearing on key aspects of the broad economy including employment, growth and inflation.

Figure 1. Density of the securities flows and bank claims compared



Another reason for such density fluctuation would be the investment industry diversification, deviating from conventional banks to more various players, like hedge, mutual, pension funds and others. This trend continued further and even despite the news scandals with top banks during crisis, hedge funds and other types of funds experienced a dramatic change. By 2007, hedge funds held about 50% of the 3 trillion USD worth of highly risky derivatives (Lysandrou, 2013). Overall bank share in the international financial network has declined significantly in past years. In the U.S banks' share of the financial markets declined 8 percentage points over past decade as well as in Germany, with a bank-based financial system decline is 6 percentage points (Barth J.R., 2009).

Figure 2. Density of the equity and debt securities flows compared



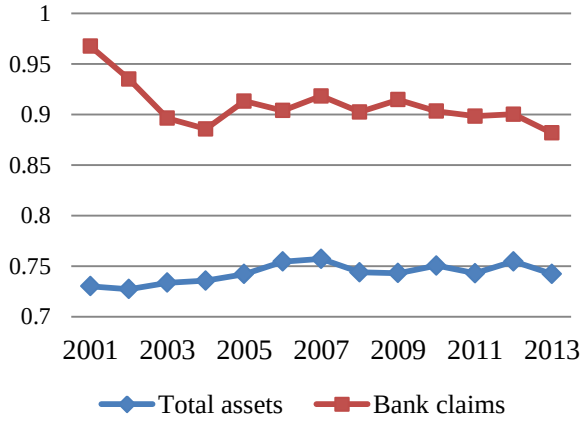
With the sub-prime bubble burst density of the financial network drops. It is pretty logical as financial flows are surging, lack of trust fears the markets and instability diminishes cross-border investments. Density of the debt flows is constantly higher than equity ones and according to the most recent years it is only increasing (see Figure 2).

Step down in 2011 is explained by a second wave of financial crisis. The stock markets fall in August of 2011 across the US and the global financial network happened due to fears of contagion of the European sovereign debt crisis and mostly concerns over the slow economic growth of the United States and its credit rating being downgraded. As markets were shaky global traders rushed to liquidate their positions and raise profit before panic spread.

Clustering

Global clustering coefficient was calculated using Gephi software. Coefficient is calculated using direction and weights, which means it is strongly affected by larger weights of the edges-flows. This type of clustering coefficient, as analyzed by Tabak et al, can be used as a measure of systemic risk. (Tabak, 2014) High clustering of bank claims in 2006 and spike in securities flows clusters in 2007 provides a practical evidence of high systemic risk that followed by bubble burst (see Figure 3).

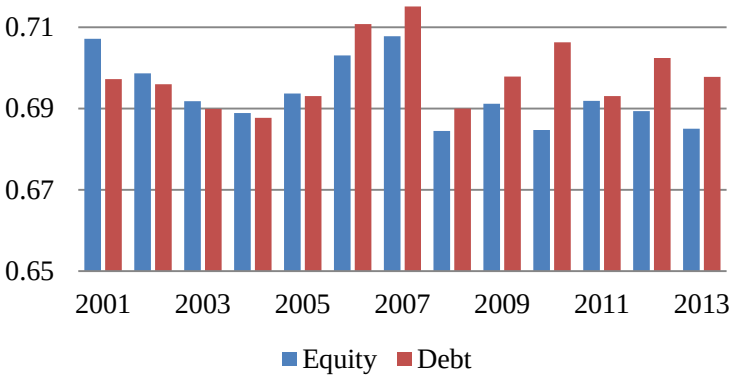
Figure 3. Clustering coefficient of the securities flows and bank claims flows compared



Lagged effect of bank behavior on securities clustering can be explained by the nature of reported data. For portfolio investments survey securities are reported when being in hands of end-investor, while bank lending data is reported on immediate borrower basis. Therefore, significant increase of securities input to the financial network is reported by end-investors at least next year. Significant easing of bank loans started far before the crisis and was spiking already in 2006, which has evidence of highest point of securities clustering in 2007.

Overall the clustering coefficient in flows, equity and debt is constantly quite high. It starts from being on the level of approximately 0.7 in 2001 (see Figure 4). There is some downwards trend until 2004 and then strong increase with 2007 being on peak. Important thing to notice is that before by 2007 debt securities significantly outweighed equity securities in the international financial markets. Indeed based on the "Flow of Funds" data of March 2006, published by the Board of Governors of the Federal Reserve System for the fourth quarter of 2005, there was approximately $34,818 billion in outstanding debt instruments and about $18,199 billion in outstanding corporate equities. Thus, the size of the debt market already in 2005 was about twice that of the equity market and kept growing. Most of the systemic risk that led to bubble burst in 2007 apparently came from debt securities high clustering.

Figure 4. Clustering coefficient of the equity and debt securities flows compared



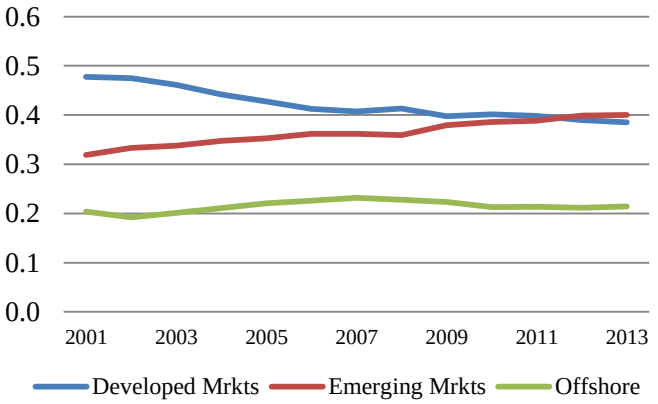
Authorities and hubs

Analysis was done using Kleinberg's HITS algorithm, where authority score estimates the importance of the node *p* and the hub score estimates the influences of the node *p's* outgoing links.

$$Au(p) = \sum^{n} Hub(i) \qquad Hub(p) = \sum_{i=1}^{n} Au(i)$$

Interpretation of them in financial network is that authorities are the countries - main investors, holding biggest volumes of the securities, while hubs are main borrowers or securities issuers. Paper follows an assumption of Chinazzi that financial authorities and hubs are not defined based on lent/borrowed volumes, but rather by number of overlapping common borrowers or lenders. Thus, every country has two scores, for authority and for hub; and developed countries are expected to have both of them very high. Like, USA is an authority and a hub, because it is the most common lender and borrower for other nodes. (Chinazzi, 2013)

Figure 5. Authority scores compared across groups of countries



Identification of main authorities and hubs can be particularly important for the financial networks. This is a crucial measure to use, because countries with the highest scores are possible risk sources and thus should be closely regulated. Banking regulation is and should be imposed as a soft law on these core countries. Initially it was created as a regulatory framework to establish same playground for developed countries, because of their systemic importance. However, spillover of the regulation to

emerging markets happened as capital requirements implementation were wrongly perceived as banking sector reliability sign. As authorities and hubs of the datasets overlap, it is a clear sign of these countries' role in the resistance of international financial network. Top 10 authorities of the banking and securities networks are exactly the same countries, which is even surprising, because they are as well as top hubs. The United States, Great Britain, Spain, Italy, Belgium, Germany, France, Japan, Switzerland and Sweden comprise the core network. Considering by groups of developed, emerging markets and offshore centers, scores of developed and emerging countries converge when it comes closer to the crisis and further (see Figure 5). This is a sign of how close participants of the international financial network came to each other as well shows the level of integration and diversification.

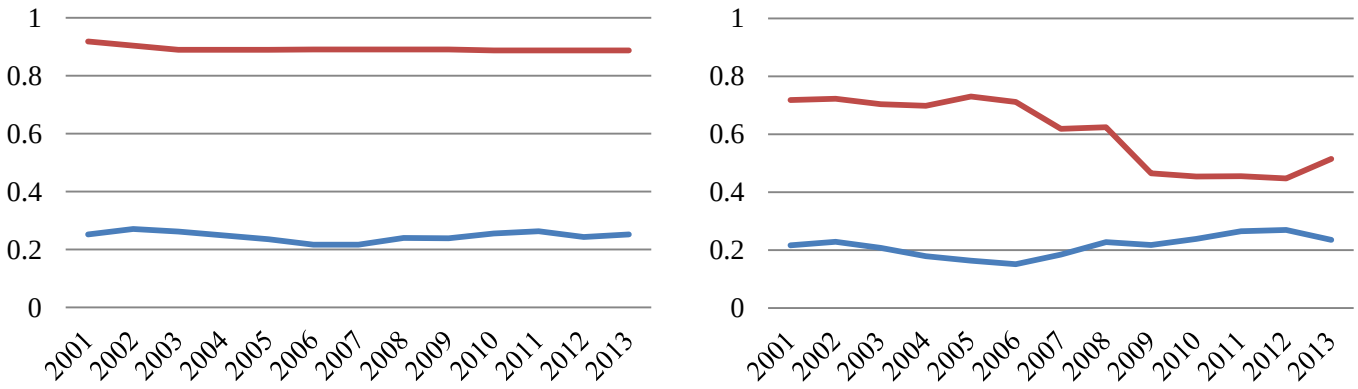
Top emerging markets quite expectedly are Russia, Brazil, South Korea, Argentina, Greece, Turkey, Poland, South Africa, Philippines, Thailand and Poland. These countries are becoming more and more integrated into the global financial network due to favorable investment environment and improved local regulations. Another important layer of the network, offshore centers are not increasing their centrality as significantly as emerging markets. However, still there is a slight convergence with the developed markets that continues even after crisis. Top offshore countries, based on the data, are Cayman Islands, Bermuda, Honk Kong, Singapore, Netherlands Antilles, Panama, Malaysia, Jersey and Guernsey. Maintenance of the offshore centers is a separate and as important topic of the banking regulation. Concluding before the crisis there was a broad-based investment boom, spreading the network further and bringing different layers of it closer.

Asymmetry measure

Network asymmetry helps to identify if most of the linkages are bilateral. In case of the international financial network it is essentially useful. Considering the probability that any outgoing link with a given weight is reciprocated with a similar weight can be another measure to understand how interrelated countries are with their securities portfolios and bank claims. If network is fully symmetric, meaning all links are reciprocated with the same weight, it implies that international financial network is perfectly balanced and stable. Thus a higher asymmetry means larger link unbalances in bilateral interactions and weight skewedness on particular countries. Regardless of the direction of skewedness unbalance in the global securities flows creates a possibility for a risk contagion.

Following method of (Chinazzi, 2013) I calculate two indices of asymmetry, absolute weighted and absolute binary indices.

Figure 6. Asymmetry measure of the network. Left: Absolute binary, Right: Absolute weighted. Red line: Bank claims, Blue line: Securities flows, total assets

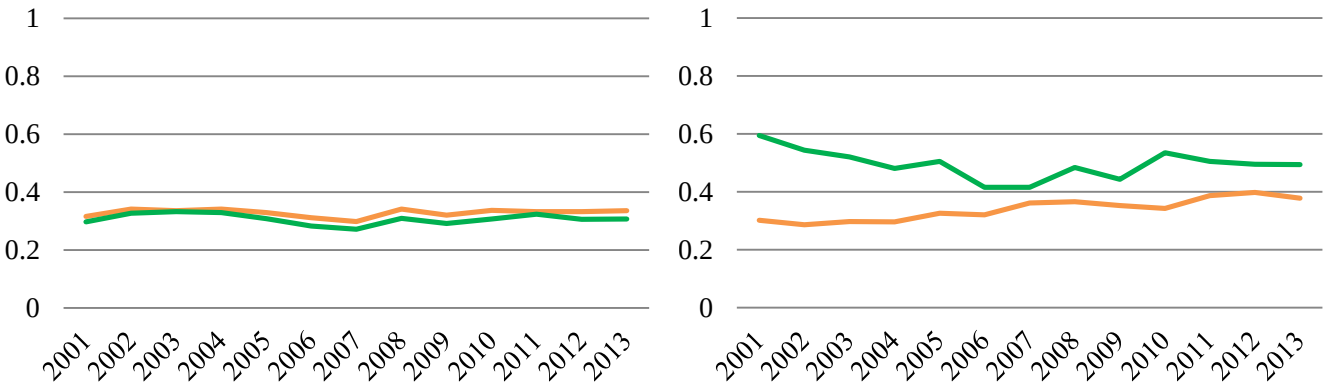


For flows of total assets securities both measures give more or less constant result over years. Cross-border bank claims are marked by higher network asymmetry in both cases with significant volatility measured by absolute weighted index. Results are in line with plots of

Chinazzi (see Figure 6, 7). Considering binary measure that checks for presence of the links, asymmetry doesn't seem to change much over years.

However, weighted asymmetry measure shows some volatility, especially for debt securities flows. Steadily decreasing up to 2005 and then experiencing some spikes in 2008 and especially in 2010. Equity securities asymmetry has more constant upward trend for both measures.

Figure 7. Asymmetry measure of the network. Left: Absolute binary, Right: Absolute weighted. Green line: Debt securities flows, Orange line: Equity securities flows



Core - Periphery Structure

The concept of core - periphery structure in networks for a long time was an intuitive notion. Basically it assumes each network having two groups of nodes. Central or "core" group is characterized by a high value of nodes interconnection. Periphery group consists of nodes more loosely connected to the core and lacking cohesion within them. A specific model was formalized for the first time by Borgatti in 2000 as a two-class partitioning of the nodes. One class is called core and the other one is the periphery. Borgatti explains a concept by two models: a discrete and a continuous. Under discrete model, there are two strictly defined groups of nodes: core and periphery, while second model allows presence of semi- periphery class of partitioning

(Borgatti, 2000). In continuous model, instead of being assigned to one of the classes, each node has a measure of "coreness". I apply the core periphery description to the international network. Based on the visualization (Appendix C) I verify that core countries are developed economies with higher node degree surrounded by a periphery or developing economies or emerging markets.

Coreness membership of each country node is calculated using k-core decomposition algorithm. It allows characterizing networks beyond the degree distribution and uncovering structural properties and hierarchies due to the specific architecture of the system and by focusing on the network's regions of increasing centrality and connectedness properties (Alvarez-Hamelin, 2005). Algorithm defines the nodes to be part of the core with maximal closeness when k-core is a maximal sub graph with minimum degree k.

Core-periphery analysis of cross-border banking claims, as expected, identified one core group of countries that includes all nodes of the network. High density and clustering as well as small number of the nodes predicts that all nodes form a core group. Analysis of the securities flows instead gives some interesting insights. Over the observed 13 years share of core countries in the network is increasing, confirming higher clustering and thus concentration of the flows around these core countries. Composition of core countries is not changing much though. Countries are still the same the most developed countries, however with some new players, like Ireland, Singapore, Korea, Malaysia, Bermuda and Israel. This is another sign that offshore countries are becoming more and more significant players.

Changes in composition

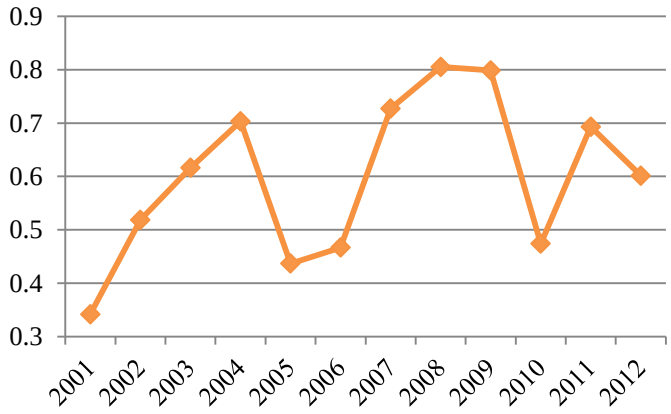
To test changes in the compositions, adjusted rand index was applied. Rand index is used for measuring the degree of similarity between two partitions. The Rand Index is a number between 0 and 1, with 0 representing little agreement and 1 representing strong agreement. Index values how clustering composition changes not only of core, but also periphery group. The Rand Index tends to give quite large values even when clustering methods are in substantial disagreement. Even a random assignment of points to clusters can lead to large Rand Index values.

Hubert and Arabie (1985) proposed an adjustment to the Rand Index in order to account for agreement by chance. They did this by considering a distribution for assigning points to clusters under the condition that cluster sizes remained unchanged (Hubert, 1985) .

$$\text{Adjusted Rand} = \frac{\text{Rand Index} - \text{Expected Rand Index}}{\text{Max Rand Index} - \text{Expected Rand Index}}$$

So, as ARI is the corrected-for-chance version of the Rand index. It rather measures not only changes in composition of the network, but also change normalized by maximum possible randomized change.

Figure 8. Adjusted Rand Index



Changes in the index are correlated by real economic events, changing measure of the country's coreness. Sharp shifts in the index are observed in 2005, 2007 and 2010-2011 (see Figure 8). Most of the swings can be explained by interest rate changes. For example, in 2005 six

countries, like Estonia, New Zealand, Kazakhstan, Iceland and Indonesia joined the core group. Indonesia had a new appointed finance minister that introduced an adjusted monetary policy with an inflation targeting and lower interest rates spread, from 7.7% to 6%. Other core newcomers, Iceland and Kazakhstan had similar tightening monetary policy solutions. In 2006- 2007 six more countries became part of core group: Poland, Panama, Slovak Republic, Bahrain, Latvia and Bulgaria. This time movement is in opposite direction which can be explained by rising interest rates. Expansion of the group continues to 2010 and then drops in 2011.

Index changes less volatile, but has clear trend if considered separately only for debt and equity securities. In both groups, a significant number of countries joined core class in 2007, causing a sharp change in the index. For all observed years, core group of 2007 has the biggest number of countries, with periphery group having the least. It can be explained by a boom in investing preceding 2007-2008. For example, Baltic countries, Latvia, Lithuania and Estonia were experiencing a housing bubble from 2005-2006 that led them to become core countries in the debt securities network. However, during crisis they experienced a dramatic decline as many other countries. It is worth to note that changes in the index for 2013 are almost as significant as in 2007 which can be a warning sign for the regulators.

Figure 9. Adjusted Rand Index for equity and debt securities flows compared. Blue line: equity. Orange line: debt.

Changes of core-periphery structure in debt and equity securities sub-networks speak of turns in investing behavior of the countries (see Figure 9). Higher interest rates negatively affect debt securities, mainly bonds, moving markets interests towards stocks and other equity securities.

There are clear trends differentiations before 2007 and after, showing shifts in investors' appetite.

Conclusion

Inter-crisis years were indeed marked with a high volatility and important structural changes in the network. Summarizing changes and trends in the topological measures of the international financial network, it can concluded that it is far from being stable and still has a chance of risk contagion, thus requires more attention from regulators.

Particularly, with overall density of the network being steady and clustering being not significantly different from 2007, there is a high level of interdependence in the network. Based on asymmetry measures observation, cross-border banking claims network is getting even more unbalanced. Same can be seen on breakdown of securities flows and as we know, unbalanced network has a higher possibility of risk contagion.

Another important measure, core periphery structure of the network suggests increasing integration in the core group of countries. Recalling convergence of emerging and developed markets, this should raise special attention to accurate country based risk allocation.

Evolution of the regulatory framework

This chapter aims to introduce main pillars of the banking regulation and a general timeline of its changes. I start with providing a literature review for regulation and continue with a non-technical analysis of the accords, differences between them and how they may have influenced the international financial network.

Literature on regulation research

It is a general view that harmonizing financial regulation across countries has a positive effect on the stability as well as higher integration of whole international financial system. Vlachos proves it with an empirical evidence that regulatory differences have a strong negative effect on cross – country securities holdings (Vlachos, 2004). Author has made estimations based on bilateral portfolio investment holdings, same data that is used in this thesis. Vlachos considers costs associated with differences in regulation across countries as one of the determinant of international investment patterns. Although such factors as religious, cultural and institutional differences do play a significant role in cross-border investments, regulatory differences have the strongest negative impact among countries. Analysis concludes that such results are caused more by differences in regulatory structure rather than in regulatory effectiveness. (Vlachos, 2004) However, as regulation is more and more harmonized across the international financial system, next issue to consider is whether it is actually effective. As I focus on the banking regulation, here I try to construct a theoretical base of analyses conducted regarding Basel accords.

First comprehensive analysis of the Basel regulation as a "soft law", options on how to enforce it, comments on the effectiveness, particularly on the Core Principles of Effective Banking Supervision are discussed by (Alford, 2005). Discussing role of central banking in international

financial system, author correctly mentions that the Basel Committee has typically reacted to bank and financial crises.., but has not issued standards in a proactive attempt to anticipate weaknesses (Alford, 2005). It is pretty common conclusion among researchers that one of the most important regulations lacks preventive measures and rather lags with implementation.

Caprio says that "neither a static rulebook, nor an ever increasingly complex on, will ever provide safety and soundness" and suggests a "radically different approach, focusing on the oversight and accountability of regulators and greater transparency, both of bank and the regulatory process" (Caprio, 2013). Author strictly states that the Basel Approach is too complex to be effective and decisions made are often related to politics, rather than policy driven. Based on this view, he suggests radical reforms, from abandoning risk weighting of capital to changing membership in committee. Comparing current banking regulation with diktats of Soviet Union, Caprio suggests simpler rules, disclosure of information and monitoring of regulators.

Another solution to financial regulation is provided by (Prates, 2013). Just like Caprio, author talks about a necessity of creating new rules, but rather emphasizes an importance of correct implementation, paying more attention at building a solid and well-developed financial safety net. Paper suggests finding "a private solution instead of a public one when it comes to deal with failure in the financial system; particularly reducing the moral hazard" (Prates, 2013). As an example, this can be done through imposing personal liability of executives for the losses caused by failed financial institution. Such intra solutions will contribute to strengthening a confidence in financial system and thus ensure its stability, while minimizing government intervention in post crisis periods. Interpreting with network measures, this approach ensures strength of individual nodes as a crucial factor for the stability of the whole GBN.

Nowak offers a comprehensive empirical analysis to examine the power of capital adequacy ratios and other tools of the regulation to detect and mitigate banks' failures. Author addresses two most important issues of the Basel regulation: its legal force and effectiveness of capital and liquidity ratios. Having applied several empirical analysis tools, Nowak found the total tier capital ratio to be more effective metric for bank risk than common equity ratio. Considering bindingness of the regulation, author concludes that even though regulation is not legally enforceable on its own, it creates economic constraints for banks and induces bank's behavior (Nowak, 2011). This thesis aims to see if impact of the regulation can be seen in the network evolution.

A comprehensive view on both network analysis of the global banking network and its regulatory framework is presented by (Haldane A. G., 2009). Author provides a bigger picture of financial network history, using network terms and emphasizing how complexity and dimensionality of banking network has enhanced lately. He states that evolution in network topology meant that sharp discontinuities in the financial system were awaiting and crisis is just a materialization of them (Haldane A. G., 2009). It implies more effective tools of financial system analysis; possibly different approach would lead to milder consequences of crisis. Thus, author indicates "three crucial areas for enhancing the robustness of the financial system: mapping, regulating and restructuring" (Haldane A. G., 2009).

Banking regulation

There are three main types of the financial regulation. These include: systemic, prudential and conduct of business. Systemic regulation, as definition speaks for itself, is designed to ensure stability of financial system and prevent from crisis contagion. Prudential regulation covers monitoring and supervision of the financial institutions with particular attention to their liquidity and solvency. Last but not the least, conduct of business rules ensures standards of honesty, integrity and other fair business practices. It is hard to state which of the parts of regulation plays more important role in the stability of global economy. However, it is no doubt that their successful synergy and consistency of standards across countries is crucial. For the purposes of analyzing international banking network, I focus on systemic and prudential regulation.

Established in 1974, The Basel Committee on Banking Supervision plays an important role of initiating a banking regulation on a global scale. It provides a forum for regular cooperation on banking supervisory matters. Best known for its standards on capital adequacy, the broader objective of the BCBS is to enhance understanding of key supervisory issues and improve quality of banking supervision worldwide. Committee members come from nearly 30 countries, including all major financial centers around the world. Although regulatory harmonization is an implicit goal, the standards, recommendations and guidelines developed by the BCBS have no legal force.

Scope

On the macro level, the scope of the regulation was targeted only to the member states of the Basel Committee, which are particularly G-10 developed countries. The agreement explicitly stated not applicability for the emerging economies, because of the risks associated with not optimal banking reforms. First accord was defined considering domestic financial instruments as

the most reliable, which is true only for developed economies. Therefore it could result in the false sense of security in the emerging markets. Despite of this being published more than 100 countries implemented the first accord of the Basel regulation in some form. Such a spread had some underlying reasons. Countries that adopted a Basel regime were considered more creditworthy and therefore more preferable by the financial markets. As international official community was encouraging use of the regulation, financial institutions from not complying countries had difficulties with accessing important financial markets. In a short period of time the Basel regulation became a sort of soft international law.

Basel I

The origins of capital requirements can be seen in the first Basel capital accord which was released in 1988 and fully implemented by all the BCBS signatories by 1992. First accord of the regulation, formally called "International Convergence of Capital Measurements and Capital Standards" was very simple and based on four pillars.

Table 2. Structure of the Basel I

Pillar I	The Constituents of Capital
Pillar II	Risk Weighting
Pillar III	A Target Standard Ratio
Pillar IV	Transitional and Implementing Agreements

Basel I set out eligibility requirements for regulatory capital by specifying three capital "tiers" in the first pillar. Under regulation local regulators were allowed a fair amount of discretion when implementing the requirements.

Table 3. Capital Tiers composition

Tier 1	Tier 2	Tier 3
− Common equity − Disclosed reserves − Non-cumulative perpetual preferred stock *Goodwill is deducted	*Upper Tier 2:* − Perpetual subordinated debt and disclosed reserves *Lower Tier 2:* − Subordinated long term debt	− Subordinated debt with a maturity over 2 years

Second pillar or Risk Weighting stands for a bank's asset classification system. This system of asset calculation is used in determining the capital requirement or Capital Adequacy Ratio (CAR) for a financial institution. It groups assets into five risk categories with a certain risk weight for each category. For example, commercial loans are weighted at 100%, while OECD debt is considered less risky and thus weighted at 20%. Obviously, this system gives priority in risk weighting to any OECD government debt, which may include developing countries with unstable credit worthiness, like Greece, Mexico and Hungary.

The third pillar states a target standard ratio of capital to be held against risk weighted assets (RWA). It is a minimum standard which international banks are expected to achieve. This capital adequacy ratio (CAR) is

$$CAR = \frac{\text{Regulatory Capital}}{\text{Risk-Weighted Assets}} >= 8\%$$

The fourth pillar, Transitional and Implementing Agreements, sets the stage for the implementation of the Basel Accords. Central bankers are responsible for monitoring and enforcing the process.

The first accord addressed credit risk only. In 1996 the capital accord incorporated a market risk as well, setting capital requirements for the risk exposures due to market operations. Banks had to hold additional capital against market risk positions across asset classes, such as interest rates, equities, foreign exchange and commodities. If before simple market-based calculations were applied, with this amendment banks were required to develop their internal value at risk models to calculate capital requirements.

Implementation and impact

The Basel I recommendations were adopted across all major banking jurisdictions in the 1990s. However, the regulations were subject to significant criticism. The most important flaw was that risk weighting scheme was too simplistic. Therefore loans assigned to the same credit weighting could vary significantly in credit quality and thus calculated capital possibly could be not sufficient. Also limited differentiation of the risk degree created incentives for regulatory capital arbitrage among banks. Meaning banks were selling assets for which the regulatory capital requirements higher in exchange for those with lower requirements. In this case even though technically banks complied with the regulation, in reality they were holding too little capital. In 1999, the BCBS announced its intention to overhaul the proposals and a new framework was largely completed by 2004 and proposed to be implemented by 2006.

Basel II

Second accord of the regulation was more complex and aimed to (1) create a more risk sensitive framework; (2) capture more comprehensively the risks a bank is exposed to and (3) strengthen risk management, governance and transparency. Structure was similarly based on so called "pillars".

Table 4. Structure of the Basel II

Pillar I	**Pillar II**	**Pillar III**
Minimum Capital Requirements	Supervisory Review Process	Market Discipline
Credit risk	Evaluate Capital Adequacy Strategies	Increased information disclosure
Operational risk	Certify Internal Models	
Market risk	Proactive monitoring of capital	
	Level of capital charge levels and ensuring remedial action	

Basel II introduced a significant change to the basic capital adequacy requirements by requiring capital to be held against operational risk for the first time. The calculations of capital

requirements under Pillar 1 represent minimum amounts of capital. However, for credit and operational risk, Basel II prescribed both simple and advanced capital calculation methodologies. The parameters are designed to give an incentive to adopt more sophisticated risk measurement methodologies (lower RWAs mean lower capital requirements and therefore lower capital costs). Minimum Capital Requirements also included a more sensitive measurement of a bank's risk-weighted assets to solve the problem of capital arbitrage.

Pillar 2 aims to identify and quantify all other major risks not captured by banks' Pillar 1 calculations. It is more qualitative in nature as it ensures that banks assess their capital adequacy positions relative to their overall risks, and that banking supervisor's review and take appropriate actions in response to those assessments. Based on these assessments, local regulators may require banks to hold capital in excess of minimum regulatory capital ratios or take other remedial measures such as strengthening pertinent risk management and other practices.

Pillar 3 captures another important issue: information disclosure. It covers quantitative data, such as financial statements as well as qualitative information about bank's business model, management strategies and valuation approaches.

Implementation and impact

Basel II recommendations have been adopted across most major banking jurisdictions, but with widely varying timelines. Implementation started only around 2006-2007, so requirements were not fully embedded by the time crisis hit. In truth, few countries have chosen to implement every detail of the Basel recommendations and local interpretations of various aspects of the recommendations differ from one country to another. In Europe there has been more consistency

because regulators were set out in the Capital Requirements Directive (CRD2) applicable to EU members.

One of the shortcomings was that a new accord to some extent increased competition between banks in developed and developing countries. Because of introduction of more sophisticated rating methodologies and required advanced internal, some developing countries, including India and China, have announced that their banks will not be required to comply with Basel II (Barth J.R., 2009). Another flaw of the regulation was that even partial compliance with the regulation created a false sense of confidence that other actors were following the Basel rules. Another and more dangerous issue was a belief that Basel II was designed well enough to capture and prevent all possible flaws of the international financial system. In reality crisis was closer than anyone expected.

Regulation explicitly incorporated credit ratings in assigning capital adequacy requirements to the particular assets, while in the time leading to the crisis, agencies failed to adequately assess risks of certain innovative financial assets. Originators sought high ratings in order to enhance marketability and to increase asset sale prices. Asset purchasers benefit from higher ratings under Basel II because higher rated assets are assigned to baskets that require less capital to hold (Verri, 2012).

In fault of crisis or not, first response to financial crisis was a decision to significantly increase capital requirements, so to say Basel II.5, as defined by Bailey, addressing the widely recognized undercapitalization of risk in banks' trading operations (Bailey, 2014). This was transitory step with an implementation date of 2012 and a new direction towards tackling a problem with insufficient volume of capital.

Basel 2.5

In July 2009, the BCBS issued some enhancements to the market risk framework in light of the financial crisis. The revisions were introduced because there was a higher level of loss from banks' trading books than expected. A major contributing factor was that the existing framework failed to capture some key risks because they were not incorporated into VAR models or they were oversimplified. In addition, there were inadequate assumptions about valuations and market availability.

Summarizing, Basel II guidelines (initial one and amended) were considered unable to adequately assess and handle risks taken by financial institutions and which was one of the reasons of the financial crisis in 2008. Three main issues are believed to have caused the crisis: excessive leverage, erosion of the level and quality of the capital and insufficient liquidity. Based on its lessons and experience, the BCBS developed new guidelines to introduce more controls in risks taken by banks and thus ensure stability of the international financial network.

Basel III

New accord was developed and published after witnessing the crisis aimed to improve risk management process for financial institutions. Main improvements were made with regards to quality of capital, liquidity and leverage, introduction of countercyclical buffers, and comprehensive assessment of counterparty risk.

Complex structure of the accord following logic of previous ones and based on the so- called "pillars" didn't change. However, ratios and requirements increased significantly. The difference between the total capital requirement of 8% and the Tier 1 requirement can be met with Tier 2 capital.

Table 5. Capital ratio compared

Regulatory capital ratio	Basel III	Basel II
Tier 1 Capital ratio	4.5% - 6% by 2015	4%
Core Tier 1	2% - 4,5% by 2015	2%

As seen in the 2008 meltdown, liquidity base without sound supervisory standards was not enough to ensure solvency of the financial industry. In response to this, two new minimum requirements were implemented in the new accord. First one, Net Stable Funding Ratio is a measure of long term capability of the bank. Stable funding is defined as equity and liability amounts from reliable sources over a one year horizon while the required funding is based on the liquidity characteristics of its assets including off-balance-sheet items (BIS, 2014). Second one, Liquidity Coverage Ratio ensures bank's short term solvency by requiring holding a certain amounts of high quality liquid assets to meet capital needs in case of 30 days stressed scenario.

Implementation and estimated impact

After Basel III was finalized and published in 2010, its impact and implementation on European level is being closely monitored by the BCBS and European Banking Authority. Basel III is expected to affect banks significantly through its range of new and stricter regulations, including the liquidity standards, wider risk coverage and the leverage ratio. Stricter capital definition reduces banks' capital available for investments. However, with increased trading books positions and the RWAs for securitization, realized capital ratios will decrease dramatically. Estimated by the BCBS, full implementation of the Basel III would cost the industry a lot, reducing core capital by more than 40% and therefore creating a shortfall. In addition to the stricter capital requirements, the introduction of the LCR and NSFR may force banks to rethink

their liquidity position, and potentially require banks to increase their stock of high-quality liquid assets and to use more stable sources of funding. (Accenture, 2011).

Practical evidence: cross country banking supervision survey

Given a basis of the regulation and its accords, one can take a look at the empirical evidence of its implementation and impact on the network. For this I turn to a survey designed particularly to track success of the regulation acceptance and estimate its efficiency from the point of view of financial network participants. World Bank group of researches has been conducting a banking survey with the purpose of evaluating changes and more importantly impact of the banking regulation. Survey was conducted in 2001, 2003, 2007 and latest in 2011-2012. It provides data for 143 countries, of which 37 are advanced economies and 106 are emerging markets. Survey covers most major economies such as G20 countries except for Japan and Saudi Arabia and countries from emerging markets. Respondents are generally heads of banking supervision in the central banks or separate supervising agency.

Almost 300 questions of the survey provide information on comprehensive set of issues related to bank regulation and supervision. Half of the questions in the latest survey are consistent with previous versions, while the other half was added particularly to capture matters related to the implementation of the new Basel rules.

Survey considers crisis countries in two groups: those experienced a systemic banking crisis in 2007-2009 and those witnessed a borderline systemic crisis. First group consists of 13 countries, including USA, UK, Iceland, Ireland, Latvia, Belgium, Luxembourg, Netherlands, Austria, Denmark, Germany, Kazakhstan and Ukraine. Second group includes 8 countries such as France, Greece, Hungary, Portugal, Russia, Slovenia, Spain and Switzerland. All crisis countries except

for Ukraine are core countries in the analyzed previously network. Other countries are treated by survey as non-crisis countries.

Results

The general conclusion of the survey is that a regulatory response to the crisis was rather slow and there is a lot to improve (Cihak, 2012). Overall changes identified from the results of the survey are the following: capital ratios increased (mostly among non-crisis countries), deposit insurance schemes became more generous and slight reforms in the area of bank governance and resolution (Cihak, 2012). An important result is that crisis countries are identified to have had fewer restrictions on non-bank activities such as insurance, investment banking and real estate as well as loose treatment of the band loans. Having lower capital ratios, there were weaker incentives for the banks' risk monitoring.

Survey reveals significant differences between crisis and non-crisis countries with regards to regulation. Thus, crisis countries use capital built up with more diversified types of assets other than cash or government securities, like allowing hybrid debt instruments to be part of Tier 1. A vast majority of crisis countries have applied their own credit rating model leading to lower capital ratios comparing to non-crisis countries (Cihak, 2012).

Considering stringency of the regulation, banks in crisis countries enjoyed fewer limitations in their engagement in non –core activities such as insurance, real estate as well as non-financial activities. As the crisis has proven, this diversified exposure has increased a possibility of the risk contagion among various industries. Surprisingly enough, with such a complex structure of leverage, more than half of crisis countries did not have adequate asset classification systems during crisis years, 2007 and 2011 (Cihak, 2012).

Another important difference is in the regulators power. In 83% of non-crisis countries local regulators had the power to request banks to put up equity, comparing to only 65% in crisis countries. The fact that they had stronger information disclosure requirements, approved credit ratings and risk management procedures speaks more not about a lack of regulatory framework, but rather of weaker implementation and monitoring.

Particularly on countries that have adopted Basel accord, there is no evidence of its positive impact on the stability of the banking system, enhancing the efficiency of intermediation or reducing a possibility of risk contagion. Moreover, the desire of some countries to fulfill capital adequacy requirements has negatively influenced banks development, returns and efficiency of the system. A restrictiveness of the banking activity followed an increasing trend, meaning that there were more restrictions on what banks could do. Specifically, the analysis highlights the riskiest countries of 1990s, such as Argentina, Indonesia, Korea, Malaysia, Mexico, Philippines, and Russia. Most of these countries went to the direction of restricting banking sectors, except for Mexico that in contrary eased banking regulation in 1994. US also followed opposite direction, dismantling Glass-Steagall Act of banking activity separation.

Concluding remarks on the Basel regulation

Even though there are gradual improvements in the regulation, like increase in capital ratios and other reforms, important conclusion is that a recent financial crisis did not trigger major and sudden changes in local and global supervisory frameworks. There are several issues preventing the Basel regulation from serving as an effective tool to ensure a stability of the international financial network. Root of them can be considered a general complexity of the framework, causing additional costs to the firms and delays in the implementation.

Financial organizations have to amend an operational process to incorporate additional human resources, systems for accurate application of the regulation. This causes lags in the regulation framework and prevents it from catching a high speed of financial network changes. After the crisis of 2007 especially, the effectiveness of global financial regulation, as promoted by the Basel Committee on Banking Supervision, has been questioned. Conventional minimum capital requirements like the tier capital ratio seem to have failed in reducing the risk of bank failures. Due to regulatory changes various players had to conduct cost reallocations and trading books adjustments.

Conclusion

Comparing changes in banking supervising framework and changes in the underlying financial network gives us a main conclusion: regulation did not have a significant positive effect, rather a slight negative.

By the time network analysis starts, 2001, Basel I is in force with an amended market risk part. Some researchers argue that capital requirement may have enhanced the development of the securitization which is considered as the main driver of the financial crisis. Need to spread the credit risk to fulfill capital requirements while not having comprehensive risk measures fostered the deviation of banks from "originate-and-hold" model to "originate-and-distribute". The concept of securitization aims to decrease a risk exposure by diversifying the portfolio of lending. However, (Greenlaw, 2008) found that almost half of the sub-prime securitization exposure comes from the US domestic leveraged sector, meaning different types of banks and funds. One possible explanation can be that most of the securitized assets are not reflected in the balance sheets and thus a financial institution is highly exposed to an off-balance sheet entity. As regulation did not cover off-balance sheet items until second accord gave financial markets players a freedom to speculate and conduct a capital arbitrage. Implementation of Basel II in EU started only in 2007, which is exactly the year of the financial crisis. Counter cyclicality of the regulatory rules was widely discussed as introducing capital requirements when there is a liquidity shortage in the market may have deepened the consequences of the crisis.

As we have seen in the network analysis chapter, pre-crisis years, especially 2005-2007 witnessed a steady increase in the securities flows. Particularly debt securities have prevailed in the network as interest rates were rising and most of the highly risky derivatives, like

collateralized debt obligations or mortgage backed securities were based on debt obligations as can be seen from increasing density and clustering.

A simple comparison of release and implementation timeline of Basel accords with network trend over past 14 years shows lagged behavior of the regulation. Released in 2005, Basel II was an improved version of the regulation with more comprehensive risk-weighting scale, more granular coverage of the capital and tighter capital ratios. Let it be published and implemented a couple of years earlier, it may have some preventive effect on the financial network.

Table 6. Regulation and network evolution compared

Year	**2001**	**2003**	**2005**	**2007**	**2009**	**2011**	**2013**	**2015**
Regulation	Basel I is in force		Published Basel II	Implementation of Basel II	Published Basel II.5		Published Basel III	Implementation is spread over 10 years with a final deadline in 2019
Network systemic risk	− Steady increase of the density and clustering − Convergence of coreness of the developed and emerging markets − Leading to the crisis					− Second wave of crisis		

The most developed accord of the regulation, Basel III, seemingly captures all possible aspects of the financial risks. It was published in 2013, but implementation was spread over 10 years with a final deadline in 2019. Such a long timeframe distorts an intended effect of the regulation due to not only imbalances in implementation, but also high costs of these changes. Financial players are facing enormous costs associated with structural reforms they had to introduce in order to comply with capital requirements.

The reason for such a failure was and is being analyzed and studied by numerous academics and policy makers. Andrew Haldane (Bank of England) once compared catching crisis to a playing with Frisbee (Haldane A. G., 2012). Just as physicists can apply very sophisticated tools to estimate a right angle of Frisbee trajectory, regulators can weigh a complex array of various

factors in order to manage a crisis. Yet just as the best strategy for Frisbee game is to keep it simple, Haldane claims, the same strategy should be applied for financial system supervision.

Analyzing the failure of global banking regulators, Haldane points out a main problem: the complexity of the regulation and suggests that the only effective solution is to make it simple. Simple strategies can work better than complex ones mainly because they do not require collecting and processing costly information and therefore prevent cost-induced deviations from rational decision-making by market players.

Haldane suggests a simple model not only for analysis, but also for crisis prediction. He provides a number of examples of how simple algorithms outperform complex ones (Haldane A. G., 2012). Assuming this is true, I apply a simplified algorithm of default contagion on my sample of the international financial network.

Default simulation in the international financial network

In the previous two chapters, we have considered the evolution of the international financial network as well as of regulatory framework. Based on the results of cross-analysis it is obvious that regulation has lagged a lot and doesn't contribute much to the stability of the financial system as it is supposed to. Now I take a look at the network in 2013 and apply a default simulation algorithm based on (Elliott, 2014). It is conducted to measure a contagion possibility of the international financial network wherein one of the countries is hit by a banking crisis. I do not expect contagion to happen in the first round, however throughout the iterations, failure of one country can trigger a chain of failures, the domino effect. Following simplifications of (Elliott, 2014), I assume that all institutions in a country's financial industry respond similarly to a shock.

Theoretical model

Authors introduce a simple model of determining organizations' values and cross-holdings. There are n organizations making up a set N. Each organization has assets and shares of other organizations. An exogenous, sudden shock is introduced and assumed to hit an organization and exhaust all its assets. It experiences a discontinuous drop resulting from cash flow problems due to disrupt production, bankruptcy costs etc. Drop in a value of one organization leads to a drop in values of others they have financial arrangements with leading to default cascades across the set. Following the default of an initial organization, the shock spreads through cross-holdings to other organizations and results into domino type chain of failures.

Applying their model to the data of cross-border portfolio investments (total assets); I have a set of countries. Following their simplification of the values, I consider a total value of each

country's assets equal to 1. As an exogenous shock, value of one of the countries is dropped to zero. Algorithm recalculates values of other countries considering this loss in value. Applying threshold when a country is considered default, it counts a number of defaulted countries per iteration. Default is defined to be when a financial sector's capital, less loss caused by contagion, is smaller than the minimum threshold.

Cross holdings matrix

An adjacency matrix of the underlying total assets network for 2013 is a raw cross – holdings matrix, where the column represents the country creditor and the row is the country – debtor. To convert it into a fractional cross- holdings matrix, one needs to estimate the total amount of debt issued by one country. Elliott and Golub state their ratio of total debt held outside the issuing country as 1/3, based on estimation of (Reinhart, 2011) . Considering that 1/3 of the debt is held outside of the country and 2/3 correspondingly is a country's own assets, I convert a raw matrix into the weighted cross- holdings matrix.

Scope and algorithm of the simulation

The matrix includes 74 countries and they start with asset values of $p=1$. Certain country asset's value is dropped to 0. Algorithm recalculates values of other countries' assets. Considering theta (fraction of a country's initial value it needs to stay solvent) threshold it records number of failures and which countries have defaulted. Default range considered is between 0.8 and 0.99, with a step of one iteration equal 0.01.

A composition of the network is 49 core and 25 periphery countries. Instead of dropping the value of a random country, I consider how the number of defaults differs depending on which country defaults first. Whether a country is core or periphery, developed, emerging or offshore

can be useful for the analysis of regulation based on its systemic importance. For example, main regulatory body of EU, European Central Bank emphasized that centrality measure (coreness) can be used for identification of potential systematically important institutions and therefore for more accurate regulatory action (ECB, 2010).

Results

Obviously this simplified algorithm is based on several strong assumptions and rough estimates, therefore results should be interpreted with caution (Elliott, 2014). Moreover, to have more or less complete matrix of cross holdings only reporting countries data is used as if they do not have any financial linkages outside of the network. And again due to a nature of the data even these values might not be complete. Nevertheless, simulation algorithm gives a sense of the approach to analyze, estimate and forecast crisis arising from financial network links. It allows making some general conclusions and pointing out areas for improvement. To test if the results are reasonable, simulation is applied for two types of securities flows: total assets and debt.

Overall the number of defaults in both cases varies 1-3 and increases sharply in the extreme values of default threshold. At theta above 0.96 significant number of countries default, from 25 to more than 50. Average total number of failures for debt securities matrix is higher than for total assets. This may be explained by its greater interconnectedness measured in density and clustering. Results are even higher comparing debt in 2013 with 2008. Crisis peak can be measured in the network with dramatically higher probability and wider spread of defaults.

Iterations with the number of failures above the mean are associated mostly with periphery countries and particularly emerging markets and offshore centers. This is true for all three

matrices and might imply an importance of specific regulation and supervision of their financial sectors. Recalling their increasing coreness and converging with developed markets,

In general results show how certain network features can affect the possibility of the default contagion. An interconnectedness of the international financial network, as seen in chapter 1, has been growing even after the crisis. Its role of risk diversification was outweighed by its triggering crisis cascades: a single country or financial product default propagated liquidity shortages and market panic.

Inferring from analysis of the individual countries can be tricky and not accurate. For that, we need more precise cross-holdings data, actual default costs and thresholds (Elliott, 2014). This algorithm being a simplified version of a stress test recently conducted by the global regulators, illustrates how network models can help identifying which countries are affected in subsequent rounds and thus determine which of them need a more thorough supervision. Considering a network tendency to change over time, repeating such simulations may provide early warning signals of a possible crisis.

Policy implications

The global financial system is diverse and interconnected, but also prone to sudden, sometimes counterintuitive behavior. In some respect, regulators are caught up in never ending race with financial institutions. Banks will introduce products and practices which maximize revenue while minimizing regulatory costs, perhaps by creating a product that has not been considered under existing regulations. By the time regulations have been amended, another product has been introduced. Innovation in search for profit is impossible to prevent.

Improvements to existing banking regulation and global macroprudential policy should be done in three directions: mapping the network, regulating the network and restructuring the network (Haldane A. , 2009). For each direction, several steps should be taken. To accurately map the network, financial regulators need to ensure relevant and consistent data. Information- sharing agreements between countries could help in building a comprehensive set of data on cross-border exposures.

Regulating the network can be enhanced in both micro and macro, more global approach. One of the micro-focused changes in the regulation would be splitting the nodes of the international financial network either by their size or type of activity. Targeting the main hubs and authorities may help to prevent and control depth of failure cascades. It can be done through imposing capital requirements on financial institutions based on their systemic importance and therefore weight in systemic risk. Also improved corporate governance and internal incentives to ensure sustainability of the firm will serve better than externally imposed regulation. Narrow banking rather segregates the financial institutions by their business models and therefore limits their exposure, decreasing interconnectivity and homogeneity in the network. Such approach as the

Volcker rule may enhance a resilience of the global financial system by introducing modularity and diversity among nodes.

Global or system- wide approach involves tackling a recognized main flaw of the regulation, its complexity. Recent accord, Basel III involved moving to internal risk models and highly detailed assets risk weightings. An individual institution has to estimate roughly several thousands of default probabilities and loss-given-default parameters (Haldane A. G., 2012). Such a granularity makes it even more difficult to account for differences across the network therefore questioning a robustness of the regulatory framework as a whole. Simplification of the banking regulation thus contributes to more accurate and timely supervision of the network.

Structuring the network can be improved with regards to analysis of its topological characteristics. Such measures provide important insights on how the network functions and how to make it more efficient. For example, Haldane states that hierarchical networks function better than non-hierarchical ones, because their structure allows for more buffers and "firebreaks" that decrease the chance of contagion (Haldane A. , 2009). Moreover, analysis of the network structure can help in predicting the possibility and way of risk spread.

The regulation was developed with an aim to serve as a playground for financial markets participants, ensuring everyone is on the same safety and solvency levels. However, as the crisis has shown, the international financial network is rather a street fight than regulated playground.

Works Cited

1. Accenture. (2011). *Basel III and its consequences. Confronting a new regulatory environment.*
2. Affinito, M. &. (2014). *The interbank network across the Great Financial Crisis: evidence from Italy.*
3. Alford, D. (2005). Core Principles for Effective Banking Supervision: An Enforceable International Financial Standard? *Boston College International & Comparative Law Review*.
4. Allen, F. &. (2000). Financial contagion. *Journal of political economy*, 1-33.
5. Allen, F., & Babus, A. (2008). *Networks in finance.*
6. Alvarez-Hamelin, J. I. (2005). *k-core decomposition of Internet graphs: hierarchies, self-similarity and measurement biases.*
7. Alves, I. F. (2013). The structure and resilience of the European interbank market. *European Systemic Risk Board (ESRB) Occasional Paper*, 3.
8. Bailey, A. (2014). The capital adequacy of banks – today's issues and what we have learned from the past. *Bank of England.*
9. Barth J.R., G. J. (2009). *Global banking regulation and supervision: what are the issues and the practices?* Nova Science Publishers.
10. Bhattacharya, S. &. (1985). *Preference shocks, liquidity, and central bank policy.*
11. BIS. (2014, October). *A brief history of the Basel Committee.* Retrieved February 2015, from Bank for International Settlements Web site: http://www.bis.org/bcbs/history.pdf
12. BIS. (2014). *Basel III: The Net Stable Funding Ratio.* Basel Committee on Banking Supervision.
13. Borgatti, S. P. (2000). Models of core/periphery structures. *Social networks, 21(4)*, 375-395.
14. Caprio, G. (2013). Financial regulation after the crisis: how did we get here, and how do we get out? *LSE Financial Markets Group Special Paper Series.*
15. Chinazzi, M. F. (2013). Post-mortem examination of the international financial network. *Journal of Economic Dynamics and Control*, 1692-1713.
16. Cihak, M. D.-K.-C. (2012). Bank regulation and supervision around the world: a crisis update. *World Bank Policy Research Working Paper*.
17. Cihák, M. S. (2011). The Bright and the Dark Side of Cross-Border Banking Linkages. *IMF Working Papers*, 1-41.
18. Davydenko, S. A. (2012). A market-based study of the cost of default. *Review of Financial Studies*.

19. ECB. (2010). Financial networks and financial stability. *Financial Stability Review*, 150-160.

20. Elliott, M. B. (2014). Financial Networks and Contagion. *American Economic Review*, 3115-3153.

21. Espinosa, M. S. (2010). Cross-border financial surveillance: a network perspective. *IMF Working Papers*, 1-27.

22. Fourel, V. H. (2013). *Domino effects when banks hoard liquidity: The French network.*

23. Gai, P. K. (2010). Contagion in financial networks. *Proceedings of the Royal Society of London A: Mathematical, Physical and Engineering Sciences*.

24. Garratt, R. M. (2011). *Mapping systemic risk in the international banking network.* Bank of England.

25. Greenlaw, D. H. (2008). *Leveraged losses: lessons from the mortgage market meltdown.*

26. Haldane, A. (2009). Rethinking the financial network. *Speech delivered at the Financial Student Association, Amsterdam*, 1-26.

27. Haldane, A. G. (2012). The dog and the frisbee. *Revista de Economía Institucional, 14(27)*, 13-56.

28. Hubert, L. A. (1985). Comparing partitions. *Journal of classification 2(1)*, 193-218.

29. IMF. (2011). *Mapping Cross-Border Financial Linkages: A Supporting Case for Global Financial Safety Nets.* Linkages, I. C. B. F.

30. Lydeka, Z. &. (2013). International financial network characteristics as the measure of financial integration. *Taikomoji ekonomika: sisteminiai tyrimai*, 59-69.

31. Lysandrou, P. N. (2013). *The Shadow Banking System and the Financial Crisis: A securities production function view.*

32. McGuire, P. T. (2005). The international banking market. *BIS Quarterly Review*, 15.

33. McGuire, P. W. (2005). The BIS consolidated banking statistics: Structure, uses and recent enhancements. *BIS Quarterly Review*.

34. Minoiu, C. &. (2013). A network analysis of global banking: 1978–2010. *Journal of Financial Stability*, 168-184.

35. Nobi, A. M. (2013). *Network Topologies of Financial Market During the Global Financial Crisis.*

36. Nowak, R. (2011). *How Effective is Global Financial Regulation?*

37. Prates, M. M. (2013). Why Prudential Regulation Will Fail to Prevent Financial Crises: A Legal Approach. *Central Bank of Brazil Working Paper*.

38. Reinhart, C. M. (2011). The Forgotten History of Domestic Debt. *The Economic Journal*, 319-350.

39. Schiavo, S. R. (2010). International trade and financial integration: a weighted network analysis. *Quantitative Finance*, 389-399.

40. Soramäki, K. B. (2007). The topology of interbank payment flows. *Physica A: Statistical Mechanics and its Applications*, 317-333.

41. Tabak, B. M. (2014). Directed clustering coefficient as a measure of systemic risk in complex banking networks. *Physica A: Statistical Mechanics and its Applications*, 211-216.

42. Tarullo, D. K. (2008). Basel I. In D. K. Tarullo, *Banking on Basel: the future of international financial regulation.* Peterson Institute.

43. Toivanen, M. (2009). Financial interlinkages and risk of contagion in the Finnish interbank market. *Bank of Finland Research Discussion Paper*.

44. van Lelyveld, I. (2014). Finding the core: Network structure in interbank markets. *Journal of Banking & Finance*, 27-40.

45. Verri, M. (2012). *The Impact of Basel II on EU banks, procyclical effects.* Institute of Advanced Legal Studies, University of London.

46. Vlachos, J. (2004). *Do Regulatory Similarities Increase International Portfolio Holdings?*

Appendix A. Comparing full datasets. Regression results

	Dependent variable: Securities Flows (Total Assets)					
	(1) OLS	(1) OLS	(2) Fixed effects	(2) Fixed effects	(3) Random effects	(3) Random effects
Banking claims	1.004***	0.542***	0.589***	0.300***	0.686***	0.458***
	(0.0386)	(0.0388)	(0.0398)	(0.0381)	(0.125)	(0.0383)
GDP		0.285***		0.773***		0.387***
		(0.0289)		(0.0475)		(0.0287)
Constant	92,870**	-27,401	328,735***	-527,678***	174,528***	-71,996
	(41,263)	(29,684)	(30,188)	(58,248)	(51,543)	(61,185)
Observations	462	278	462	278	462	278
Number of countries	N/A	N/A	77	68	77	68
R-squared	0.595	0.841	0.363	0.752	N/A	N/A

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix B. Core and periphery countries composition over years

	Years												
Country name	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Countries always in Core group													
Russian Federation	1	1	1	1	1	1	1	1	1	1	1	1	1
Ireland	1	1	1	1	1	1	1	1	1	1	1	1	1
Greece	1	1	1	1	1	1	1	1	1	1	1	1	1
Argentina	1	1	1	1	1	1	1	1	1	1	1	1	1
Korea, Republic of	1	1	1	1	1	1	1	1	1	1	1	1	1
Australia	1	1	1	1	1	1	1	1	1	1	1	1	1
United Kingdom	1	1	1	1	1	1	1	1	1	1	1	1	1
Austria	1	1	1	1	1	1	1	1	1	1	1	1	1
United States	1	1	1	1	1	1	1	1	1	1	1	1	1
Belgium	1	1	1	1	1	1	1	1	1	1	1	1	1
Jersey	1	1	1	1	1	1	1	1	1	1	1	1	1
Bermuda	1	1	1	1	1	1	1	1	1	1	1	1	1
Netherlands	1	1	1	1	1	1	1	1	1	1	1	1	1
Brazil	1	1	1	1	1	1	1	1	1	1	1	1	1
Sweden	1	1	1	1	1	1	1	1	1	1	1	1	1
Canada	1	1	1	1	1	1	1	1	1	1	1	1	1
Guernsey	1	1	1	1	1	1	1	1	1	1	1	1	1
Switzerland	1	1	1	1	1	1	1	1	1	1	1	1	1
Hong Kong	1	1	1	1	1	1	1	1	1	1	1	1	1
Chile	1	1	1	1	1	1	1	1	1	1	1	1	1
Isle of Man	1	1	1	1	1	1	1	1	1	1	1	1	1
Cayman Islands	1	1	1	1	1	1	1	1	1	1	1	1	1
Italy	1	1	1	1	1	1	1	1	1	1	1	1	1
Cyprus	1	1	1	1	1	1	1	1	1	1	1	1	1
Japan	1	1	1	1	1	1	1	1	1	1	1	1	1
Germany	1	1	1	1	1	1	1	1	1	1	1	1	1
Luxembourg	1	1	1	1	1	1	1	1	1	1	1	1	1
Denmark	1	1	1	1	1	1	1	1	1	1	1	1	1
Portugal	1	1	1	1	1	1	1	1	1	1	1	1	1
Spain	1	1	1	1	1	1	1	1	1	1	1	1	1
Singapore	1	1	1	1	1	1	1	1	1	1	1	1	1
Finland	1	1	1	1	1	1	1	1	1	1	1	1	1
Turkey	1	1	1	1	1	1	1	1	1	1	1	1	1
France	1	1	1	1	1	1	1	1	1	1	1	1	1
Hungary	1	1	1	1	1	1	1	1	1	1	1	1	1
Countries switching between groups													

Czech Republic		1	1	1	1	1	1	1	1	1	1	1	1
Norway	1	1	1	1	1	1	1	1	1	1	1	1	
Lebanon	1		1	1	1	1	1	1	1	1	1	1	1
Malaysia	1	1		1	1	1	1	1	1	1	1	1	1
South Africa		1	1	1	1	1	1	1	1	1	1	1	1
Mexico			1	1	1	1	1	1	1	1	1	1	1
Israel			1	1	1	1	1	1	1	1	1	1	1
Thailand		1		1	1	1	1	1	1	1	1	1	1
Poland	1		1	1	1		1	1	1	1	1	1	1
Uruguay	1			1	1	1	1	1	1	1	1	1	1
Panama	1		1	1	1		1	1	1	1	1	1	1
Bahamas, The	1	1	1	1	1	1	1	1	1	1		1	
Macao SAR		1	1	1	1	1	1	1	1	1		1	
Netherlands Antilles	1	1	1	1	1	1	1	1	1				
Slovak Republic		1		1	1		1	1	1	1		1	1
Indonesia					1	1	1	1	1	1	1	1	1
India				1	1	1	1	1	1	1	1	1	
Bahrain, Kingdom of	1						1	1	1	1	1	1	1
Mauritius						1	1	1	1	1	1	1	1
Iceland					1		1	1	1	1	1	1	1
Kazakhstan					1		1	1	1	1	1	1	1
Philippines	1	1	1	1	1	1	1			1			
New Zealand		1			1		1	1	1	1			1
Latvia							1	1	1	1	1	1	1
Bulgaria		1					1		1	1		1	1
Estonia					1		1	1	1	1			1
Colombia	1			1	1			1		1			1
Venezuela, Republica Bolivariana de	1			1	1					1			1
Slovenia									1	1	1	1	1
Lithuania									1	1	1	1	1
Egypt				1	1	1	1				1		
Barbados						1	1	1					1
Aruba												1	1
Total number of core countries	**47**	**47**	**47**	**55**	**60**	**53**	**63**	**61**	**62**	**64**	**56**	**60**	**61**

	Years												
Country name	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Countries always in Periphery group													
Malta	1	1	1	1	1	1	1	1	1	1	1	1	1
Romania	1	1	1	1	1	1	1	1	1	1	1	1	1

Costa Rica	1	1	1	1	1	1	1	1	1	1	1	1	1
Ukraine	1	1	1	1	1	1	1	1	1	1	1	1	1
Countries appearing from time to time in Periphery group													
Pakistan		1	1	1	1	1	1	1	1	1	1	1	1
Kuwait			1	1	1	1	1	1	1	1	1	1	1
Aruba	1	1	1	1	1	1	1	1	1	1	1		
Gibraltar				1	1	1	1	1	1	1	1	1	
Venezuela		1	1			1	1	1	1		1	1	
Egypt	1	1	1					1	1	1		1	1
Bulgaria	1		1	1	1	1		1			1		
Barbados			1	1	1				1	1	1	1	
Estonia	1	1	1	1		1					1	1	
Colombia		1	1			1	1		1		1	1	
New Zealand	1		1	1		1					1	1	
Kazakhstan	1	1	1	1		1							
Philippines								1	1		1	1	1
Iceland	1	1	1	1		1							
Mauritius	1	1	1	1	1								
Vanuatu	1	1	1		1	1							
Indonesia	1	1	1	1									
Kosovo										1	1	1	1
Slovak Republic	1		1			1					1		
Bolivia											1	1	1
Bahrain				1	1	1							
Macao SAR	1										1		1
Mongolia											1	1	1
Uruguay		1	1										
Israel	1	1											
Panama		1				1							
Thailand	1		1										
Poland		1				1							
Bahamas											1		1
Malaysia			1										
Czech Republic	1												
South Africa	1												
Latvia						1							
Lebanon		1											
Total number of periphery countries	**20**	**20**	**23**	**17**	**13**	**21**	**10**	**12**	**13**	**11**	**21**	**17**	**13**

*** Highlighted by yellow countries switching between core and periphery

Appendix C. Securities Network mapping, 2013