REPUBLIC OF TURKEY
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INTERNATIONAL FINANCIAL INTEGRATION: A COMPLEX NETWORK ANALYSIS

MASTER THESIS

Ornela VLADI

International Trade Department

Thesis Supervisor: Assoc. Prof. Hakan TUNAHAN
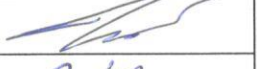
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TABLE OF CONTENTS

ABBREVIATIONS

BIS   **:** Bank of International Settlements

CPIS   **:** Coordinated Portfolio Investment Survey

EU   **:** European Union

FDI   **:** Foreign Direct Investment

GBR   **:** Great Britain (United Kingdom)

IMF   **:** International Monetary Fund

IFI   **:** International Financial Integration

IFN   **:** International Financial Network

OECD **:** Organisation for Cooperation and Development

SENA **:** Social and Economic Network Analysis

USA   **:** United States of America

WWI   **:** World War 1

WWII **:** World War II

LIST OF TABLES

LIST OF GRAPHS AND FIGURES

Title of the Thesis: International Financial Integration: A Complex Network Analysis	
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The concept of financial integration is not new and globalization itself is not a novel phenomenon. International financial integration was mainly accelerated due to removal of barriers on international capital flows, deregulation policies, technological evolution, increased international cooperation, etc. Still, the world is far from being fully integrated and international financial network clearly demonstrates a core-periphery structure.

This thesis employs a network approach to explore typology and evolution of international financial network. Main data source is Coordinated Portfolio Investment Survey (CPIS) published by IMF and covers a period from 2004 until 2015. 70 countries are included in the analysis and sample is restricted due to data availability. Key network parameters used to assess financial web patterns and evolution are: network density, clustering coefficient, degree centrality, betweenness centrality, closeness centrality and hubs & authorities centrality. Applying a complex network analysis, main purpose of this thesis is to map and explain the typology and evolution of international financial integration.

Empirical results of this thesis show that while there is an increasing number of countries holding geographically diversified portfolio of assets issued by non-residents, most influencing country in the financial network is the USA. Japan, GBR, Luxembourg, France and Germany as well appear to be influential in the network owning large portfolios of internationally issued financial assets. In general, this thesis' findings are in line with previous studies considering financial network as a core-periphery structure, with a small number of countries located in the core of network and maintaining intensive relation both among each other and with the rest of network. On the other side, countries classified as periphery tend to establish relations with core countries and have less incentive to connect with other countries positioned in the periphery layer. Lastly, unlike expected, global and European financial crises did not significantly change position of countries in the international financial network.

Keywords: International Financial Integration, Complex Network Analysis, Core-Periphery Network, Financial Offshore, Financial Globalization.

Tezin Başlığı: Uluslararası Finansal Entegrasyon: Karmaşık Bir Ağ Yaklaşımı	
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Finansal entegrasyon yeni bir kavram olmadığı gibi küreselleşme de yeni bir fenomen değildir. Finansal entegrasyon; sınır ötesi sermaye hareketliliğindeki engellerin kaldırılması, deregülasyon politikaları, teknolojinin evrimi ve artan uluslararası işbirliği imkanları ile hız kazanmıştır. Yine de, dünya tamamen entegre olmaktan uzaktır ve artan sınır ötesi sermaye akışlarından gerçekten fayda sağlamayı başaran birkaç ülke vardır.

Yapılan tez çalışması, uluslararası finansal ağın analiz tipolojisine ve evrimine ağ yaklaşımı ile ışık tutmaktadır. Ana veri kaynağı, IMF tarafından yayınlanan Eşgüdümlü Portföy Yatırım Anketi (CPIS) olup, 2004'ten 2015'e kadar olan dönemi kapsamaktadır. Analizde 70 ülkeye yer verilmiştir. Finansal ağ kalıplarını ve evrilmesini değerlendirmek için kullanılan ağ parametreleri: ağ yoğunluğu (network density), kümelenme katsayısı (clustering coefficient), düğüm merkeziliği (node centrality), aradalık merkeziliği (betweenness centrality), yakınlık merkeziliği (closeness centrality) ve merkezler ve otoriteler (hubs and authorities – HITS Algorithm). Bu tez çalışmasında, karmaşık bir ağ modeli kullanarak, finansal ağın haritasını çıkarılması ve onun topolojisini ve emrimini analiz etmek amaçlanmaktadır.

Bu tezin ampirik sonuçlarına göre, dış varlığı elinde bulunduran ülkeler artmaktadır, lakin en büyük portföy ($ cinsinden) ABD tarafından tutulmakta ve finansal ağdaki en etkili ülke olarak mutlak liderliğini sürdürmektedir. Japonya, İngiltere, Lüksemburg, Fransa ve Almanya da ağda oldukça etkili görünmektedir. Bu ülkeler büyük miktarda uluslararası çapta yayınlanmış finansal varlıklara sahiptir. Genel olarak, yapılan tez çalışmasının bulguları önceki çalışmaların sonuçları ile uyumludur. Finansal ağ merkez-çevre yapısıdır ve ağın merkezinde bulunan az sayıdaki ülke ve hem kendi arasında hem de geri kalan çevre ülkelerle finansal ilişkiler sürdürmektedir. Çevresel olarak sınıflandırılan ülkeler, merkez ülkelerle ilişkiler kurma eğilimindedir ve bu ülkelerin diğer ülkelerle bağlantı kurma konusunda daha az istekli oldukları görülmektedir.

Anahtar Kelimeler: Uluslararası Finansal Entegrasyon, Karmaşık Ağ Analizi, Merkez-Çevre Ağı, Kıyıötesi (offshore) Finansal Merkez, Küreselleşme.

INTRODUCTION

Research background

The concept of financial integration is not new and globalization itself is not a novel phenomenon. Last decades have witnessed an unprecedented increase in capital flows among developed countries (North-North), as well as from industrialized to developing countries (North-South) and the other way around. Concepts such as 'financial openness', 'financial globalization', 'financial integration', 'financial liberalization' and so on have been used interchangeably to describe the phenomenon of increased international capital flows.

Removal of barriers to international capital mobility has been a key driver to the increased international capital mobility during the last decades (Bai and Jing, 2012: 17; Lane and Milesi-Ferretti, 2008: 3). Deregulation policies and technology evolution as well contributed a lot fostering further financial globalization (Xu and Corbett, 2015: 2; Bordo, 2002: 20; Nardo et al., 2017: 4; Das, 2010: 2). Still restrictions to international capital flows, information asymmetries, barriers to entry in international banking system, insufficient harmonization of financial legislation and policies, poor governance, national borders and so on (Ananchotikul, Piao and Zoli, 2015: 5; IMF, 2016: 16) are significant for many countries (especially in developing world), consequently de facto integration remains well below to what is predicted by standard empirical models (Alfaro and Charlton, 2008: 2). Conventional wisdom usually relies on assumptions such as frictionless markets and information symmetry; nonetheless, despite all effort made in national and international levels, financial markets are far from being frictionless or perfect (Choi, Sharma and Strömqvist, 2007: 9; Schmukler, 2004: 2; Mishkin, 2005: 1).

International financial flows are usually channelled via some global financial hubs, which are basically most industrialized economies, in the same time most financially developed ones (Das, 2010: 91). Emerging markets as well have experienced an increase in both regional and international financial integration and have gained an increasing importance in international financial markets (Alberola and Serena, 2007: 9). Still, the world is far from

being globally integrated and the outcomes obtained from capital mobility occurred so far have been asymmetrically distributed among participating countries, especially among developing ones (Choi, Sharma and Strömqvist, 2007: 16; Underhill and Blom, 2013: 16). Considering Yu (2015: 129)'s classification of financial integration stages (financial autarky, two-country integration, core-periphery integration and global integration), world is currently in the third stage (core-periphery structure) of financial integration and it has a long way to go before it moves to the next stage, that of global integration. A core-periphery structure is composed of a small number of countries positioned in the centre of network acting as hubs for the rest of the network and the rest of countries positioned in the periphery layers. These countries tend to establish direct links with core countries, meanwhile display less incentives to interact with other countries considered as well as periphery.

Mono-centric world economy, with its economic hubs in a few countries and with the rest of the world counting as a periphery of it, has been one idiosyncratic feature for about half a century. During both eras of financial globalization world economy has been highly dominated by the United States of America (USA). Nonetheless establishment of the European Union (EU) which soon emerged as a new economic centre, and after Far East leaded by China and Japan, transformed the global economy in a poly-centric world with three main economic hubs: USA, EU and Far East. Transformation from a mono to a poly centric world is one of the most significant developments in the global economy and such global shifts made huge contributions to total world GDP, improved welfare, deeper economic and financial integration, etc. (Tilly, Welfens and Heise, 2007: 4). Still the role of the USA in international finance is just irreplaceable. Even though the USA is no longer and will not be for a relatively long time the world largest economy (PwC, 2017: 4), it is still the most important international financial hub and is the core of global financial network (Rose, 2012: 17).

While increased financial integration is presumed to bring many benefits, including more efficient allocation of resources and risk sharing, it is still a hot topic among scholars weather these benefits are worth enough to justify the costs associated to increased cross-border dependency. After the last financial crises 2007-2008, one of the most debated

topics was crisis and contagion implications of financial globalization (Xu and Corbett, 2015: 5). Emerged in the USA's subprime mortgage market, crisis soon spread throughout international financial markets and it is widely recognized as the most severe crisis since the Great Depression (Underhill and Blom, 2013: 16). There are scholars claiming that the last financial crises terminated the so-called second era of financial globalization or '*great moderation*' (Das, 2010: 20).

Lastly, financial globalization did not come out as an orchestrated event (Lothian, 2001: 8). It emerged just as naturally as globalization itself. During the gold standard till the beginning of World War I (WWI), a high economic and financial integration was recorded. Nonetheless the start of WWI arrested this wave of integration for about three decades. This is known as well as a period of de-globalization. The contemporary era of financial globalization has accelerated since the end of Bretton Woods Systems and beside many crisis around the world [Tequila Crisis - Mexican peso crisis (1994-1995), Asian Financial Crisis (1997-1998), Rubble Crisis - Russian financial crisis (1998), Brazil Crisis (1999), Ecuador Crisis (2000), Turkey Crisis (2001), Argentina Crisis (2001), Uruguay Crisis (2002) etc.] it continued to grow uninterrupted till the start of last financial crisis or is still undergoing, yet to be theoretically and empirically framed by literature (Underhill and Blom, 2013: 27; Das, 2010: 30).

Significance statement and research contribution

There is a treasury of literature available regarding financial globalization and its implications, testifying the importance of this study area. Despite this, debates over evolution, measurements and models, costs and benefits, especially possible implications to crisis, growth and welfare are still ongoing. Conventional wisdom supports the fact that moving forward from financial autarky to financial integration can bring many direct and indirect benefits for many countries (Yu, 2015: 130) nonetheless, perfect integration may not be the general optimum: in a two-option choice - autarky and perfect integration - there may be cases where autarky prevails against full integration (Stiglitz, 2010: 2).

Economic and financial integration is among major research area in international financial economics and it is still source of inspiration for many researchers and scholars interested

on further exploring some important puzzles of international finance and economics. Financial integration phenomenon has managed to 'gain currency' as a research topic only during the last decades (Das, 2010: 5) and since then it has been a key issue for both economic debates and political agenda (Volosovych, 2011: 1). As Quinn, Schindler and Toyoda (2011: 489) state in their research, *'Increased cross-border financial assets flows … have created an increasingly complex terrain for policymakers'*, therefore *'incentives for better understanding the economic implications of financial openness and financial integration are extremely important'*. Most of the theoretically presumed benefits from integration have not been realized yet (Dickinson, 2007: 109), questioning traditional econometric models on their ability to explain the complexity of international financial relations. Consequently, any effort made to better understand the complexity of financial networks via modern approaches such as network models would help policymakers and other stakeholders to benefit more from this 'two-edge sward' phenomenon.

In addition, even though the literature on financial globalization is rich, most of researchers in this area employ different traditional econometric models and develop analysis based on different assumptions. Previous studies have mainly used convergence approach or co-integration analysis to test for financial integration. Consequently, in most of the cases obtained results are contradicting and inconclusive. Literature employing social and economic network analysis (SENA) to detect and analyse the typology of international financial relations is less available compared to the one using traditional models. Prominent literature recognizes network approach to economic puzzles as a powerful tool offering a deep understanding on the typology and complexity of different types of relations that exists in the real world. An important goal of this thesis is to enrich existing literature on SENA applications to financial integration, and contribute to a rapidly expanding research area.

Das (2010: 17), emphasizing the importance of financial integration as a research area, states that the academic debate raised is quite polarized. Some scholars consider this phenomenon as a 'magic bullet' for fostering economic growth meanwhile other opponents consider it as a highly risky phenomenon difficult to be managed. Being an opponent or

proponent of this phenomenon means getting a biased position, failing in this way to offer a clear prospect of what really financial integration represents. Basically, financial integration can be both good and bad, and therefore studying the complexity and dynamics of this phenomenon is complicated but a necessary task.

This master thesis aims to contribute to knowledge in four ways. *First*, this thesis documents financial network among 70 countries for a period from 2004 until 2015. Different from most of previous works, this thesis maintains a static country sample during the whole considered period. *Second*, a complex weighted network model is introduced for measuring financial integration. Up to author's knowledge, this is the first work employing CPIS data in a weighted directed network analysis. *Third*, network models are still novel in this research area and prominent literature widely supports works employing this approach as a powerful tool to detect patterns of financial networks, unable to be captured by traditional econometric approaches. Most of previous works heavily rely in traditional statistical measures, meanwhile this thesis runs a (mainly) network metrics based analysis. *Lastly*, this research contributes to an emerging research area, employing network models in international economics and specifically international finance. Findings from this research can be used to question different relation in financial networks and inspire future research in this area of wide interest.

Research purpose and objectives

Applying a complex network analysis, main purpose of this thesis is to map and explain the typology and evolution of international financial integration.

Key objectives of this thesis consist of four parts:

- ✥ Empirically address the typology and evolution of international financial networks before and after global (2007-2008) and European (2011-2012) financial crises.
- ✥ Determine key players in the financial network and evolution of their position over time.
- ✥ Assess whether there is preferential attachment among countries sharing similar characteristics. Two main attributes are used, geographical locations and income.
- ✥ Analyse both total equity portfolio and total debt (short and long-term debt) network's composition and evolution.

Thesis Propositions

Existing literature suggests several possible propositions from this research. *First*, due to increased multi-level international cooperation, international financial network has become denser over time. *Second*, similar to impact of global and European crises to global trade network, consequences of these crises are reflected as well on the international financial network. More specifically, position of USA as global financial crisis generator it is expected to have changed after 2007. In addition, most affected European countries from 2011-2012 European debt crisis, will fail to excess the same power as they did just before crises. On the other side, similar to changes in global trade network, emerging economies by default is expected to have an increased importance in the international financial web. *Third,* intuitively most developed economies and in the same time most financially developed ones play a key role as both issuer and investor in the international financial network. *Fourth*, countries sharing similarities such as level of development, geographical proximity, legal and tax system, language, currency, etc. tend to establish more financial ties in both number and intensity. *Lastly*, equity and debt networks display similar patterns with total assets network. A different result can be obtained by short-term debt network due to its short-term nature. Usually, countries tend to financial domestically their short-term needs. Consequently, integration in short-term debt network will by default be lower than other sub-networks of total assets.

Summary of research methodology

Using a sample of 70 countries for a period from 2004 to 2015, this thesis employs a complex network analysis as a modern approach to explore international financial integration. Main data source is CPIS and as unit of analysis are considered total asset holdings, and its subcategories [total equity portfolio and total debt (short and long-term debt)]. Main tools used to process data obtained from IMF are UciNet (network measures computation), Gephi (visualisation) and Excel (matrices and distribution graph design). Key parameters used are network density, clustering coefficient, betweenness centrality, closeness centrality and hubs & authorities centrality (HITS algorithm). Lastly, direction of capital mobility is considered relevant on identifying most influential holders and

prestigious issuers in the network, therefore a directed network model is developed. Up to author's knowledge, this is the first time CPIS data are used in a directed weighted network analysis.

Thesis Layout

This research is structured as following:

Chapter 1 - Literature Review provides the theoretical background of financial integration, discussing topics such as evolution of financial integration, key terminology, costs and benefits from integration, measures of financial integration and drivers of this process.

Chapter 2 – Network Models and Finance provides a brief introduction to network and graph theory, and their applications to finance.

Chapter 3 – Implementation and Empirical Results, explains methodological approach employed and discusses obtained results from network analysis.

Last, *Conclusions*, summarize thesis' main theoretical and empirical findings, and conclude by identifying research limitations and possible extensions to this research in the future.

CHAPTER 1 – INTERNATIONAL FINANCIAL INTEGRATION: THEORETICAL FRAMEWORK

1.1. Evolution of Financial Globalization: A Brief History

Evolution of financial globalization has been in focus of many researches during the last decades. Most of scholars agree that there are two main eras of this phenomenon. Some economic historians mention as the first wave of globalization (therefore, financial globalization) period from the beginning of 1870s till the start of World War 1 (WW I), known as well as 'Gold Standard Era' (1870s-1914). As per regarding the contemporary phase of financial globalization, there is a debate among researchers regarding the start of this period. Some economic historians believe that this new era of financial globalization started in early 1950s, after the end of World War II (WWII). Majority of considered literature strongly supports the idea that the so-called second era of financial globalization started somewhere around the end of 1970s, after demolition of the Bretton Woods system, and lasted till the beginning of recent financial crisis (one view) or maybe is still ongoing (another view).

Since the introduction of gold standard, world economy and finance have passed through several up and down periods, which can be grouped in five main phases: first wave of financial globalization, starting with Gold Standard and lasting till the beginning of WW I; de-globalization era covering the period between two world wars; precursor of second era of financial globalization, starting from the end of WWII till the abolishment of Bretton Woods System; second era of financial globalization, starting around the end of 1970s and beginning of 1980s till the last financial crisis; and, post-crisis era, yet to be define its nature and implications.

There have been cross-border exchanges since the Islamic Golden Age, when ancient world recorded high flows on goods, people, knowledge and culture (Das, 2010: 7). During Renaissance period, Italian city of Florence played a key role in both finance and trade in Europe. Medici family and its powerful network transformed Italian banking system in the centre of European finance. Latter Italian dominance was substituted by the Dutch Republic, transforming Amsterdam city in one of the most important financial hubs in the

world (Lothian, 2001: 2). After about one century of Dutch leadership in international finance, London emerged as a new financial hub. Since ancient times, world economy has been dominated by specific regions and until the first era of globalization, cross-border capital flows have been highly concentrated, and the variety of international transactions performed has been very limited. End of the Napoleonic wars and the introduction of gold standard spurred international financial cooperation marking the beginning of the first era of financial globalization (Bordo, 2002: 21).

The Gold Standard Era lasted for about four decades. The progress in financial integration during this period was unprecedented, encouraged mainly by the adoption of gold standard, Industrial Revolution, steady decline in tariffs and transportation costs, economic and political stability, steady-state monetary regimes, laissez-faire doctrine with some tariff barriers and restrictions on migration (Das, 2010: 9). During this period, securities and foreign exchange markets recorded high levels of integration (Lothian, 2001: 3). In addition, during 1st era of financial globalization high wave of immigration continued, often following the same trend and directions as capital flows (Das, 2010: 14). Nonetheless, financial integration was far from being global, with participation of only few countries exchanging in a limited number of sectors and assets categories.

The breakout of WWI marked the end of 1st era of financial globalization and for about three decades world passed through the most severe political and economic stagnation in the history of industrialization. De-globalization of this period reached its peak during the Great Depression (Volosovych, 2011: 5). Economic nationalism was the essence of every decision and international cooperation was no longer an issue in national political agendas. Key characteristics of this period were suspension of gold standard, lack of political and economic cooperation, aggressive approach of US towards its allies requesting for a repayment of loans, high increase on tariffs and other trade barriers, etc. (Tilly, Welfens and Heise, 2007: 12). In a very short time global economy jumped from an almost laissez-faire doctrine to a system pretty like autarky state (Das, 2010: 57). The 'impossible trinity' (Mundell-Fleming trilemma) of pre-WWI (fixed exchange rate & free cross-border capital flow) was replaced by a combination of independent monetary policy and cross-border capital flow with restrictions.

End of WWII marked a positive trend in international cooperation and financial integration. In the post-WWII era, world leaders recognized the importance of collaboration and cooperative measures for a quick recovery from the consequences of wars. Adoption of Bretton Woods System, establishment of supranational institutions such as IMF and the World Bank, and creation of General Agreement on Tariffs and Trade (GATT), establishment European Coal and Steel Community (ECSC) followed by European Economic Community (EEC) and latter EU, are some of the key developments of post-war collaborative measures (Das, 2010: 23). Level of integration achieved by the end of 1960s' is comparable with the one achieved during the Gold Standard (Volosovych, 2011: 5). The impossibility trinity paradigm was questioned during this period, when despite the independent monetary policy and fixed exchange rates, countries were able to constrain their cross-border capital flow. The world of this period was mono-centric with its only economic and financial centre US and the rest of the world marked as the periphery (Tilly, Welfens and Heise, 2007: 4).

After the abolishment of Bretton Woods System in 1973, a new era of financial globalization started. Gradually, all industrialized countries started to eliminate barriers to cross-border capital flows. Soon many developing countries embraced as well liberal policies to international capital flows and joined the process of international integration (Cipriani and Kaminsky, 2007: 10). Nonetheless, in the aftermath of Bretton Woods's abolishment, a series of crises in different parts of the world questioned the real benefits of financial globalization (Agénor, 2001: 4), more specifically efficiency of international financial markets and adapted regulations (Aizenman and Pinto, 2011: 2). Still, beside successive financial and economic shocks, the process of financial integration was not interrupted, and it reached remarkable high levels during 1990s. One of the most important achievements of this era of financial globalization is the explosion of the middle class which promoted the development of human capital. Some studies argue that this wave of financial globalization has affected the life of about 70 million people around the world, who have jumped from low to middle-income class (Das, 2010: 55).

Appetite for financial globalization is believed to be interrupted by the recent financial crisis emerged from mortgage market in the US but which soon spread all over the world

and affected the prosperity and growth of global economy with at least three decades. The global recession of 2007-2008 followed by the European Crisis (2011-2012), obstructed financial integration process and some voices argue that these crises marked the end of the 2nd era of financial globalization (Das, 2010: 31). Notwithstanding high cost of last financial crises (estimated cost of more than $10 trillion), these shocks encouraged the global power shift process and after more than one century of US dominance, 'tectonic plates' of world economy finally started to move in favour of other large emerging economies (Das, 2010: 2). According to a study of PwC "The World in 2050", global economy by 2050 will have as leading powers China and India, and US will be third largest economy (PwC, 2017: 7). Regardless the switch of powers in the global economy and trade network, recent financial crises did not bring any significant change in the composition of core countries leading.

1.2. Definitions of Financial Integration

Like in many other research areas, it is hard to find a single universal definition for key concepts used to define financial integration phenomenon. The same happens with measures and methods employed in this research area (Ananchotikul, Piao and Zoli, 2015: 5; Auster and Foo, 2015: 13). The terminology associated with financial integration research has an extensive use of concepts such as: financial integration, financial globalization, financial liberalization, financial openness, financial autarky, etc. Many studies considered in this research use concepts such as financial integration, financial globalization and financial openness interchangeably, nonetheless there are scholars that emphasize the importance of distinguishing between these concepts.

Eyraud, Singh and Sutton (2017: 6) argue that financial openness and financial liberalization are not sufficient conditions for financial integration. De Nicolò and Juvenal (2010: 15) as well argue that there is a substantial distinction between financial openness and financial integration concepts. According to them, financial openness is necessary but not sufficient for financial integration. Another opponent of this equivalence is Fratianni (2015: 20) who disagrees with the equivalence put in between financial integration and high levels of cross-border capital flows. According to him it takes much more to achieve

the condition of global finance; less restriction or increased cross-border capital flows is necessary but not sufficient for a global financial network.

Auster and Foo (2015: 13) defines financial integration as '*a multidimensional process through which the allocation of financial assets becomes increasingly borderless*'. Tilly, Welfens, and Heise (2007: 61) suggest two different perspectives for defining financial integration: one considers cross-border flows and the other takes into consideration the '*the dispersion of prices for near or close substitutes*'. Eyraud, Singh and Sutton (2017: 5) define financial integration as '*the process through which the financial markets of two or more countries or regions become more connected to each other*'. According to them, process of financial globalization is multidimensional, and it includes activities such as cross-border capital flows, foreign direct investments (FDI), information and know-how exchange, etc. Authors emphasize the importance if price convergence among different markets as use as direct measures of integration degree of cross-border financial activity and degree of convergence and consolidation across markets. Their definition is close to the one provided by Ho (2009: 71) and Schmukler (2004: 2). Das (2010: 5) uses the concept financial globalization as a synonym for financial integration and defines it as *'the integration of the domestic financial system of an economy with the global financial markets and institutions'*.

Referring considered literature, within the scope of this thesis, concepts such as financial integration, financial globalization, financial openness etc. are not considered as mutually exclusive concepts. Said in other words, these concepts are considered as synonymous referring to the same phenomenon. Regarding financial integration as concept and its definition, this thesis relies in quantity measures. Consequently, literature that considers financial integration as the amount of money crossing domestic borders or domestically held but which is of foreign origin, suits better the logic of this thesis.

1.3. Benefits and Costs of Financial Integration

One of the most explored issues in financial integration research area is the identification of cost and benefits associated with this phenomenon. Conventional wisdom argues that financial globalization is "*neither a magic bullet to spur growth … nor an unmanageable*

risk" (IMF, 2007: 1), it is both '*a blessing and a curse*' (OECD, 2011: 288). It is a two-edged sword and to get some of the presumed long-term benefits, certainly some short-term cost will arise though (Rose, 2012: 21). Either way, globalization and so financial globalization are not matter of choice – regardless of whether we call it good or bad - important is to embrace this phenomenon properly (Mishkin, 2005: 1).

Since the last financial crisis this issue has gained currency (Devereux and Yu, 2014: 1) and many authors suggest that the benefits from this phenomenon are not fully exploded yet, especially in Euroarea (Tilly, Welfens and Heise, 2007: 5). Nowadays, financial integration is a key issue in international financial governance and policy agenda; so, careful consideration of its implications is highly recommended if we aim to rip all the possible benefits from this phenomenon (Jang, 2011: 17). Policymakers struggle to find a balance between benefits and associated costs of financial integration and they must take decisions about these in an ever increasing complex and challenging environment (Quinn, Schindler and Toyoda, 2011: 489).

Beside presumed substantial benefits from financial integration, for several reasons many countries are unable to get them and deal only with the drawbacks of this phenomenon. Kose, Prasad and Taylor (2009: 2) suggest that a careful attention should be payed to collateral benefits of integration (known as well as indirect benefits), as they are presumed to be much higher than the direct ones. Most of these collateral benefits are attained from main forms of cross-border flows (FDIs and portfolio equity flows), meanwhile debt exposing the country to a much higher risk is not believed to generate many collateral benefits. Still, a certain "threshold" (macroeconomic policies, economic institutions, stage of financial development, openness level, human capital, etc.) should be successfully passed in order for a country to be able to get the presumed indirect benefits from financial integration and mitigate as much as possible costs that arise from increased volume of cross-border capital flows (Kose, Prasad and Taylor, 2009: 2; Fecht, Grüner and Hartmann, 2012: 150; Abiad, Leigh and Mody, 2009: 244).

Literature offers a set of contradicting theoretical and empirical results, and this comes mainly because of different proxies used to measure financial integration, data source, country sample, time period under investigation, and econometric methodology (estimation

techniques) employed, etc. (Quinn, Schindler and Toyoda, 2011: 501; Kose et al., 2009: 19; Arteta, Eichengreen and Wyolosz, 2001: 3; Edison et al., 2002: 2). Reviewed literatures introduce a wide range of possible costs and benefits from financial integration, usually classified as direct and indirect costs and benefits.

1.3.1. Potential Benefits from Financial Integration

1. Direct Benefits

a) Encourage diversification, international risk sharing & consumption smoothing
Conventional wisdom widely recognizes that advancements in financial integration encourage portfolio diversification and international risk sharing (Abiad, Leigh and Mody, 2009: 244; Stavarek, Repkova and Gajdosova, 2011: 5; Ho, 2009: 73; Yu, 2015: 130; Kose, Prasad and Taylor, 2009: 2; Kose et al., 2009: 7; Kose, Prasad and Terrones, 2006: 179; OECD, 2011: 288). In addition, attempts have been made to empirically measure the impact of financial integration on consumption smoothing. In his research, Islamaj (2012: 14) concludes that financial integration has a positive non-linear effect on consumption smoothing. Nonetheless, there are other empirical studies opposing the widely accepted belief that financial integration has a positive effect on diversification, risk sharing and consumption smoothing. Billio et al. (2017: 150) argue that advancements in financial integration will positively affect equity return convergence and so in long-term less benefits from diversification will be obtained. Coeurdacier, Rey and Winant (2015: 3) argue that *'financial integration has very heterogeneous effects depending on the stochastic structure of shocks, the size of countries and their initial degree of capital scarcity'*. Bai and Jing (2012: 17) as well empirically oppose conventional wisdom approach arguing that financial integration not always helps increasing international risk sharing. Yu (2015: 130) claims that the key presumed benefits from financial integration can be fully attained only when we move from financial autarky to perfect integration. In addition, he dismisses the claims of conventional wisdom that advancements in financial integration increase risk sharing. According to him, the key weakness of conventional wisdom theory is that they assume frictionless financial markets.

b) More efficient capital re-allocation

A second widely agreed direct benefit of financial integration is improved capital re-allocation and so reduction of cost of capital (Ho, 2009: 73; Coeurdacier, Rey and Winant, 2015: 1; Stavarek, Repkova and Gajdosova, 2011: 5; Yu, 2015: 129). Countries and institutions have the possibility to choose to finance their activity from a much larger pool of funds (international markets) and diversify their investment portfolio. In addition, re-allocation of funds makes easier the access of excessive funds by borrowers which prior integration were unable to sufficiently finance their activity. This contributes fostering financial deepening and therefore development for countries participating in the international capital transactions.

c) Spur economic growth, domestic investment and income convergence

Growth and welfare benefits have been widely considered as direct benefits of financial integration associated with improved risk sharing and more efficient reallocation of capital (Stavarek, Repkova and Gajdosova, 2011: 6; Kose, Prasad and Taylor, 2009: 4; Bonfiglioli, 2008: 338; Arteta, Eichengreen and Wyolosz, 2001: 2). Financial Integration - growth - welfare nexus is still a widely debated topic and beside rich theoretical and empirical literature available, results are still inconclusive (Schularick and Steger, 2010: 756; Ho, 2009: 74; Friedrich, Schnabel and Zettelmeyer, 2013: 522). Ho (2009: 73) argues that the effect of financial globalization on growth and welfare can be both positive and negative. While financial integration is believed to encourage international risk sharing, more efficient allocation of capital and diversification, it can as well retard growth in countries with weak political, economic and financial infrastructure.

Regarding welfare implications of financial integration, Hoxha, Kalemli-Ozcan and Vollrath (2013: 97) calculates a positive welfare effect of financial integration up to 9% for developing up to countries and up to 14% for the most capital scarce ones. This effect can reach up to 24% and 34% respectively, *'with a reasonable increase in the share of income accruing to capital'*. Both growth and welfare benefits are implications of improved risk sharing and more efficient capital re-allocation, so basically financial integration direct outcome. Other empirical researches argue for much less welfare gains from integration, for instance Coeurdacier, Rey and Winant (2015: 45) but this is mainly due to reasons

explained earlier in this section. Yu (2015: 143) claims that there are welfare benefits only at the beginning and these benefits tend to decrease as new countries join the network. In addition, when moving from autarky to financial integration, welfare for large countries increases while for small ones decreases.

Another discussion on growth and welfare benefits from financial integration considers the development stage of country joining the global financial network. Kose, Prasad and Taylor (2009: 2) and Hoxha, Kalemli-Ozcan and Vollrath (2013: 90) argue that developing countries can benefit much more than developed ones from integration. The main reason for this is that developing countries are have capital scarcity but have a rich labour force, consequently increased availability of funds from abroad will spoor domestic investment and therefore economic growth. Beside this, developing economies are more volatile compared to developed ones, and so potential welfare gains are presumed to be higher. Arteta, Eichengreen and Wyolosz (2001: 3) argue that it is impossible to precisely measure effect of financial globalization on growth, since the world economy system it too complex to be able to measure variables and phenomenons isolated from each - other. Kose, Prasad and Taylor (2009: 2) suggest that by decomposing capital flows and using micro-data when analysing growth benefits from financial integration would improve the accuracy of estimations.

2. Collateral Potential Benefits

Kose et al. (2009: 8) argue that there are many collateral benefits from financial integration which can contribute positively to growth and prosperity. Potential collateral benefits include but not limited to: domestic financial sector development, greater discipline on governments, banks and other financial institutions, commitment to better economic policy, improved employability, product innovation, transfer of technological and managerial know-how, promotion of specialization, etc. (Kose et al., 2009: 10; IMF, 2007: 3). Basically, most of considered collateral benefits from integration are in the same time pre-requisites for integration.

One of the most important collateral benefits of financial integration is domestic financial sector development which is in the same time a prerequisite for a successful financial integration (Stavarek, Repkova and Gajdosova, 2011: 5; IMF, 2016: 21; Kose, Prasad and

Taylor, 2009: 2; Schmukler, 2004: 2; Abiad, Leigh and Mody, 2009: 257). Intensified competition, together with know-how and technological inflows encourage development of domestic financial sector (Ho, 2009: 74; Schmukler, 2004: 3). Schmukler argues that two main channels through which financial integration can encourage development of financial system are increased availability of funds and improved financial infrastructure, which further can help in reducing information asymmetry. In addition, adaptation of international financial and reporting standards as well positively contributes in increasing transparency (Schmukler, 2004: 7).

1.3.2. Potential Costs of Financial Integration

Financial integration has been widely blamed for triggering financial instability, greater exposure to crises and contagion effect. Many scholars consider as the main drawback of financial integration increased exposure to external crisis and shocks, and possibility to import them via cross-border financial linkages (Stavarek, Repkova and Gajdosova, 2011: 27; Bordo, 2002: 27; Kose et al., 2009: 20; Devereux and Yu, 2014: 2; IMF, 2011: 36). Nonetheless, empirical findings in this area are still elusive and inconclusive, the same as for benefits from financial integration.

Bonfiglioli (2008: 351) finds in her paper that crisis occurrence depends on the measures used and country sample. When IMF de jure measures are used, there is a *'1.7% higher probability of minor banking crises'* and when adding Quinn's measure this probability becomes 22%; meanwhile, de facto integration seems to affect only the likelihood of currency crisis. Regarding country sample, when measured for de jure integration, there is an increase of probability of crisis (banking and currency) in developed countries but de jure integration seems not to be a threat of crisis for developing countries. This can be partially explained by core-periphery network architecture. By measuring de facto integration in both developed and developing countries, author concludes that likelihood for banking crisis increases by 11% in developed countries (Bonfiglioli, 2008: 351). In addition, in the context of a core-periphery world financial network, Rose (2012: 3) argues that *'economies with stronger bilateral financial ties to the United States (but not the large*

17

Asian economies) experienced milder crises, though it is by no means enough to be conclusive'.

In the same logic, most industrialized countries (and at the same time most integrated ones) have not experienced more sever crisis compared to the less integrated countries or emerging economies (Bordo, 2002: 27; Rose, 2012: 12). Kose et al. (2009: 7) argue as well that higher integration brings better risk sharing and so there is less likely that more integrated countries will suffer more severe crisis or consumption/production volatility. Bordo (2002: 27) compares two waves of financial globalization, and concludes that the number of crises has increased during the second wave of financial globalization, but they are less severe than crises during first era of financial integration. In addition, the worst crises are the so called twin crisis (banking and currency crises) and these crises have been much more devastating during the first era of financial globalization, mainly due to undeveloped financial infrastructure (Bordo, 2002: 27). Devereux and Yu (2014: 34) as well argue that even though there is an increased probability of crises during integration, still they are less severe than during financial autarky. The point in here is to find a trade-off between probability of crises occurrence and their severity.

Schmukler (2004: 8) emphasizes the fact that domestic factors are the key drivers of crises, nonetheless cross-border financial ties can contribute as well to import crises and accelerate their negative impact. Anyhow, blaming financial integration for financial crises is just wrong; crises are to complex, and they can be initiated and fuelled from dozens of domestic and international factors (Schmukler, 2004: 9). Good governance combined with developed domestic financial sectors lowers the likelihood of financial crises, domestic or imported from other countries in the network. Lastly, Kalemli-Ozcan, Sorensen and Volosovych (2014: 1) suggest that when looking for financial integration implications on crises and volatility, decomposing cross-border capital flows (bank landing, portfolio investment, FDI) would provide more accurate results on the real source of volatility and help mitigating this potential risk of integration. In BIS (2012:17)'s report as well it is argued that financial integration itself cannot be a source of crises and instability, nonetheless it is the channel through which contagion occurs.

1.4. Measuring Financial Integration

Measuring financial integration is not straightforward and attempts made so far to measure this phenomenon have provided contradicting results. In these circumstances, discussing the accuracy of existing empirical approaches is a challenging enterprise. In addition there are no standard measures of financial integration (Ho, 2009: 72; Stavarek, Repkova and Gajdosova, 2011: 12; Islamaj, 2012: 16; Quinn, Schindler and Toyoda, 2011: 489; OECD, 2011: 293). Financial integration is a complex phenomenon, with a wide range of transactions. Further, these cross-border flows are subject to different price and quantity controls, and the consequence of such restrictions may differ from country to country, due to many domestic reasons (Ho, 2009: 72). Nonetheless, literature has developed several sound measures and in principal two main dimensions used to estimate financial integration are level of cross-border capital flow (holdings or magnitude) and rate of foreign ownership in domestic financial system (foreign participation) (BIS, 2012: 16).

In principle, measures employed to capture levels of financial globalization can be classified in three main categories: de jure, de facto and hybrid measures which is a combination of the two first ones. These measures capture different aspects of the phenomenon and so a combination of them would provide richer results (Quinn, Schindler and Toyoda, 2011: 504; Kose et al., 2009: 9; Baltzer et al., 2008: 4; Volosovych, 2011: 1; Edison et al., 2002: 750). Nonetheless, deciding which measure or empirical model to use it is not easy at all, and a balance between both complexity of analysis and accuracy of measurements should be found (Billio et al., 2017: 150). In addition, lack of data constitutes a major obstacle on choosing certain measures.

a) De Jure Measures

Main source of de jure measures is the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) (Quinn, Schindler and Toyoda, 2011: 490; Kose et al., 2009: 12; Edison et al., 2002: 753; Islamaj, 2012: 23). AREAER indicators are quite straightforward but in the same time offer limited information. AREAER is basically a set of variables expressed in binary system and each indicator is assigned wither 0 or 1. Based on AREAER measures, Chinn and Ito introduced an extensive measure of de jure

AREAER measure, KAOPEN, and it was recently updated (July 2017) based on AREAER 2016 updates. The same as AREAER, KAOPEN reflects levels of regulatory restrictions on international financial flows (Ito and Chinn, 2017).

Based on AREAER text, Quinn develops two important measures, capital account (CAPITAL) and financial current account (FIN_CURRENT). The data are available for 122 countries, from 1949 (number of countries varying based on their reporting to IMF) and cover six categories: payments for imports; receipts from exports; payment for invisibles; receipts from invisibles; capital flows by residents; and by non-residents (Quinn, Schindler and Toyoda, 2011, p. 492). CAPITAL measures (2 categories) can get a value from 0 to 4 and FIN_CURRENT measures (four categories) from 0 to 8. For purpose of comparison and interpretation the values are recalculated on a 100-scale basis. The main drawback of Quinn's measures is that the data are measured only for a couple of years ('58, '73, '82 & '88) (Edison et al., 2002: 750). There exist as well several non-AREAR de jure measures which are less common than the previous ones (Quinn, Schindler and Toyoda, 2011; Kose et al., 2009). Quinn, Schindler & Toyoda (2011) and Islamaj (2012) in their paper describe in detail most prominent AREAER based and non-AREAER de jure financial openness measures (used as well to approximate level of financial integration).

b) De Facto Measures

Despite their straightforwardness, de jure measures are not based on the real cross-border flows and, so they do not reflect the actual degree of financial integration. For this reason, de facto measures (known as well as 'blended' measures) are employed as complements of de jure indicators, trying to explain financial integration based on real data of cross-border flows and foreign ownership. These measures can be grouped in three main categories: quantity-based, price-based, and hybrid measures (Quinn, Schindler and Toyoda, 2011: 494; Stavarek, Repkova and Gajdosova, 2011: 12).

Price-based measures: These measures consider differences between external and domestic prices and operate on the assumption that among financially integrated economies, price differentials of similar assets in different locations should vanish due to arbitrage. The logic is simple, irrespective of the volume and direction of flows, de facto integration will be

measured by cross-border price convergence of similar financial assets. A drawback is that inefficient arbitrage may reflect domestic rather than international financial frictions. In addition, using price based measure from a practical perspective is not easy because many such measures are available only for individual countries (Quinn, Schindler and Toyoda, 2011: 495) and reporting from emerging and developing countries is not performed in regular basis. In addition, using these measures in emerging and less-developed economies context is difficult due to complexity of analysis, related mainly to domestic risk. Generally speaking, attempts to measure financial integration by price-based means in large country sample or long period of time is challenging (Kose et al., 2009: 14). Even though these measures capture important information on price discrepancies among countries, other approaches such as quantity based measures may provide to be more useful as measure of financial integration (Baltzer et al., 2008: 7).

Quantity-based measures: Regarding these measures, among most popular measures is Lane and Milesi-Ferretti's TOTAL indicator (2006, 2007, 2016) (TOTAL = $\frac{\text{country's aggregate assets} + \text{liabilities}}{GDP}$) and it covers cross-border flows such as portfolio equity, FDI, debt, etc. UNCTAD provides two other quantity measures, which are inward FDI flow and stock from 1970 and 1980 for most United Nations countries. The data can be normalized with respect to a country's GDP (In_FDI_GDP) or its share of the world's FDI flows (In_FDI_W) (Quinn, Schindler and Toyoda, 2011: 494). Kose et al. (2009: 14) suggest that this category of indicators are the best available measures of financial integration and this thesis relies in this conclusion, by employing a complex network approach to detect patterns and evolution of international financial network.

Hybrid measures: There exist several hybrid measures, which are basically a combination of price and quantity based measures. Quinn, Schindler and Toyoda (2011) offer an extensive work on financial openness measures. Some of the hybrid measures they introduce are FORU, The Economic Globalization (e-Globe), etc.

1.5. Determinants of International Financial Integration

As already mentioned, IFN is a complex architecture, composed of a vast number of actors (country, banking or non-banking institution, international organization, etc.) and covers a wide range of financial assets being traded internationally (stock, bond, derivatives, etc.) (Thakor, 2015: 1). Challenges on identifying and measuring implications of integration were already discussed in previous sections. It is not easier to identify drivers of financial integration, making management of this phenomenon even more complex. Conventional wisdom heavily relies on econometric and statistical models to capture correlation and co-movement between different variables. In principle and widely supported by literature is the argument that there are several pre-conditions to be fulfil before integration and as suggested, several thresholds need to be crossed (Kose, Prasad and Taylor: 2009).

Prominent literature considers as prerequisites for financial integration drivers such as:

- Trade openness,
- economic development (GDP p.c.),
- financial development,
- financial liberalization (entry barriers, capital restrictions, interest differentials, etc),
- markets size,
- technological development,
- population,
- common language,
- common adherence (EU, OECD, NAFTA, etc.),
- geographical area,
- institutional quality,
- foreign bank participation,
- accounting and auditing standards,
- previous colonial dependency,
- financial centres and offshore,
- legal environment and tax policy,
- level of educational development, etc.

(Rodrik and Subramanian, 2009: 124; Endres, 2011: 6; Furceri, Guichard and Rusticelli, 2011: 7; Papaioannou, 2005: 28; Ananchotikul, Piao, and Zoli, 2015: 12-13; Almekinders et al., 2015: 8; De Nicolò and Juvenal, 2010: 22; Koskenkylä, 2004: 10; Lee, 2008: 6; Lane and Milesi-Ferretti, 2008; Vo and Daly, 2007: 228; IMF, 2011: 33).

Papaioannou (2005: 9-10), exploring drivers of international bank lending, finds a positive correlation between population and level of financial integration. This means, that for countries with larger population there is a higher incentive to be involved in international bank lending. While considering number of population positively correlated with funding needs, this holds not so true for countries such as Luxembourg (Population in 2016: ~ 583,000) or Switzerland (Population in 2016: ~ 8,372,000). In the same time, author finds out that distance is negatively correlated with bank lending. It has been widely agreed and accepted in literature that level of trade integration determines level of financial integration (therefore banking system integration), and in the same time distance is a key parameter in the gravity model of international trade.

Relation between international capital flows and geographical area is found to be negatively correlated. This can be interpreted as an incentive of geographically larger countries to export less capital and finance it need mainly domestically. This finding as well seems to be ambiguous since IFN for a very long time has as its main capital imports and exports a very heterogenous group of countries (USA, Netherlands, Switzerland, Japan, France, Germany, etc.). Author as well calculate a positive correlation between economic development and level of in-coming capital flows. This is in line of Lucas Paradox, arguing that unlike expected capital flows from poor to rich countries. Lastly, institutional quality, privatization and liberalization appear to be positively correlated with level of financial integration (Papaioannou, 2005: 19).

Ananchotikul, Piao and Zoli (2015) empirically calculates a positive correlation between trade integration, financial openness and financial sector development with level of financial integration. In addition, a positive correlation is proved to be true between financial regulation convergence and level of bilateral financial ties established. In other words, countries with similar financial regulations and practices tend to financially connect

more with each-other. Accounting and auditing standards as well appear to be significant in determining direction of cross-border capital flows. Lastly, foreign bank participation in a country supports international capital flows nonetheless governmental incentives to control foreign ownership in national banking system may has a negative effect in the cross-border capital flows.

Furceri, Guichard and Rusticelli (2011: 2), testing the importance of structural policies as drivers of financial integration, find that these policies are important long-term determinant of cross-border capital flows. Authors define as structural policies domestic financial sector development, institutional quality and good governance, competition encouragement measures, product market regulation, flexible labour markets, etc. Authors analyse the impact of these policies both in the level and composition of cross-border capital flows (p. 5). Furceri, Guichard and Rusticelli (2011) as well calculates a positive correlation between trade and financial openness, and financial sector development with the level of financial integration of a country. According to authors, financial development stage of a country is a key determinant of foreign assets portfolio held by the country.

Financially most developed countries accumulate more FDI and portfolio equity portfolio, due to their lower risk, and are less willing to hold large amounts of debt. Capital account liberalization impact in almost the same way the composition of foreign holdings for a country. Institution quality is an important determinant of direction of flows as well, where better institutions attract more in-coming flows but by satisfying domestic investors, they are less willing to invest abroad (out-going capital flows). Lastly, in all the mentioned cases, authors find that the net foreign asset positions decrese (Furceri, Guichard and Rusticelli, 2011: 15).

Rodrik and Subramanian (2009: 27) argue that '*Poor economies are poor because there are many things that are wrong with them.*'. Any attempt made to fix all these problems simultaneously would be just a fail. Even countries with well-established financial sector may face challenges to manage their foreign assets portfolio. Obviously, these challenges are much higher for developing countries and the rest of the world. In addition, authors

emphasize the increased of complexity of financial system due to integration and especially due to currency effect (exchange rates), integration may work differently in different countries. A better domestic financial sector (especially banking sector), would better collect saving from savers and use them for investment. This will result in a devaluation of domestic currency. On the other side, a better access to international financial markets will have an adverse effect on exchange rates and consequently on economic growth (Rodrik and Subramanian, 2009: 124).

Quinn and Toyoda (2007) tests another possible driver of financial integration, which is global spread of ideas. According to authors, circulation of ideas and opinions has a considerable impact in international and local on liberalization policies and strategy a country decides to follow. Such spread of ideas influences both economic and financial integration. In addition, there is a considerable influence of neighbours' openness policies (positive impact) and top countries (negative impact) on country's openness and liberalization policies.

Relying in previous researches, Kose et al. (2010) discusses 'pull' and 'push' drivers influencing direction and composition of capital flows (to developing countries). These factors are related to both domestic developments in developing countries and changes in international financial network. As already mention, in the category of domestic drivers are included factors such as capital account openness measures, improved institutional quality and governance, privatization, etc. Changes in international financial markets refer to factors such as refers to *growing importance of depositary receipts and cross-listings, and the emergence of institutional investors as key players driving international capital flows to emerging markets'* (Kose et al., 2010: 4292).

IMF (2011: 33)'s working paper organizes determinants of cross-border capital flows as static and variable over time. Location and history (distance, time zone, legal system similarities and language) have been considered as important no-variable drivers of financial integration. As variable drivers three main categories have been identified: level

of economic development, level of financial sector development and common regional and global institutions / groups / agreements presence.

To sum up, there is little deep consideration on drivers of financial globalization. While gravity model has been widely employed in analysis exploring determinants of trade integration, the use of this model to explain drivers of financial integration has been limited. Maybe this can be explained with the unique nature of financial assets – they are physically weightless which means that one of key parameters of gravity model (distance) would be meaningless in this kind of analysis (Lee, 2008: 6). Another weakness of literature on drivers of IFN is that they usually rely in previous researches by repeating in most of the cases what have been done before or they do limit their analysis up to availability of data for already known drivers of integration (Arribas, Perez and Tortosa-Ausina, 2009: 9); meanwhile Quinn and Toyoda (2007: 344) explores a completely new dimension of financial integration.

CHAPTER 2: NETWORK MODELS AND FINANCE: OVERVIEW

2.1. Graph and Network Theory: A Brief Introduction

International financial connections have rapidly accelerated into a hugely complex and hard to be managed network. Recent financial crises brought to focus the importance of graph and network models as powerful tools that can offer better understand on structural properties, architecture and evolution of international trade and finance (Minoiu and Reyes, 2010: 3; Kali and Reyes, 2007: 2; Rönnqvist and Sarlin, 2016: 7; Caballero, 2015: 128; De Benedictis and Tajoli, 2011: 1418; Schiavo, Reyes and Fagiolo, 2010: 389). Although international trade and finance have been conceived as a network since long ago, literature employing SENA models in economics and finance has received extensive attention only in the aftermath of recent financial crises (Allen and Babus, 2009: 4; Rauch, 2010: 986; European Central Bank, 2010: 7; Giudici and Spelta, 2013: 5).

General speaking, performing SENA is not easy. The quality of such analysis highly depends on data availability. Technological advancements have improved computational power allowing for more complex and large-scale network analysis (Jackson, 2014: 4). In addition, there exist dozens of relationship dimensions which can be captured by the network approach. As earlier mentioned, most of the existing network literature in finance is focused in addressing stability and contagion issues (Allen and Babus, 2009: 13) and little consideration is payed to network typology, formation or other network patterns.

Network and graph models as multi-disciplinary mathematical tools have shaped research in various disciplines such as engineering, computer science, applied mathematics, biology, ecology, epidemic, etc. but only recently they have managed to gain currency in international economics and related study areas (Schiavo, Reyes and Fagiolo, 2010: 391; Xu and Corbett, 2015: 4; Jackson, 2014: 18; Kali and Reyes, 2007: 2). The first research on network analysis is believed to be Euler's paper (1736), employing graph theory to propose a solution for 'Königsberg bridge' problem. Soon after, Quesnay (1758) published his Tableau Economique, which is known as the first application of network theory to explain financial issues. By the end of 1960s and beginning of 1970s network approach was brought to focus as a powerful tool in explaining the topology of trade and financial

networks, unable to be explained by traditional econometric models, nonetheless it was not until the recent financial crises that this approach emerged as a powerful tool for explaining financial globalization's complexity.

2.2. Network Theory: Basics

Network as a notion can be defined based on the context used. Nonetheless, in principle, a network can be defined as a set of *nodes* (vertices, agents, actors, players, etc.) and *links* (edges, ties, connections, etc.) (Jackson, 2017). There is no standardized form of networks; they can have many shapes and sizes. Nevertheless, there are some key concepts and parameters widely used to define a network's patterns and its evolution over time. This brief introduction to network and graph theory has extensively benefited from UciNet's book (Hanneman & Riddle, 2005) and Stanford University Online Course on SENA (Jackson, 2017). Within the scope of this thesis, the following concepts and measures are used.

Nodes can represent countries, banks or other financial institutions and links represent cross-border flows. Graph theory defines networks as following: N={1,…, n} representing the vector of all nodes; A_{ij} indicates presence/absence or intensity of link; and, network is represented as matrix (N, A). Basically, a square matrix with a finite number of entries is known as *adjacency matrix,* which is an N x N matrix with zero values in its diagonal. Links may have intensity (*weighted network*) or they may be simply represented by 0 and 1 values depending on the absence or presence of a link between two nodes (*binary network*). Both binary and weighted networks can be *directed* (separating in and out flows) or *undirected* (symmetric metric). The simplest form of analysis is binary and undirected. Theoretically, a network is directed if $A_{ij} \neq A_{ji}$, and a network is undirected if for every pair of nodes i and j, $A_{ij} = A_{ji}$. A network can be either *homogenous* (there is no dominance of some specific nodes) or *heterogeneous* (core - periphery networks, where some nodes dominate the network because of their position on it).

In theory, four main network structures can be identified: random network, regular network, small-world network, and scale-free network. A *random network* is a set of 'n' isolated nodes connected with successive links between them at random. A *regular network*

is a network where in and out degrees of each node are equal to each-other; each node has the same number of vertexes and network itself is highly ordered (homogenous network). A *small world network* displays features of both random and regular network, it has small average path length (like random network) and high clustering coefficient (like regular network); high modularity is another feature of this network and this means that certain nodes are highly connected to each-other but not with the rest of the network. A *scale-free network* is a highly heterogeneous network, usually following 'power law' distribution. Because of high variety in degree distribution, there are a few nodes with a lot of connections (important or centric nodes) and there are many nodes with only some connections (can be referred as peripheral nodes).
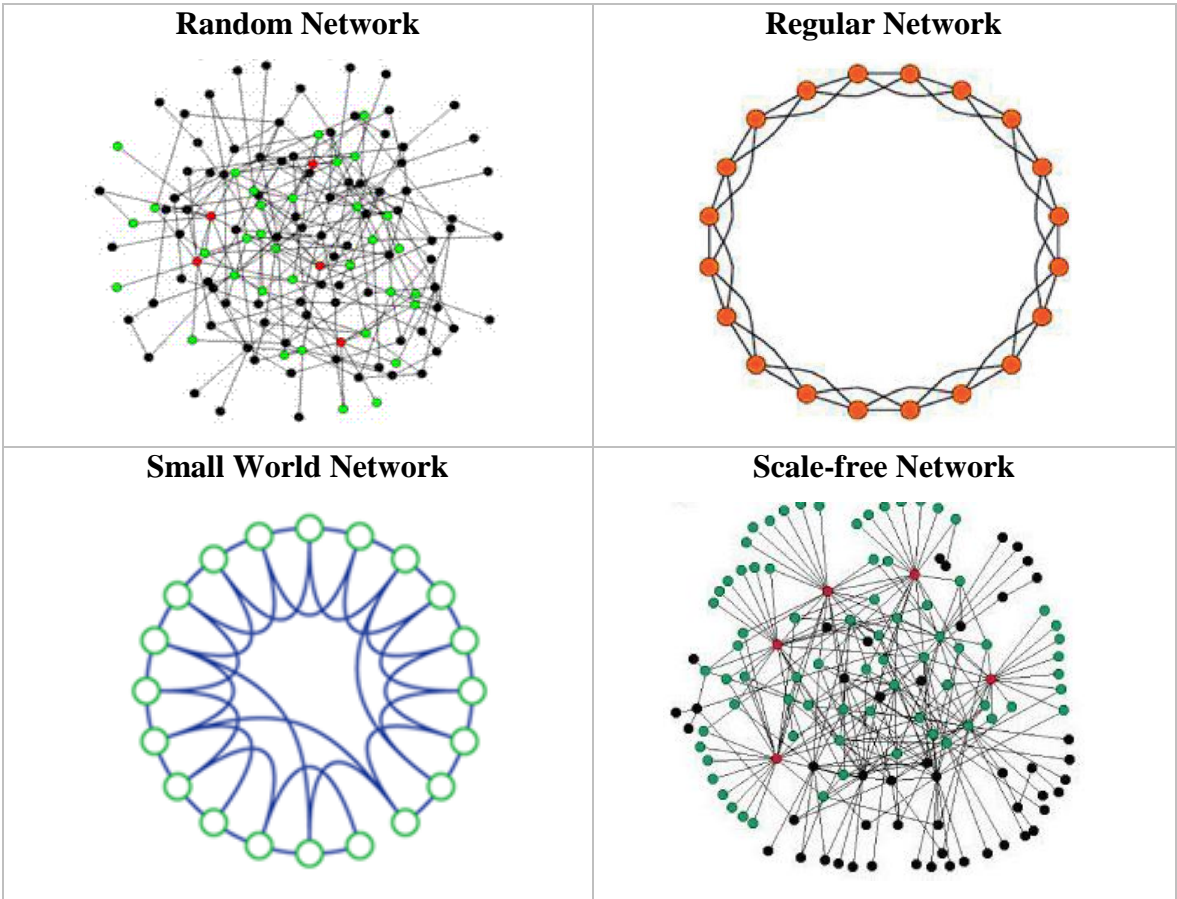
Figure 1: Different types of network

2.3. Social and Economic Networks in Finance: Key Metrics

Network approach offers a wide range of indicators, able to capture different dimensions of international financial web. Usually, network applications in economics and finance have borrowed from other research areas, especially from social sciences. Even though networks are complex and unique in their typology and formation, still there are some key measures offering relevant information on architecture and evolution of them. Key network measures are briefly introduced in the following sections.

2.3.1. Network Density

Network density is the first most straightforward measures of global patterns of a network. For a binary network, it is calculated simply as the ratio between total established relations over total possible number of edges. A high density indicates a dese network, while the contrary means that network is sparse. Direction of flows matters in calculating density of a network. For an undirected web, density is calculated as following:

$$D = \frac{2 * m}{n * (n - 1)}$$

(D = density; m = number of edges; n = number of nodes in the network)

and for a directed network, density is calculated as following:

$$D = \frac{m}{n * (n - 1)}$$

2.3.2. Clustering Coefficient

One of the most important measures of a neighbourhood structures of a network (local pattern) is clustering coefficient (CC). This measure aims to capture the likelihood that direct connections of an ego-node establish connections among each-others as well. Most widespread practice used to measure CC is by simply counting total number of closed triangles a node / actor has formed. Tw different CC can be calculated: global CC and local CC. Global CC is simply total number of closed triangles multiplied by 3 (counts for each

node in the triangle) divided by total number of triples (three connected nodes - both forming a triangle or a line). Local version of CC is calculated in the same way, but in neighbourhood level.

2.3.3. Degree Centrality

Centrality measures are key parameters in a network analysis. Degree centrality (Freeman's Approach) represents the most straightforward centrality measure. It is both affected by edges' intensity and direction. For a simple undirected binary network node degree (ND) is calculated. It simply counts total number of direct links an actor has. In case of weighted ties, node strength (NS) is computed. For asymmetric networks, direction of flows matters, therefore both incoming and outgoing flows should be considered separately. In case of directed networks, in- and out- degree (binary network) or in- and out- strength centrality measures are calculated. Intuitively, nodes with higher node degree or strength are considered as more important or central in the network. Usually SNA software offers another degree centrality measure, normalized degree, which is simply the degree centrality divided by max possible degree centrality (the one of star network, equal to n-1).

2.3.4. Closeness Centrality

Degree centrality represents an intuitive centrality measure but still offers limited understanding on positions specific actors have in the network. Other measures were developed to consider not only direct but as well undirect connections of a given node. Closeness centrality captures physical or geodesic distance of a node in approaching all other nodes in the network. The higher this measure, the more central is the node in the network. A key limitation of this measure is that it does not work properly for disconnected networks. Basically, closeness centrality can be interpreted as the spread of information spreading in a network.

2.3.5. Betweenness Centrality

Like closeness centrality, betweenness measures considers position of an ego-actor in the network. In principle, betweenness centrality measures the extent to which an actor lies

between two other actors in the network, in other words works as a broker, bridge, gatekeeper or intermediary in the structure. The extent to which a node lies between other nodes in the network. An intermediary position is considered as advantageous and determines the importance of a node in network. Betweenness centrality is not affected by direction of flows. Basically, a central node is the one positioned in many shortest geodesic paths connecting any two other nodes in the network.

2.3.6. *Eigenvector Centrality*

In real networks, especially in social and economic webs, edges intensity does not rarely mean geodesic distance among nodes. To consider weight of edges in both direct and undirect connections of a node, a more sophisticated centrality measure was developed. Eigenvector centrality is basically the most 'reliable' indicator of a node's importance in a given network. Simply said, being connected with other important nodes in the network, make a node important or central as well. In other words, this measure is proportional to the sum of centrality of its neighbours. Beside its relevance as centrality measure, eigenvector may offer biased information in case of directed networks. Usually, most of SNA software automatically symmetrize matrices data while computing eigenvector centrality. For this reason, adjusted versions of eigenvector measure have been developed. Most popular algorithms are Google's PageRank and HITS algorithm (hubs and authorities). Within the scope of this thesis, as an adjusted version of eigenvector centrality measure, HITS algorithm is considered.

2.4. Financial Integration and Network Theory: Earlier Empirical Studies

While financial integration represents an attractive research area in international economics and finance, attempts made to explore this phenomenon have usually produced polarized views and contradicting results. Key arguments that can explain discrepancies in earlier empirical studies rely in differences in used country samples, data sets and employed empirical approaches. While there is 'a treasury' of literature using convergence or co-integration models to analyse IFI process, SENA models have gained currency only recently. Most of the existing literature employing economic network models attempts to

address economic integration (Nguyen, Pham and Vallée, 2016; Schiavo, Reyes and Fagiolo, 2010; Kali and Reyes, 2007; Capannelli and Filippini, 2009) or trade integration issues (De Benedictis and Tajoli, 2011; Fagiolo, 2010; Arribas, Perez and Tortosa-Ausina, 2008; Maluck and Donner, 2015; Beaton et al., 2017).

Graph and network theory applications to international financial integration are still at early stages, and data availability has been a major constrain. Two main data sources used in network based analyses are Coordinated Portfolio Investment Survey (CPIS) Data, published by IMF and bank data provided by Bank of International Settlements (BIS). In addition, most of the existing literature relies in bank's data to measure financial integration and it usually focuses in risk and contagion effects in international or regional banking networks.

As earlier mentioned, literature exploring typology of financial networks, their formation and evolution is limited. In addition, existing literature has not sufficiently stressed the importance of node's attribute in a financial network and usually has employed only binary metrics and designed scenario-based analysis.

Minoiu and Reyes (2010) develop a network analysis for international banking lending using BIS data. They use a sample composed of countries and their analysis covers a period over three decades (from 1978 to 2009). They conclude that international banking has experienced several shocks during the considered period, with a significant volatility in international banking flows (especially borrowings or in-coming flows). In addition, banking and other financial crises has negatively impacted level of international banking network density. Authors claim to be the first to consider geographical attribute in the context of international banking network and different from previous works, they use international banking flows rather than exposure. Authors as well argue that based on their findings, for the considered period several eras of financial globalization have been experienced. This statement is not in line with what conventional wisdom has defined as waves of globalization (therefore, financial globalization). They as well find out that most globally connected lenders are Belgium, France, Germany, Switzerland, and GBR, with Japan, Switzerland, US are top-lenders in the international banking network. Few changes

have been noticed in the overall composition of categories (core or periphery) during time. Situation seems to be quite different for borrowing countries. During crises time, most affected countries tend to be as well most central in the borrowings network. For instance, during Latin America Debt Crisis most affected countries in this region were as well most central countries in the borrowings network (Argentina, Brazil, Chile, Mexico, and Venezuela) were the most central borrowers in the network. Later these countries were substituted by East Asian emerging economies, followed in the next years by rapidly increasing centrality of BRICs countries in borrowings network.

Oatley et al. (2013) in they work argue that global financial system is a hierarchical structure and clearly demonstrates a core-periphery pattern. Based on BIS and CPIS data, they develop two separated network analyses from 2000 to 2010 in a sample composed by 68 countries. Network analysis is completely based on directed weighted matrices. Most important hubs in the network are USA and GBR. Germany and Luxembourg as well appear to be important hubs in the European financial network, nonetheless they are less influential in the global financial web.

Giudici and Spelta (2013) employ graphical Gaussian models as a tool to measure international financial integration. They use data extracted from BIS locational banking statistics to identify key players in international banking network, and understand the impact of crisis in this network. A sample of 24 reporting countries is used and analysis cover a time period from the last quarter of 1983 to the third quarter of 2011. As a conclusion, authors split sample in three key groups potentially contagious for international banking system: key international financial hubs (US and GBR), international financial offshores (Luxembourg, Hong Kong, Finland, and Cayman Islands), and most active participants in international financial transactions (Netherlands, Switzerland, and Germany).

Arribas, Pérez and Tortosa-Ausina (2011) employ BIS data as well for a sample of 23 countries for the period 2003-2009. Their main conclusion is that for the considered time period, bank integration has rapidly increased marking levels up 45% in 2009.

Caballero (2015) relies on data collections from various sources and explores implications of real financial integration of banks to crisis incidents. Research covers a sample of 166 countries for the period 1980-2007, and the main finding is that level of integration in banking sector is a key determinant of crisis occurrence.

Schiavo, Reyes and Fagiolo (2010: 389) claim to be the first work analysing international financial assets transactions in the context of network analysis. They perform a 4-year network analysis for trade and financial integration (2001-2004). Authors reply on CPIS data to analyse financial integration in a country sample from 61 to 65 countries, varying upon data availability. In addition, they use an undirected network analysis and heavily rely on statistical (regression and correlation) approaches. This research was important for this thesis in terms of defining data source (CPIS) and variables to be used as measures of financial integration. This thesis employs as well CPIS data in a complex weighted network approach, but different from Schiavo, Reyes and Fagiolo (2010)'s work, a longer time-period is considered, and analysis is developed based on a directed financial network argument.

Xu and Corbett (2015)'s working paper aims to explore implications of financial integration to increased vulnerability to shocks. BIS database is the main data source used and analysis covers a period from 1999 to 2013. Analysis starts from 1999 due to lack of data for the USA's stock of foreign claims. Core country of international banking and financial system, USA starts to report to BIS only by 1999. Analysis is organized in three main part: global banking network, European banking network and Asian banking network. Authors use a modified version of eigenvector centrality (PageRank) to rank countries in the network based on their importance or prestige. Their findings are in line with previous researches, concluding that most connected countries globally are USA, GBR, Germany, France and Netherlands. They as well argue the increased role of China (Hong Kong) in the Asian banking network and relatively low level of regional integration of Japan compare to its integration with other countries in the international banking network.

IMF (2011)'s working paper employs network analysis to map international financial network, analyse its composition and identify key actors in the system. Availability of

bilateral data has been identified as a significant restriction on a full understanding of IFN. Data for emerging economies are less available than those for advanced economies. This report employs both BIS and CPIS data as complementary to each other. Level of financial integration is analysed using three different variables: bank claims (BIS), debt portfolio (CPIS) and equity portfolio (CPIS). FDI are not considered in this analysis since they are usually these kind of cross-border flows is relatively stable over long periods of time. Main conclusion of this working paper is the dominance of a small core of countries and for each specific category of asset class. In addition, this dominance is noticed in both direction of flows (in - out or source – recipients flows) indicating for a higher risk of financial shocks (two-directional shocks). Exploring the role of different variables to financial integration, non-variable drivers of integration are found empirically significant in determining direction and intensity of cross-border capital flow. Level of economic development as well appears to be an important determinant of intensity of cross-border financial linkages a country has. In line with previous researches, level of financial development and common regional or global institutions / groups / agreements result to be significant in defining typology of cross-border financial ties.

CHAPTER 3: IMPLEMENTATION AND EMPIRICAL RESULTS

3.1. Research Methodology

3.1.1. Research Strategy and Data Sample

This thesis employs a complex network approach as a powerful tool to explore typology and evolution of international financial network. Bilateral financial data are retrieved from CPIS database and country sample used is a composition of 70 countries. Number of countries considered is restricted due to data availability. This database constructed based on data retrieved from a direct reporting of countries on their foreign assets holdings. Considering available data from 2004 until 2015, there are some issues on reporting requiring careful consideration. *First*, there are some negative values reported as foreign assets holding. According to CPIS Guide, these values indicate a short position in assets holdings, which comes mainly due to re-sale of assets hold under repurchasing agreements. Within the scope of analysis, these data entries are considered as null. *Second*, CPIS guide invites countries to report their holdings in sound amounts but does not define any specific threshold. Consequently, values as low as $0.15 can be found in CPIS database reported as foreign assets holdings. In order to mitigate the risk of generating biased information from network indicators that are calculated based on binary matrices, a minimum threshold equal to $1,000 is set arbitrary. *Last*, throughout CPIS database there are some bilateral financial ties reported as confidential. Existing literature does not offer any recommendation on how to treat bilateral ties reported as confidential. Nonetheless, for each year and category of assets, total number of sound links and number of ties reported under the threshold or as confidential is calculated. In general, it is an optimal solution to equate this reporting with null, otherwise it will be difficult to involve them in calculations using weighted matrices. Most affected indicator by this approximation will be overall and grouped network density. A summary of countries reporting some of their bilateral financial relations as confidential is presented in the annexes section.

Typology and evolution of international financial network is studied for period 2004 – 2015, and aims to capture effect of global and European financial crises (if any) to positions

and power of countries in international financial web. In principle, network analysis can be classified as a quantity-based approach [earlier version of Schiavo, Reyes and Fagiolo, (2010)], and it offers a deep insight into real integration or de facto financial integration. Provided that binary and weighted approaches capture different aspects of typology and evolution of network, both of these approaches are employed (Schiavo, Reyes and Fagiolo, 2010: 390). Key network parameters used are network density, clustering coefficient, centrality measures (degree centrality, betweenness centrality, closeness centrality and hubs & authorities centrality). For network density, clustering coefficient, node degree, betweenness centrality and closeness centrality binary matrices are used. On the other side, node strength and hubs & authorities (HITS Algorithm) indictors are computed based on weighted matrices.

As Kose et al. (2009) and Schiavo, Reyes and Fagiolo (2010) suggest, level of integration varies based on the type of connection, and separation of cross border flows based on this logic can generate more sound results. Therefore, for the purpose of analysis, total assets investment position is first analysed as a general measure of financial integration followed by a separate analysis for both equity portfolio and debt. Furthermore, debt is decomposed in short term and long-term debt. As per regarding to network's symmetry, literature it not very clear on the method used to classify a financial network as symmetric (undirected) or asymmetric (directed). Schiavo, Reyes and Fagiolo (2010) in their research, by calculating arc reciprocity suggest that selected network is sufficiently symmetric and further separating transactions into in / out flows is not required. Nonetheless, most of the considered literature suggests that financial networks are not symmetric and therefore a directed approach is requested. Logically, in a network considered as a core-periphery structure, chances that centrality (both in number or weight) will be equally distributed are basically not feasible. In case when centrality is equally distributed, then the network will not be dominated by only some nodes. In addition, UciNet offers the option to automatically detect if a network is symmetric or not, and results obtained for financial network call for a directed analysis. In sum, within the scope of this thesis, financial network is considered directed and therefore a separated analysis is developed for 'in' and 'out' flows. Symmetricity is important in calculating node degree, closeness and hubs and

authorities centrality (for directed networks) measures. Betweenness centrality is not affected by network's symmetricity.

As per regarding to time period considered, only network density is calculated annually from 2004 to 2015. Other network measures and attribute based analysis are performed for only four years: 2004 (first dataset available), 2008 (peak of last global financial turmoil), 2012 ('controversial' end of financial crises) and 2015 (most recent dataset available). This selection is based on the logic that financial networks tend to be relatively stable and no major changes are expected in short periods of time. Results for total assets holdings are presented in this thesis and findings for its subcategories are discussed but not included in the text.

Relying on Jackson (2017) theoretical approach on simplifying network's complexity, this thesis will pursue the following research logic:

Step 1: Matrices design and data entry

70x70 adjacency matrices (binary and weighted) for total assets holdings and its subcategories (equity portfolio, total debt, total long-term debt and total short-term debt), annually from 2004 to 2015 are created. These are the main data input for social network analysis software (UciNet and Gephi). Data are retrieved from IMF CPIS database and to maintain a static panel data for the considered period, 70 countries are included into the sample. All matrices are built in Excel and after imported to UciNet translating them into DL Language.

Step 2: Global patterns of network measures computed

Density for total assets and its subcategories has been calculated annually from 2004 to 2015 via UciNet.

Step 3: Local patterns of network computed

Aiming to capture local patterns of networks, both overall graph clustering coefficient and overall graph weighted clustering coefficient are calculated.

Step 4: *Position measures calculated*

Node degree, node strength, closeness centrality, betweenness centrality and hubs & authorities (HITS Algorithm) measures have been calculated based on the logic of a directed weighted network. All these measures try to capture different aspects of a node's centrality in the network.

Step 5: *Network homophily and assortative mixing measures calculated*

Assortativity mixing basically explains how homophile a network and analyses testing preferential attachment in a network rely in nodes' specific attributes. So basically, assortative mixing analysis aims to test if there is preferential attachment among nodes sharing similar attributes such as income or geographical location. Selected countries are grouped in three distinctive categories based on income (developed economies, emerging economies and the rest) and in seven groups based on geographical location (North & Central America, South America, Europe, Asia, Caribbean, Oceania and Middle East & Africa). More information in classification is provided in Appendices section.

Step 6: *Discussion on network analysis output*

Under 'Discussion' section, results of this thesis are interpreted and compared with those obtained from previous similar studies. Up to our knowledge, most recent studies exploring financial integration phenomenon are Lane and Milesi-Ferretti (2017) (traditional model) and Xu and Corbett (2015) (network analysis). Nonetheless, Xu and Corbett's work is based on BIS database and aims to analysis international financial integration through the level of banking linkages. In addition, the only accessed previous works employing CPIS data to test level of financial integration are Schiavo, Reyes and Fagiolo (2010) and IMF (2011). Schiavo, Reyes and Fagiolo (2010) develop their analysis based on an undirected network. Up to my knowledge, this is the first work using CPIS data in a directed weighted approach.

Step 7: *Network Visualization*

Last, discussed all centrality and position measures are visually presented through network graphs, designed by Gephi Software. Graphs for total assets holdings, total equity portfolio and total debt for both 2004 and 2015 are developed.

3.1.2. Research Questions

The main underlying research question of this thesis is: "How has the architecture of international financial network changed since 2004?". This thesis is organized based on the following sub-questions:

1 - How did recent financial crises affect level of international financial integration?

> To address this question, network density from 2004 to 2015 is calculated. In addition, overall assets investment position is decomposed in four different categories (total equity, total debt, long term debt and short-term debt) and each network is considered as a separate net. By calculating annually network density it is made possible to easily identify any break in the level of financial integration for the considered time period.

2 - What is the position of each country in the network and has it changed over time?

> To address this question local and global measures of network have been computed. Clustering coefficient, node degree and strength, closeness centrality, betweenness centrality and hub & power are considered as indicator of structural changes within IFN network.

3- Is there any preferential attachment in the international financial network?

> In order to test if there is any preferential attachment among countries sharing similar attributes, two variables are considered: geographical location and income. Group density is used a direct indicator of network homophily.

4 - Is there any significant difference in the network of different classes of assets?

> Maintaining a static country sample and time period, a separate network analysis is developed for each category of assets (total equity and total debt). A summary of key findings is presented in 'Discussion Chapter'.

3.1.3. Methodology Relevance and Justification

As earlier stated in this research, financial integration is a complex network and measuring it accurately is a challenging enterprise. There is no existing model postulated as the best empirical approach to this phenomenon (Billio et al., 2017: 151). In addition, one of the

main drawbacks of existing traditional models is that they are just too simplistic to accurately capture the complexity of international financial integration (Zeitz, 2015).

Network approach is becoming increasingly influential in international economics and finance research area. There are many reasons behind increased popularity of this approach. *First*, network models can analyse complex issues of cross-border interactions, covering large samples and data set (Zeitz, 2015). *Second*, network approach can enrich our understanding regarding the way how global financial system works and the typology of cross-border capital flows. This approach helps to better understand network formation, dynamics, design, evolution, roles and effect of each country in the international financial web. By doing so, it is possible to identify key players in the network (countries, institutions, markets, etc.) and provide useful information for policy makers in both national and international levels (European Central Bank, 2010: 5; Kali and Reyes, 2007: 21). Allen and Babus (2009: 2) argue that a better understanding of global financial network typology and evolution supports policy-makers on adopting more prudent macro-economic policies. *Third*, through more complex mathematical algorithms it is possible to easily simulate and measure different networks, and so try to find most optimal financial relationships. *Fourth*, improved understanding on the typology of financial connections can help to forecast system reaction to different changes and shocks (Minoiu and Reyes, 2010: 4). *Last*, network analysis can help in assessing systematic risk in international and regional financial networks, and identify most contagious countries in the network (European Central Bank, 2010: 18; Xu and Corbett, 2015: 6).

De Benedictis and Tajoli (2011:1418) argue that, even though graph and network theory is very attractive for applications in social sciences, still these tools focus mainly in the typology of relations among nodes and not on the nods' attributes. Therefore, network analysis can be seen as a compliment of existing econometric models, such as regression analysis or gravity model. Within the scope of this thesis, international financial integration is assessed by using a complex network analysis and obtained results are discussed both in the context of previous network analysis in this research area and other researches using traditional econometric models.

3.2. Empirical Results

3.2.1. Global Patterns of Network

Before proceeding with SENA application, there are several network characteristics to be considered. As earlier mentioned, the simplest form of network is binary and undirected. Nonetheless, these types of networks are more hypothetical and real social networks are far more complicated than this. Financial networks itself are complex, where both ties' weight and direction matters. While weighting ties' importance in the network will hugely improve the analysis, deciding whether to consider flows' direction requires more critical consideration. Including flows' direction in the analysis may provide the research with useful information but in the same time it will considerably complicate the analysis. Theoretically it is easy to distinguish if a network is directed (asymmetric) or undirected (symmetric); it is just a straightforward interpretation of reciprocity output. Nonetheless, practically it is a difficult task and requires a lot of considerations before proceeding with the analysis (Fagiolo, 2006).

Existing literature offers little explanation regarding symmetricity of financial networks and thresholds to be used. Referring to Schiavo, Reyes and Fagiolo (2010)'s logic, binary matrices can be tested using reciprocity rate and for weighted matrices they have developed a specific index. Authors argue that for arc reciprocity equal to 75%, a directed analysis is not necessary. In our case, for the four years arc reciprocity for total assets matrices is higher than Schiavo, Reyes and Fagiolo (2010)'s 'threshold', therefore we can argue that an undirected approach would be appropriate in this context and this would reduce the complexity of our analysis. In their work, Hanneman and Riddle (2005) argue that a hybrid reciprocity rate of 53% is neither low nor high. Again, in our sample for the four years hybrid reciprocity is higher than 60%, supporting Schiavo, Reyes and Fagiolo (2010)'s logic that a directed approach may not be necessary. Recent literature has usually employed directed networks, but they fail to persuasively argument their choices. Logically, treating financial networks (especially weighted ones) as symmetric would offer a too much simplified analysis and relevant information may be lost. In addition, as earlier mentioned, UciNet itself offers the option to automatically detect weather network is symmetric or not.

Considering all options and arguments in favour of one or another approach, this thesis employees a directed network model, offering a more complex analysis compared to the one introduced by Schiavo, Reyes and Fagiolo (2010) and up to author's knowledge, this is the first work employing CPIS data in a directed weighted network analysis.

After deciding whether to consider or not flows' direction, first and the most straightforward parameter of a network is density. As earlier explained, density measures the portion of all potential bilateral relations which are already established among countries in the network. This measure is computed annually from 2004 till 2015, for total assets and its four subcategories. Obtained results are graphically presented in Graph 1 and Graph 2.
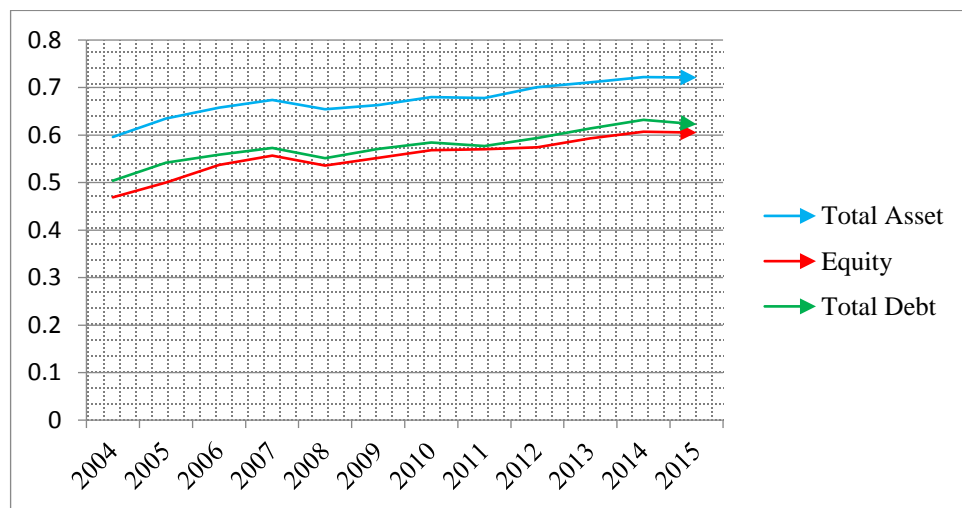
Graph 1: Total Assets, Equity and Debt Density
Source: Author's compilation (2017)

Graph 1 compares evolution of network's density for total assets and its two subcategories, total equity portfolio and total debt. As it can be noticed from the graph, there is an increasing trend for all three networks and there is a break in 2008, which can be justified with the recent financial crisis. Nonetheless, decrease from 2007 to 2008 is about 2% for total assets and equity, and about 2.2% for total debt. From 2009 ongoing, there is an upward trend for all assets categories and network density in 2010 is higher than just before crisis. Nonetheless, integration rate after 2014 slightly drops for all asset categories considered and the highest decline is recorded in short-term debt (-1.8%). This drop in higher than the one experienced during the recent financial crisis for short term debt (-

1.5%). This finding should be considered with caution due to possible errors on CPIS data reporting. Just to remind, bilateral relations reported as confidential are considered as null relations meanwhile in reality they may be ties with high intensity. To test the possibility of a decline due to data error, total number of ties with and without confidential values and reporting under the threshold are calculated. While for total assets, total equity, total debt and long-term debt slightly increased from 2014 to 2015, for short term-debt in both cases number of links in 2015 was less than the previous year.

Referring to Graph 2, density of short and long-term debt networks, integration in short-term debt is twice as lower as integration in long-term debt. In addition, during 2009 short-term debt integration continues to fall meanwhile long-term debt starts recovering. In 2011 overall integration in debt securities slightly decreased. In this case as well, total number of ties with and without data adjustments are calculated and obtained results support the idea of a real decline in debt securities integration. This break can be naturally explained by the European debt crisis (2011 - 2012). A much lower integration in short-term debt compared with long-term debt or equity can be easily justified with the fact that, in principle, countries tend to finance their short term needs with domestic funds and for larger amounts of financial and longer maturity, external funding may be more attractive.
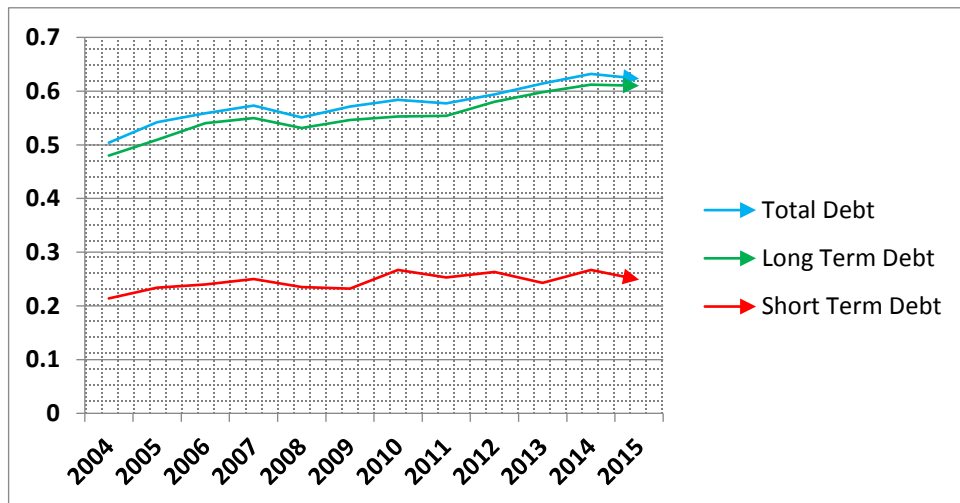
Graph 2: Total, Long – Term and Short-Term Debt Graph Density
Source: Author's calculation (2017)

3.2.2. Local Patterns: Network Transitivity and Clustering Coefficient

Network transitivity and clustering coefficient (CC) are the most popular measures of local patterns of a network. Even though they may look like centrality measures, they are actually localized version of network density measure. CC is basically the local density of every node in the network. A CC close to 1 indicates for high possibility that a node's neighbors are connected among themselves as well.

Table 1: Clustering coefficient – Total assets

	2004	2008	2012	2015
Graph density	0.596	0.654	0.701	0.721
Overall graph CC	0.738	0.751	0.768	0.779
Weighted Overall graph CC	0.683	0.718	0.749	0.762

Source*: Author's compilations (2017)

In general, network has become more clustered since 2004, and each country tends to form more closed triangles as network's density increases. Overall graph clustering coefficient (CC) referrers to the average density of each node in the network. Weighted graph clustering coefficient (WCC) is a normalized version of CC, weighting neighbourhood's density based on its size and after calculating network's CC. Results for both CC and WCC are presented in Table 1.

In 2004, most clustered nodes are Gibraltar, Romania, Barbados, Malta and Pakistan, all these countries with relatively low connections, compared to the total possible connections. On the other side, least clustered but in the same time countries with the highest number of ties are USA, GBR, Switzerland, Luxemburg and Germany. In 2015, most clustered countries are Ukraine, Pakistan, Kuwait, Egypt and Gibraltar and again, least clustered nodes are the one with the highest number of ties: USA, GBR, Luxemburg, Cayman Islands and Switzerland. These results can be argued with the simple logic of core-periphery structure of IFN. While there are countries well connected with the rest of network, there are some other countries establishing few links and they tend to connect directly to hubs or most influential countries in the network. Therefore, when computing clustering coefficient, the probability that for example neighbors of Pakistan will be as well connected among each other is high (for instance USA, GBR, Switzerland) meanwhile not all

connections of USA form 'triangles' or are connected to each-others (for instance, Pakistan, Ukraine, Gibraltar, etc.).

3.2.3. Network Positions: Centrality Measures

Even though being clustered may sound attractive, still it says little for a node's position in a network, its influence and power. At the end, more than the level of connectedness among node's neighbours, is important to have power and influence in the neighbourhood and the network as a whole. Considering node's position in a network, four different measures are computed: degree centrality (node degree and strength), betweenness centrality, closeness centrality and hubs & authorities centrality (similar to eigenvector centrality, applicable in directed weighted networks). Node strength and hubs & authorities measures are computed based on weighted matrices data, and the rest of centrality indicators are measures based on binary matrices data. All these centrality measures aim to capture different dimensions of power and influence and therefore we do not expect that all of them will generate the same results or rank countries in the same order.

3.2.3.1. Degree Centrality: Freeman's approaches

Degree centrality known as well as Freeman's approach is the most straightforward centrality measure in a network analysis. It measures total number (binary) and total strength (weighted) of a node's in and out-going direct links (directed network). The logic of this measure is very simple: if a node has many connections, then it is more central than other nodes with less connections; or, if the total weighted of a node's connections is high, than this node is more central compared to other nodes with a lower total weight of connections. As earlier stated this thesis considers IFN as asymmetric and therefore employs a directed network model. Consequently, both in- and out- degree centralities are calculated. Table 3 shows results for top-5% of nodes with the highest node-degree centrality and table 4 presents the results for top ten countries maintaining most intensive connections.

Theoretically, in-degree refers to the ties that 'enter' a node (in our case, assets' issuer) and out-degree means ties going out from one node to others (in our case, assets' holder, owner or investor). A high in-degree node is known as well as prominent or having high prestige.

In other words, these are countries issuing attractive assets for foreign investors (in-degree), so they are considered as important nodes for the network. On the other side, a high out-degree node is considered as influencer. Out-degree measures compute level of foreign ownership how diversified a country's portfolio is. Only for node degree, results are grouped in four categories following the logic of Reyes, Schiavo, and Fagiolo (2010): core countries (95%), inner periphery (between 90% and 95%), secondary periphery (between 85% and 90%), and others (less than 85%).

Table 2: Node Degree Centrality 2004-2015

	In – Degree				Out-Degree			
	2004	**2008**	**2012**	**2015**	**2004**	**2008**	**2012**	**2015**
> 95%	GBR	GBR	USA	USA	LUX	GBR	GBR	GBR
	USA	USA	GBR	GBR	DEU	LUX	JPN	LUX
		DEU	DEU	LUX	CHE	CHE	LUX	USA
		FRA	NLD	CYM	USA	ITA	IRL	CYM
		NLD	JPN			AUT	DEU	NLD
			LUX			DEU	CHE	CHE
			FRA			FRA	DNK	FRA
						IRL	NLD	JPN
						DNK	FRA	IRL
						USA	ITA	DEU
						NLD	AUT	CAN
						BEL	GGY	SWE
							USA	ITA
							KOR	NOR
								DNK
								AUT
								GGY

Source: Author's compilations (2017)

Considering Table 3, most prestigious issuers of assets held by non-residents are shown by in-degree output. We can see that by applying 95% threshold, till 2012 more a more countries join the 'club' of the most prestigious and top performing issuers for the whole period are GBR and the USA, having their assets held by almost every other country in the network. Germany, Netherlands, France and Switzerland as well issue quite attractive assets for international investors. General speaking, for the considered time period, assets issued by some of the top offshore financial centres (Bermuda, Ireland, Luxembourg, Switzerland and Hong Kong) have continuously attract more investors from different countries.

Out-degree centrality measure shows that in most influential countries in the network are Luxembourg, Germany, Switzerland and the USA. As it can be seen, more countries join the group of most influential countries during the considered period. In 2008, GBR, Luxembourg, Switzerland, Italy and Austria hold highly diversified portfolios, owning assets issued by 68 out of 69 countries in the network. Overall, interesting to be mention is the increased importance of Asia region (Japan and Korea) and offshore financial centres (Guernsey, Netherlands, Bermuda, Ireland, Panama and Barbados) during the considered time period, especially in the aftermath of recent global and European financial crisis.

Luxembourg, a small European country clearly demonstrates its important position in the international finances and represents one of the most influential countries in the network for the whole considered period. In addition, countries as Singapore, Australia, or Spain different from expectations seem to be relatively low influencers in the network. In real, their low ranking can be fully explained by their CPIS reporting. Since 2004, Australia has on average reported 18 out of 69 possible bilateral relations as confidential. Singapore as well has declared 39 / 69 (2012) and 42 / 69 (2015) bilateral relations as confidential. Since 2008 almost half of Spain's reports are declared as confidential. Consequently out-degree for these countries will be low and node degree centrality will offer biased information for their influence in the network.

Graph 3: In & Out Node Degree Distribution 2004

Source: Author's compilation (2017)

Distribution of node degree for 2004 and 2015 is shown in graph 3 and 4. As it can be seen from graph 3, more than half of countries have an in-degree higher than 30, which means that assets issued in these countries are held by resident of at least 30 other countries. This patter is the same in case of out-degree. Overall, from the general 'shape' of graph, it can be noticed a tendency for correlation between in and out degree. Countries with low in degree (for example Gibraltar, Pakistan, Aruba, etc.) have relatively low out-degree as well. On the other side, countries with high in-degree (for instance USA, GBR, Germany, Luxembourg, Switzerland, etc.) have as well high out-degree. In general, this can be interpreted as a correlation between prestige and influence in the international financial network.
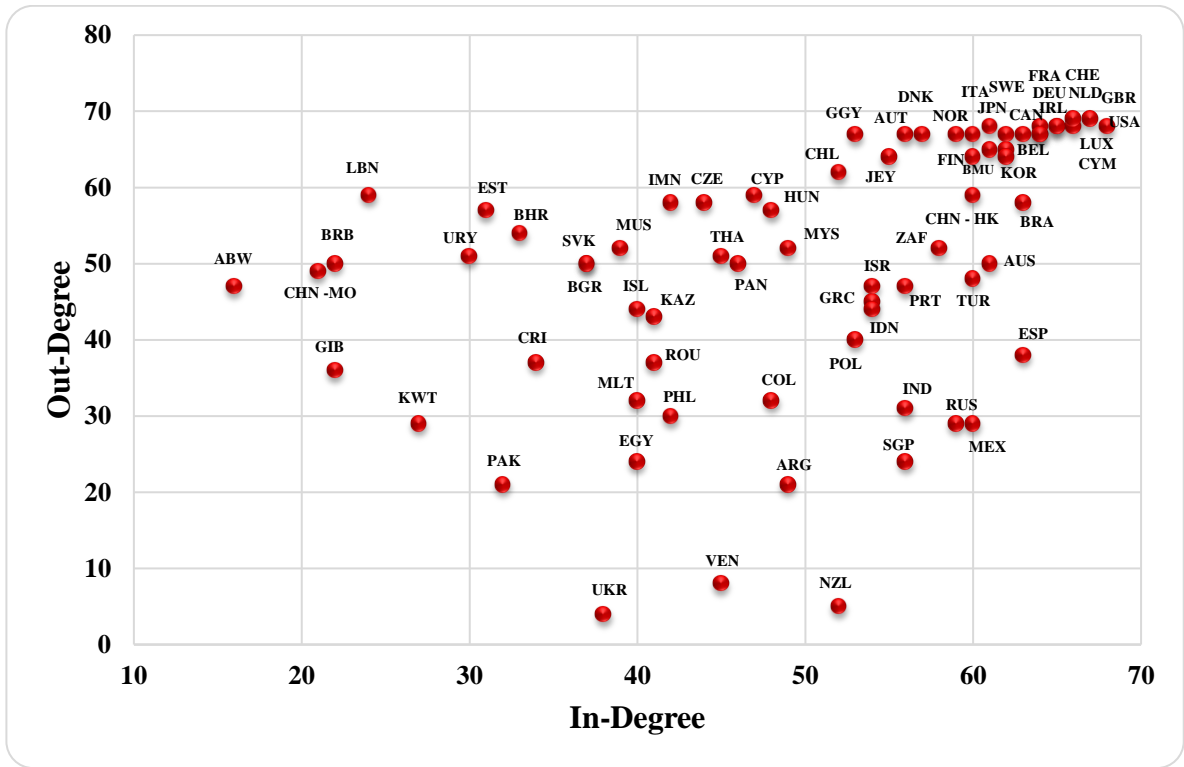
Graph 4: In & Out Node Degree Distribution 2015

Source: Author's compilation (2017)

In line with findings from density analysis, graph 4 shows evolution of network density in terms of node degree centrality. By 2015, almost 95% of countries in the network have issued assets to residents in at least 30 other countries in the network. This ratio is less but still high for out degree. Almost 85% of countries in the network hold assets issued in at least 33 other countries in the network.

Logic of node centrality is simple, total number of ties a node has and centrality in the network is positively correlated. While it makes sense to have central nodes with many connections, not always number of links determines nodes' power or influence in a network. One country may have just a few links in huge amounts and some others may be connected via weak ties with many countries in the network. In this case, we see that tie's weight matters and Freeman's measures considering node's weight is node strength centrality. Strength centrality results for total assets are shown in Table 4.

Table 3: Node Strength Centrality 2004-2015

	In – Strength				Out-Strength			
	2004	**2008**	**2012**	**2015**	**2004**	**2008**	**2012**	**2015**
Top 10	USA	USA	USA	USA	USA	USA	USA	USA
	GBR	GBR	GBR	GBR	GBR	FRA	JPN	LUX
	DEU	DEU	DEU	LUX	JPN	JPN	GBR	GBR
	FRA	FRA	FRA	FRA	FRA	GBR	LUX	JPN
	NLD	LUX	LUX	CYM	LUX	DEU	DEU	DEU
	ITA	NLD	CYM	DEU	DEU	LUX	FRA	FRA
	LUX	ITA	NLD	NLD	NLD	IRL	IRL	IRL
	CYM	CYM	ITA	JPN	IRL	NLD	NLD	NLD
	JPN	ESP	IRL	IRL	ITA	ITA	ITA	CYM
	ESP	JPN	JPN	ITA	CHE	CHE	CHE	CAN

Source: Author's compilations (2017)

As earlier explained, node strength follows exactly the same logic as node degree, with the only difference that instead of counting total number of ties (node degree), it considers total weight of ties. The same as in case of in-degree centrality, there is an absolute dominance of USA (1st) and GBR (2nd) and France (4th) as assets issuers. Other top-performing issuers exchange their positions among each-other. Germany records a considerable decrease in the total amount of domestically issued assets held by foreign residents in the aftermath of the recent global and European financial crises. Netherlands, Italy and Spain as well recorded decrease in their ranking meanwhile financial offshores became increasingly attractive for foreign investors (Luxembourg, Cayman Islands and Switzerland). An interesting point to emphasize is the US' assets held by non-residents. US' assets appears to be highly most attractive than the rest of the world for the whole period, being almost two times higher than total assets issued to foreigners by the GBR, ranked 2nd as most prestige country in the network. In 2015 US has three times more assets held by foreigner than the GBR, and a continues decrease is experienced by top-performing European financial centres (Germany, France, Netherlands and Italy) since 2008, which can be argued as a consequence of recent European financial crisis.

As per regarding international portfolio diversification, again the US leads as the most influencing country in the network, holding a foreign assets portfolio weighting almost twice of portfolio of country positioned 2nd based on out-strength ranking. This gap continuously increases in the aftermath of recent financial crisis and almost triples in 2015, when US is followed by Luxembourg, GBR and Japan. Very interesting to point out is the fact that US, even though was the epicentre of recent financial crisis, was not affected at all

from the consequences of this crisis, in terms of foreign assets portfolio holdings. Unlike the US' experience, almost all of most prominent investors in international markets experience decrease in their foreign assets position (for example, Japan, GBR, Germany, France, Netherlands). Canada as well emerged as an important influencer in the international financial network. The most impressive case is that of Cayman Islands (British Overseas Territory), which by 2015 ranks 9th and has a position comparable with Netherlands.
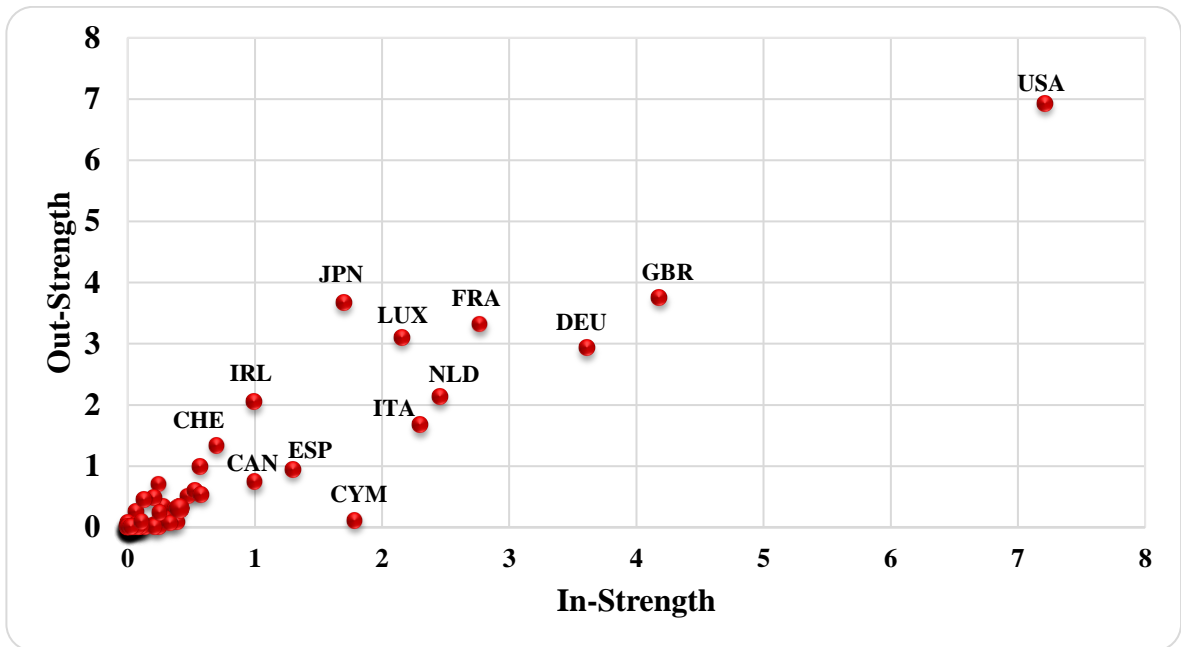
Graph 5: In & Out Node Strength Distribution 2004

Source: Author's compilation (2017)

Graph 5 and 6 visualizes node strength distribution. In both graphs x axis stands for normalized in-strength and y-axis represents normalized out-strength centrality. Different from graphs of degree distribution, here it can be noticed the high heterogeneity of the network. As it can be seen from graph, most of countries lay between 0 and 1 normalized strength centrality. Meanwhile, there is a significant gap between both holdings and assets issued internationally of the USA with the rest of the network. Surprisingly, in aftermath of last financial crises, this gap deepened even more (graph 6). Meanwhile expectations are that a crisis initiated from mortgage market in the US, would definitively worsen the

position of this country in the network, in reality largest financial hub managed to strengthen its position on the network.
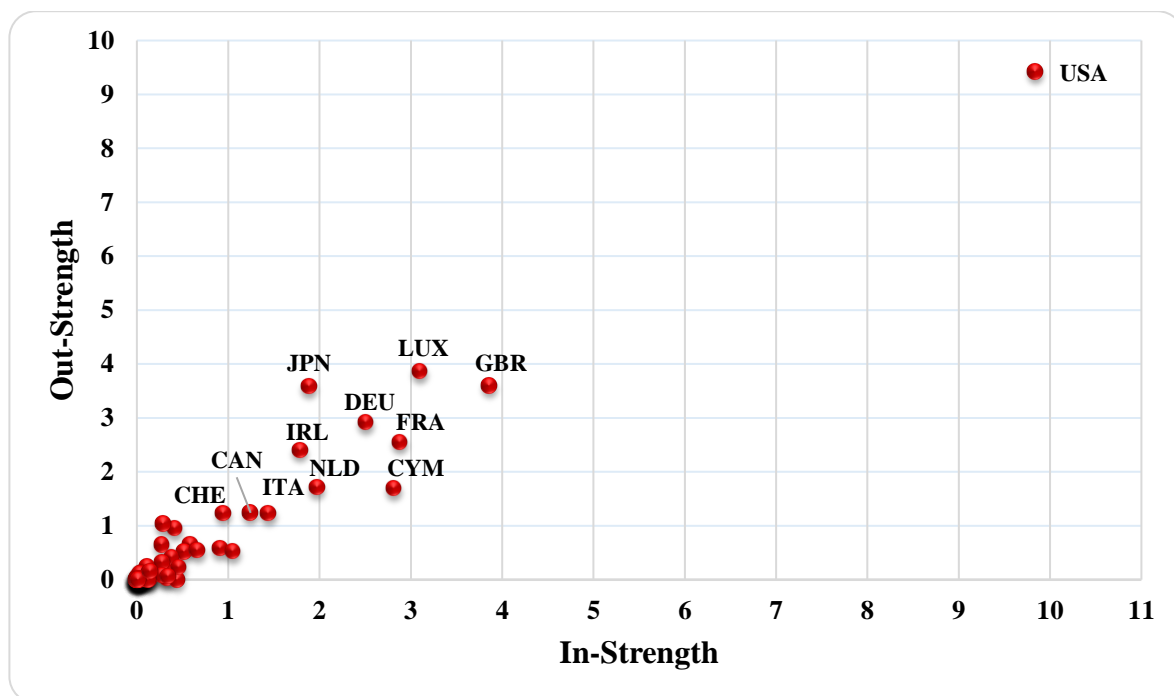
Graph 6: In & Out Node Strength Distribution 2015

Source: Author's compilation (2017)

In general, it can be seen from the data that there is just a small number of countries holding high internationally diversified portfolios, and the rest of network holds relatively small foreign assets portfolio. This is in line with previous works considering international financial system as a core-periphery structure, with few countries being positioned at the core of the network, and the rest of the world positioned in the periphery of this network, developing intensive relationships with the core and being less connected with other peripheral countries.

UciNet offers another output data, Descriptive statistics, providing useful information on distribution countries' centrality scores. In 2004, on the average, countries have an in and out degree about 41, which is relatively high in a network with 70 countries and where the maximal possible degree is 69. Both degrees (in and out) continuously increase for the whole period, and by 2015 on average countries had a degree about 50 out of 69 maximal possible degrees. In addition, the gap in out-degree is larger in the aftermath of recent

financial crisis (minimum and maximum). Standard deviation and variance as well are slightly higher for out-degree than in-degree, reflecting a higher variability across countries in terms of their influence in the network. This can be interpreted as a higher heterogeneity in network in terms of nodes' out-degree or influence in the network. As per regarding to node strength descriptive statistics, in 2004 average in and out node strength is $ 2.85 * 10^{11} meanwhile by 2015 average node strength is more than twice of what it was about a decade ago, equal to $ 5.934 * 10^{11}$. Even though the average node strength considerably increases, the gap among strength of financial ties among countries deepens as well. This gap is much higher for out-strength (assets holders) rather than in-strength (assets issuers). Out-strength gap reach its peak by 2008, when Pakistan holds the smallest internationally diversified portfolio of assets ($409,096,3.109) and the USA holding a portfolio about 994,988 times larger than Pakistan ($ 4.07 * 10^{12}$).

3.2.3.2. Closeness Centrality

Different from degree centrality, which takes into consideration only direct connections of a node, closeness centrality considers indirect ties as well. This centrality index measures the 'distance' from one node to the rest of nodes in the network. 'Distance' and 'closeness' can have different connotations, and in our case these concepts refer to the number of paths a node needs to approach all other nodes in the network. Table 5 presents the summarized output from closeness centrality analysis, both in and out closeness.

Table 4: Closeness Centrality 2004-2015

	Closeness Centrality							
	2004	2008	2012	2015	2004	2008	2012	2015
	In-Closeness				Out-Closeness			
Top 10	GBR	GBR	USA	USA	LUX	GBR	GBR	GBR
	USA	USA	GBR	GBR	DEU	LUX	LUX	LUX
	DEU	DEU	DEU	CYM	CHE	CHE	JPN	USA
	NLD	FRA	NLD	LUX	USA	ITA	IRL	CYM
	CHE	NLD	LUX	NLD	GBR	AUT	DEU	NLD
	ITA	LUX	JPN	CHE	ITA	DEU	CHE	CHE
	FRA	IRL	FRA	IRL	FRA	FRA	DNK	FRA
	AUS	CHE	CHE	DEU	BEL	IRL	NLD	JPN
	SWE	CAN	AUS	FRA	AUT	DNK	FRA	IRL
	LUX	CYM	IRL	ESP	GGY	USA	ITA	DEU

Source: Author's compilations (2017)

In-closeness centrality refers to the sum of incoming geodesic distances from other nodes and out-closeness outgoing geodesic distances to the rest of nodes in the network. In other words, in-closeness refers to easiness other countries approach a specific issuer and out-closeness refers to access a country has to other countries' assets.
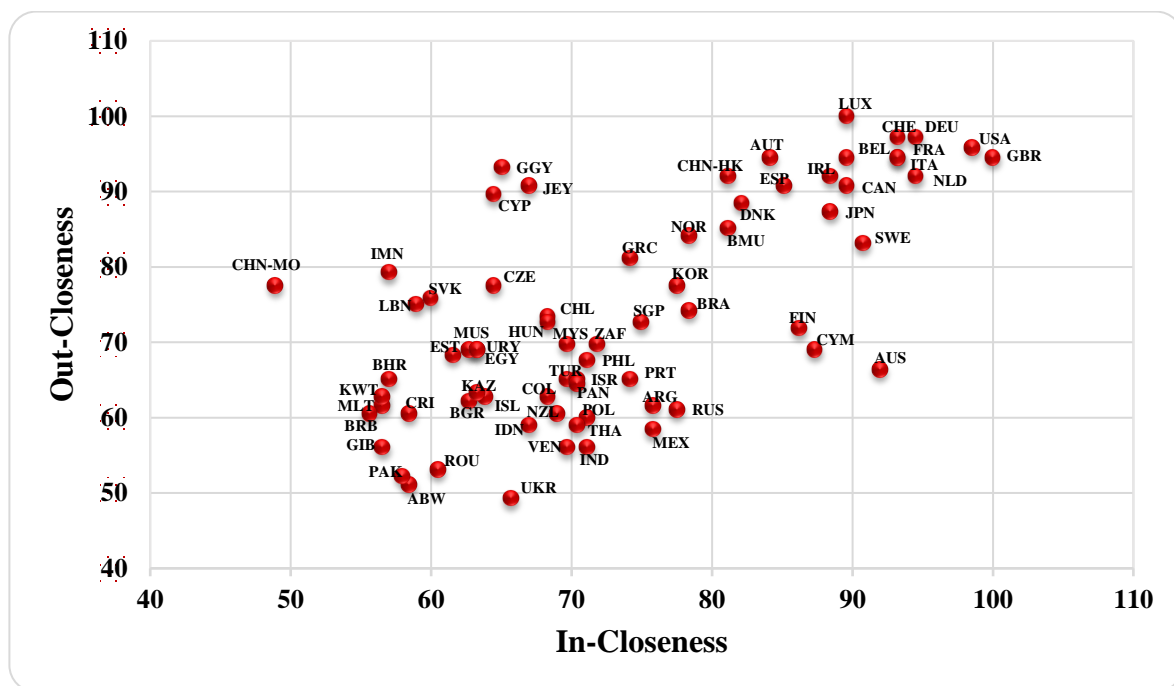
Graph 7: Closeness Centrality Distribution 2004

Source: Author's compilation (2017)

Regarding in-closeness or 'ties to', ranking of top countries for the considered period is quite stable, with GBR and the USA ranked on the top as most closely related nodes with all other countries in the network. Netherlands and Germany are as well positioned 3rd and 4th from 2004 till 2012, nonetheless by 2015 both these countries experience a decrease in them in-closeness centrality. In 2015 a rapid improvement in the position of Cayman Islands and Luxembourg can be noticed, ranked respectively 3rd and 4th. As per regarding to out-closeness, Luxembourg can easily access almost all other countries' assets, ranked in the top for the whole period. In addition, more countries enter a threshold of 10 % (countries with an out-closeness more than 90%) meanwhile Ukraine remains ranked 1st in terms of largest geodesic distance (farness). In the aftermath of crisis, Japan and Ireland

emerged as perfectly centralized countries in terms of out-centrality indicator (2012) and remained in top 10 in terms of out-closeness by 2015.

The same as for node centrality, closeness centrality tend to increase for the whole network and again a correlation tendency between in and out closeness is noticed. Countries with a relatively low in-closeness centrality ted as well to have a low out-closeness centrality (for instance Aruba, Ukraine, Pakistan, Romania, etc.) and vice versa (USA, GBR, Luxembourg, Germany, etc.).
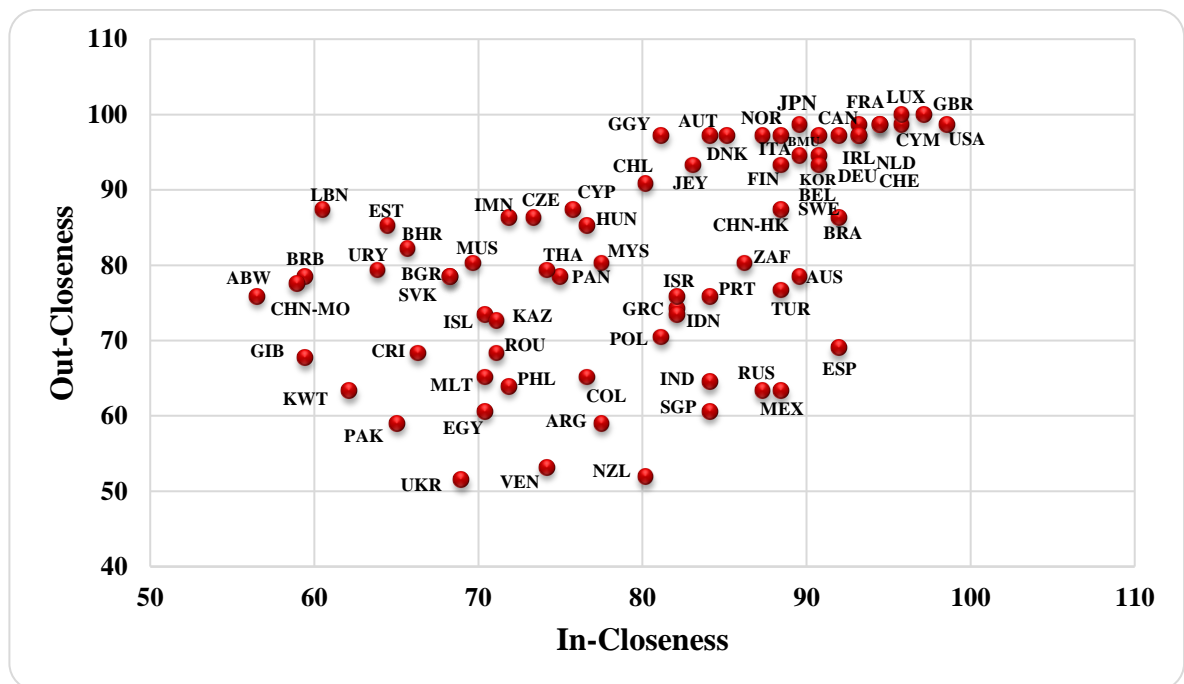
Graph 8: Closeness Centrality Distribution 2015

Source: Author's compilation (2017)

As logically expected, increase of financial ties among countries (measured by network density) will results in less distance, therefore closeness centrality for countries intensifying their links with the rest of the network will increase as well.

Considering descriptive statistics output, both average in and out closeness are relatively high for the whole period and this measure increases with about 3 decimals for three first periods and by 2015 increase is by 1 decimals for both in and out average closeness centralities. Variance in countries' closeness is relatively low, and it decreases by time.

Nonetheless, variance is slightly higher for out-closeness centrality and this can be interpreted as less homogeneity in terms of countries' access to other countries' assets.

3.2.3.3. Betweenness Centrality

As earlier mentioned, betweenness centrality refers to the ratio of shortest paths intermediated by a node i. In principle, there is a positive correlation between betweenness value and node's centrality, and a negative correlation between network density and betweenness centrality. Intuitively, a node connected with many other will be intermediator for many of its connections. Most of social network tools consider weighted ties as physical distance between nodes, therefore compute betweenness centrality as a physical distance indicator. Nonetheless in financial network weight is the value in dollar of bilateral financial ties among countries. Consequently, it makes sense to compute betweenness centrality only for binary networks. In addition, this centrality measure treats the same directed and undirected networks, and does not automatically symmetries data.

Table 6 presents a summary of betweenness centrality output based on Freeman's approach. As it can be seen in table 6, leading countries as intermediator, movers-and-shakers or broker in the network are GBR for the whole period followed by the USA (with 2012 as an exception where Netherlands ranks 2nd and the USA 3rd). As it can be seen, betweenness for each node decreases by time, as network density increases, reinforcing the logic that betweenness centrality and network density are negatively correlated. Another point to emphasize is the importance of the GBR in 2008 as intermediator, meanwhile other countries' importance in the network falls. USA, even though for the whole period is ranked 2nd or 3rd, from 2008 till 2015 has experienced a significant decline in its betweenness centrality, with a slight recovery in 2015.

Table 5: Betweenness Centrality 2004-2015

	Betweenness Centrality 2004-2015			
	2004	**2008**	**2012**	**2015**
Top 10	GBR	GBR	GBR	GBR
	USA	USA	NLD	USA
	LUX	NLD	USA	CYM
	DEU	DEU	JPN	NLD
	CHE	FRA	FRA	CHE
	NLD	CHE	LUX	LUX
	FRA	LUX	CHE	IRL
	ITA	IRL	DEU	ITA
	CHN-HK	BEL	IRL	FRA
	BEL	CHN-HK	KOR	DEU

Source: Author's compilations (2017)

Considering descriptive statistic measures, there is a very large variation among countries betweenness in 2004, having a minimum of 0 and maximum of 182,272. Variation is as well high, where for a mean equal to 27.971, standard deviation is 38.715. By 2015, countries' betweenness considerably decreases as network's density increases. In addition, compared to 2004, the gap between minimum and maximum betweenness is much lower, with a minimum value of 0.082 and maximum equal to 81.932. Smaller variation can be noticed even by comparing betweenness mean (19.271) and standard deviation (19.865).

3.2.3.4. Hub & Authorities (HITS Algorithm) Centrality

Hubs & Authorities centrality is a more complex version of eigenvector centrality, applicable in weighted asymmetric networks. In the context of international financial network, hub values refer to countries that point to countries with high authority (point by holding assets from these countries), and authority values will be large for countries assets of which are owned by large hub countries. Table 7 shows a summarized result of Hubs & Authorities centrality measure.

Table 6: Hubs and Authorities 2004-2015

	Hubs & Authorities Centrality							
	Hubs				Authority			
	2004	2008	2012	2015	2004	2008	2012	2015
Top 10	USA	JPN	USA	USA	USA	USA	USA	USA
	JPN	USA	JPN	JPN	GBR	GBR	GBR	GBR
	GBR	GBR	GBR	LUX	DEU	DEU	CYM	CYM
	FRA	IRL	LUX	GBR	FRA	FRA	FRA	FRA
	LUX	LUX	IRL	CYM	NLD	CYM	DEU	JPN
	IRL	FRA	DEU	IRL	CYM	NLD	CAN	DEU
	NLD	DEU	FRA	CAN	ITA	ITA	NLD	NLD
	DEU	NLD	NLD	DEU	JPN	JPN	JPN	IRL
	ITA	ITA	CAN	FRA	CAN	LUX	LUX	CAN
	CHE	CAN	CHE	NLD	LUX	ESP	AUS	LUX

As it can be seen from Table 7, top hubs for the whole period are USA and Japan, where Japan ranks 1ˢᵗ only in 2008. GBR, Luxembourg and Ireland as well are among top hubs in the network, and this means that all these countries manage well to point countries with high authority. On the other side, top authorities in the network for the whole period are USA and GBR, followed by Germany, ranked 3ʳᵈ for the first two years, and after in 5ᵗʰ (2012) and 6ᵗʰ positions (2015). France manages to maintain a stable position ranked as 3ʳᵈ most authoritative country in the network. Lastly, impressive is the progress of small financial offshore Cayman Islands in the aftermath of European financial crises, being ranked 3ʳᵈ most authoritative country in 2015 (following US and GBR) and ranks 5ᵗʰ in hub centrality (followed by countries such as Ireland, Canada, Germany, France, Netherlands and Switzerland).
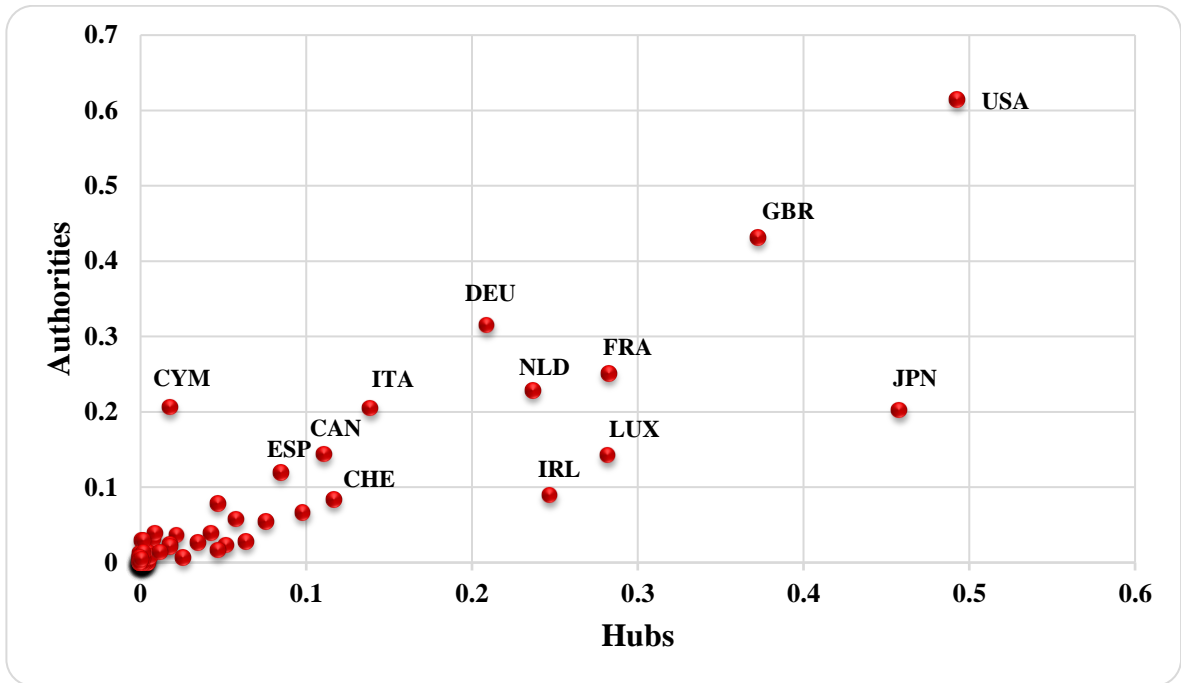
Graph 9: Hubs & Authorities Distribution 2004

Source: Author's compilation (2017)

Graphical representation of hubs & authorities shows a result quite similar to the one obtained from node strength distribution.   As already discussed, USA holds an absolute position both as hub and authority. As it can be noticed graphically, there is considerable gap in both these measures. In addition, from 2004 till 2015, gap in hub and authority is deepened, and this increased gap is more obvious in case of authority measure.
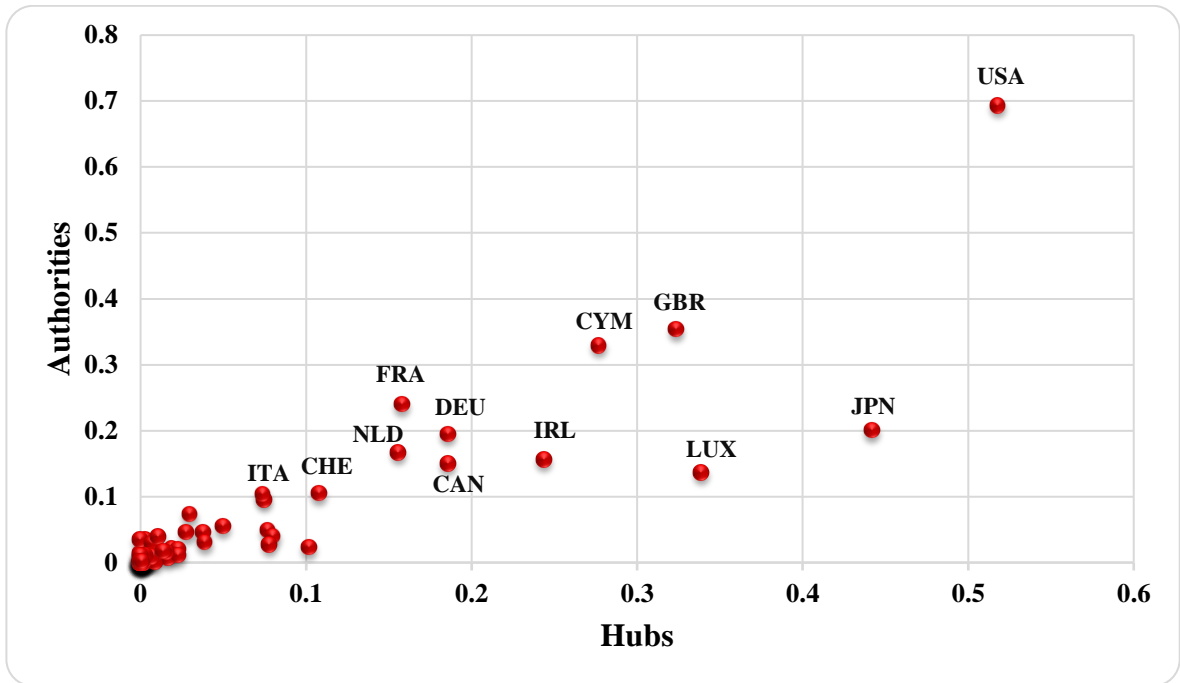
Graph 10: Hubs & Authorities Distribution 2015

Source: Author's compilation (2017)

3.2.3.5. Network Centralization

Centralization provides information on centrality values distribution for each measure introduced above. There is a positive correlation between network centralization and heterogeneity on centrality values distribution. Centralization values are compared with a star network, which represents the most heterogeneous possible, with one node having the highest possible number of links and other nodes connected only with the central node (centralization equal to 1 or 100%).

As it can be seen from the graph, variation in the centrality scores decreases as network density increases. It is logic that as more countries will form direct ties with other countries in the network, existing centrality will tend to be more homogeneously distributed. As it is illustrated in the graph, the lowest centralization is obtained for betweenness centrality, and the highest for closeness centrality, more specifically out-closeness centrality. Regarding betweenness centrality distribution, it makes sense to have low centralization of this

measure, since we already know that level of network' density or direct link is high (from 59.6% in 2004 to 72.1% in 2015).
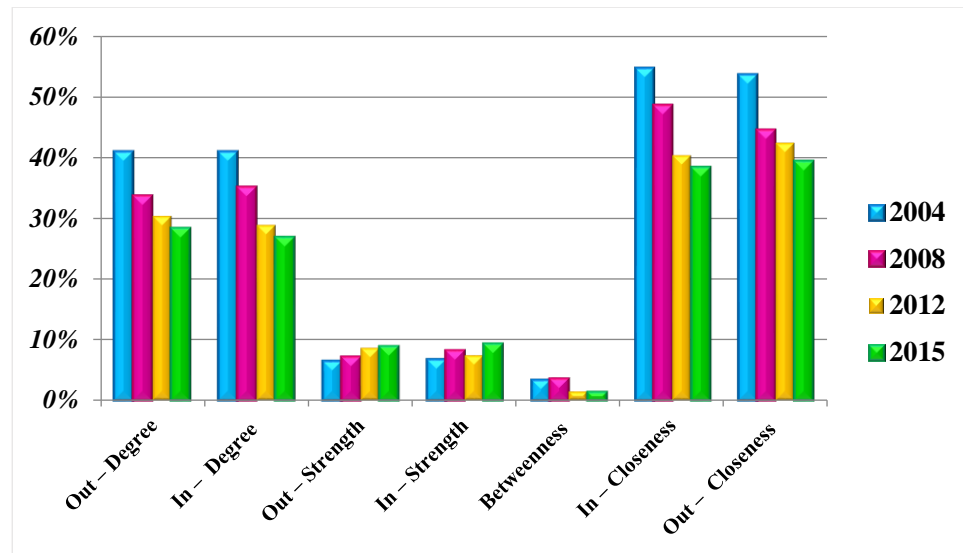
Graph 11: Overall Network Centralization

Source: Author's compilations (2017)

3.2.4. Network Homophily and Preferential Attachment

This part of analysis considers countries' attributes to explores the impact of these characteristics to network's patterns. Theoretically, if nodes that share similar attributes tend to connect to each-other, then we can conclude than the network of international finance is assortative and there is preferential attachment pattern on this network. This is known as well as homophily, "love of the same" or "birds of a feather flock together".

There are dozens of network attributes that can be used to test homophily of the international financial network. Within the scope of this thesis, geographical location and income are considered as network attributes to test for network homophily. Output retrieved from density by groups is used as direct measure of network's assortative mixing. In case there is proved that within the network there exists preferential attachment, we would say that the network is "balkanized" rather than "globalized" (Kali and Reyes, 2007). While it may sound interesting to have assortativity in a network, the chances to have strong blocks within the network and in the same time have isolated nodes which benefit little from being part of it, is high.

✥ *Location Assortativity / Homophily*

First considered assortativity mixing attribute is location and countries are separated in seven different regions based in their geographical location: North and Central America (6), South America (6), Europe (34), Asia (12), The Caribbean (4), Oceania (2) and Middle East and Africa (6). Table 8 presents density within regions themselves and among regions for 2004 and 2015. UciNet presents the output of density by groups as a squared matrix where both rows and columns define direction of flows.

Comparing regions in terms of network density may offer biased conclusions in case of regions represented by a low number of countries (such as Oceania, where region density can be 1, 0.5 or 0). In addition, we already know that both Australia and New Zealand have reported a considerable number of bilateral relationships as confidential, therefore these ties are considered as null within the scope of this thesis. Regarding other groups, most connected region is North and Central America and South America in 2004, but by 2015 a decline in financial connectedness among South American countries is experienced meanwhile density of financial ties in North and Central America increased. By 2015, after North and Central America (0.967), most connected regions are Europe (0.886) and Asia (0.826). The Caribbean has successfully managed to increase its regional financial integration (from 0.25 to 0.667). On the other side, groups that experienced decrease in regional density are Oceania (decrease that may be biased due to Australia and New Zealand's confidential reporting) and South America.

Regarding financial ties among groups, it seems that assets issued in North and Central America countries are more attractive for the rest of the world. Holdings of other regions to North & Central America increase for three regions (Europe, Asia and The Caribbean) and fall for both Oceania and Middle East & Africa countries. As per regarding to density of ties from South America to North & Central America, it remained unchanged but high for the whole period.

Table 7: Density by groups – Location Attribute

	N & C America	South America	Europe	Asia	The Caribbean	Oceania	ME & Africa
2004							
N & C America	0.900	0.917	0.632	0.486	0.625	0.833	0.361
South America	0.833	0.900	0.475	0.306	0.250	0.667	0.194
Europe	0.716	0.642	0.776	0.596	0.485	0.765	0.500
Asia	0.625	0.375	0.502	0.682	0.500	0.708	0.319
The Caribbean	0.542	0.458	0.397	0.375	0.250	0.500	0.125
Oceania	0.500	0.167	0.544	0.417	0	1	0.083
ME & Africa	0.639	0.250	0.559	0.500	0.375	0.667	0.533
2015							
N & C America	0.967	0.889	0.745	0.736	0.708	0.833	0.639
South America	0.833	0.767	0.569	0.458	0.375	0.750	0.333
Europe	0.828	0.750	0.886	0.703	0.537	0.853	0.618
Asia	0.792	0.542	0.605	0.826	0.479	0.833	0.569
The Caribbean	0.917	0.708	0.809	0.833	0.667	0.875	0.542
Oceania	0.333	0.417	0.441	0.417	0.250	0.500	0.250
ME & Africa	0.583	0.500	0.696	0.653	0.458	0.667	0.600

Source: Author's compilations (2017)

By 2004, assets issued by countries in South America seem to be especially attractive to countries located in North & Central America. Density drops by 2015 and seems like North & Central American countries have moved their focus to other regions such as Asia or Middle East & Africa. European countries as well hold assets issued by South American countries and number of European countries interest in these assets increased during the considered period (from 0.642 to 0.75). It seems like other regions are less interested in assets issued in South America by 2004, but it looks like countries in both The Caribbean and Middle East & Africa get more interest by 2015.

European assets seem to be less attractive than those issued by North America for South America, Asia and the Caribbean. Nonetheless, assets issued by European countries are still more competitive that the ones issued in most of regions. Attractiveness of assets issued by Asian countries seems to be rapidly increasing since 2004. Number of countries in North & Central America, Europe and The Caribbean holding assets issued in Asia significantly increases since 2004. In addition, regional integration as well has considerably increased during the considered period.

Largest increased in terms of regional integration is experienced by countries in The Caribbean region. Assets issued in these countries seem as well to attract residents in North & Central American countries, and slightly less European investors. Highly integrated with the rest of the world seem to be Oceanian countries included in the sample (Australia and New Zealand). By 2004, less attractive assets were those issued by residents in Middle East & Africa. Nonetheless, even though it remains 'less attractive region', it still has perfectly managed to attract residents from North & Central America and Asia.

↳ *Income Assortativity / Homophily*

Another attribute used to test for network's homophily is income or development stage of country. Referring to World Bank's classification, sample countries are classified in three main categories: developed economies (43), emerging economies (8) and the rest (19). Density by groups is presented in table 9.

Table 8: Density by groups – Income Attribute

	Developed Economies	Emerging Economies	The Rest
2004			
Developed Economies	0.746	0.642	0.563
Emerging Economies	0.526	0.500	0.395
The Rest	0.503	0.447	0.304
Developed Economies	0.832	0.823	0.727
Emerging Economies	0.663	0.714	0.520
The Rest	0.613	0.724	0.418

Source: Author's compilations (2017)

As it can be seen from the table, highest level of integration is achieved among developed countries and less among emerging economies or the rest of the world. Assets holdings of developed economies issued in emerging countries or the rest of the world significantly increase by 2015. Holdings of both emerging economies and the rest of the world to assets issued by developed countries is moderately high (increasing by 2015). Holdings of emerging markets to assets issued by countries classified as 'the rest' and vice versa are relatively small by 2004 (0.0.395 and 0.447 respectively). Nonetheless, holdings of countries classified as 'the rest' to assets issued by emerging markets significantly increased (from 0.447 to 0.724).

Overall, in line with existing literature, international financial network displays patterns of a core-periphery structure. Most of regions are mainly attracted by assets issued by developed economies and which are mainly located in Northern Hemisphere. Nonetheless, in the aftermath of financial crisis it looks like emerging economies has gained currency and more and more countries are interested to diversify their portfolios with assets issued by residents in this region. As per regarding to geographical implications to financial integration, both location and income seem to be important indicators in decisions to enter bilateral financial relationships. Stated differently, there is a tendency for preferential attachment among countries sharing similar attributes (IMF, 2011).

3.2.5. Network Visualisation

By using Gephi Software, financial networks for 2004 and 2015 are visualized as shown respectively in graph 12 and 13. Colours define income category for each country and edge thickness shows level of foreign asset holdings. With pink colour are shown developed economies, with green emerging economies and with blue the rest of the countries. Node's size depends on the total foreign assets portfolio of each country. Regarding edge thickness, thicker edges mean higher foreign asset holdings and as network attribute are used out-strength data for 2004 and 2015.
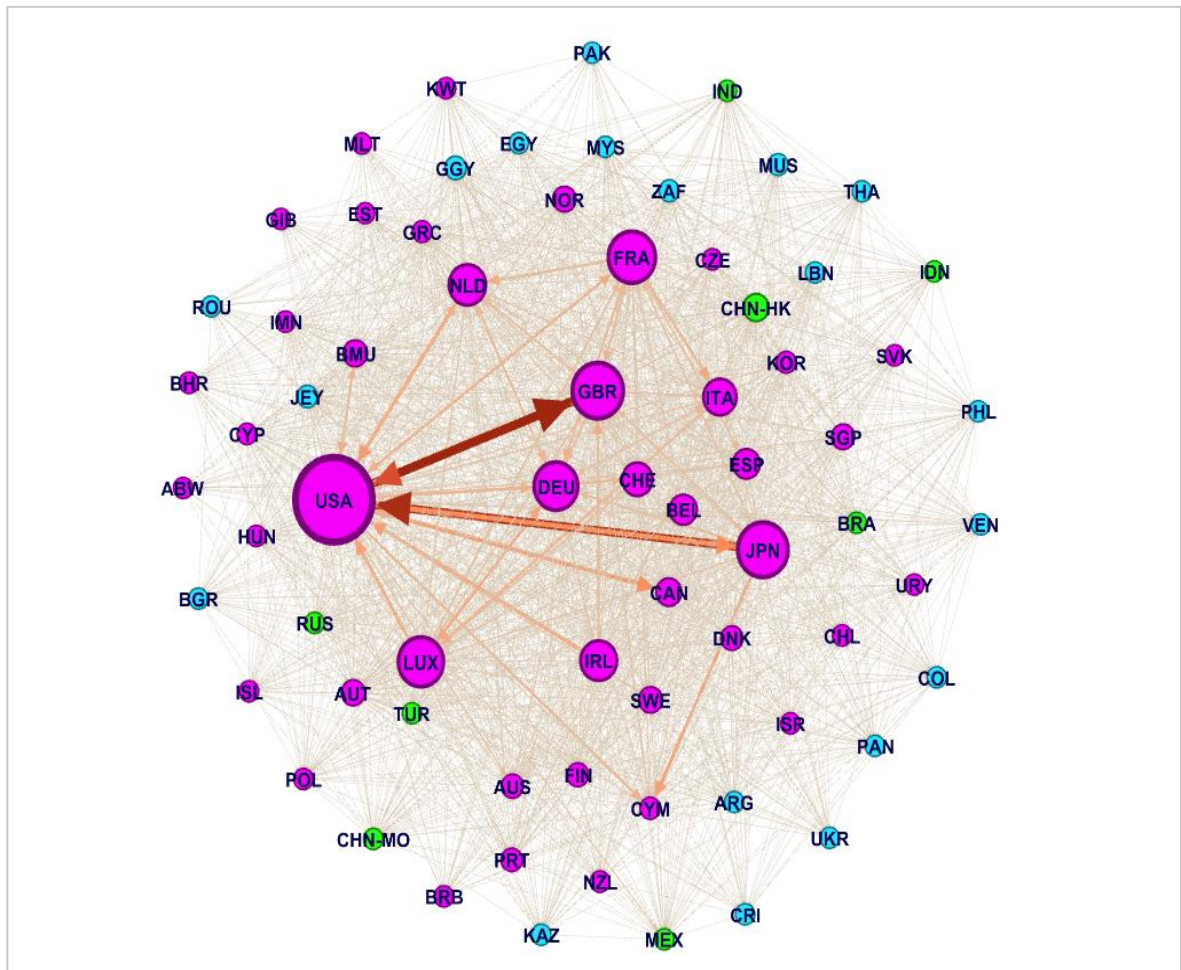
Graph 12: International Financial Network 2004

Source: Author's compilations (2017)

As it can be seen from graph 12, by 2004 network is fully dominated by developed countries, with the USA holding largest foreign assets portfolio. In terms of bilateral financial relations, USA holds at most assets issued in the GBR, meanwhile in country level for Japan highest issuer is USA. USA as well seems to have a relatively high portfolio of assets issued in Japan. GBR's holdings in USA are as well at considerably high levels. Other pair of countries maintaining relatively intensive financial ties are Luxembourg => USA, Netherlands => USA, France => USA, Bermuda => USA, Germany => USA, Germany => Luxembourg, France => Italy, etc. Noticeable is the position of emerging

economies in the network. As it can be seen, all of them maintain relatively small portfolio of foreign assets (determined by node's size).
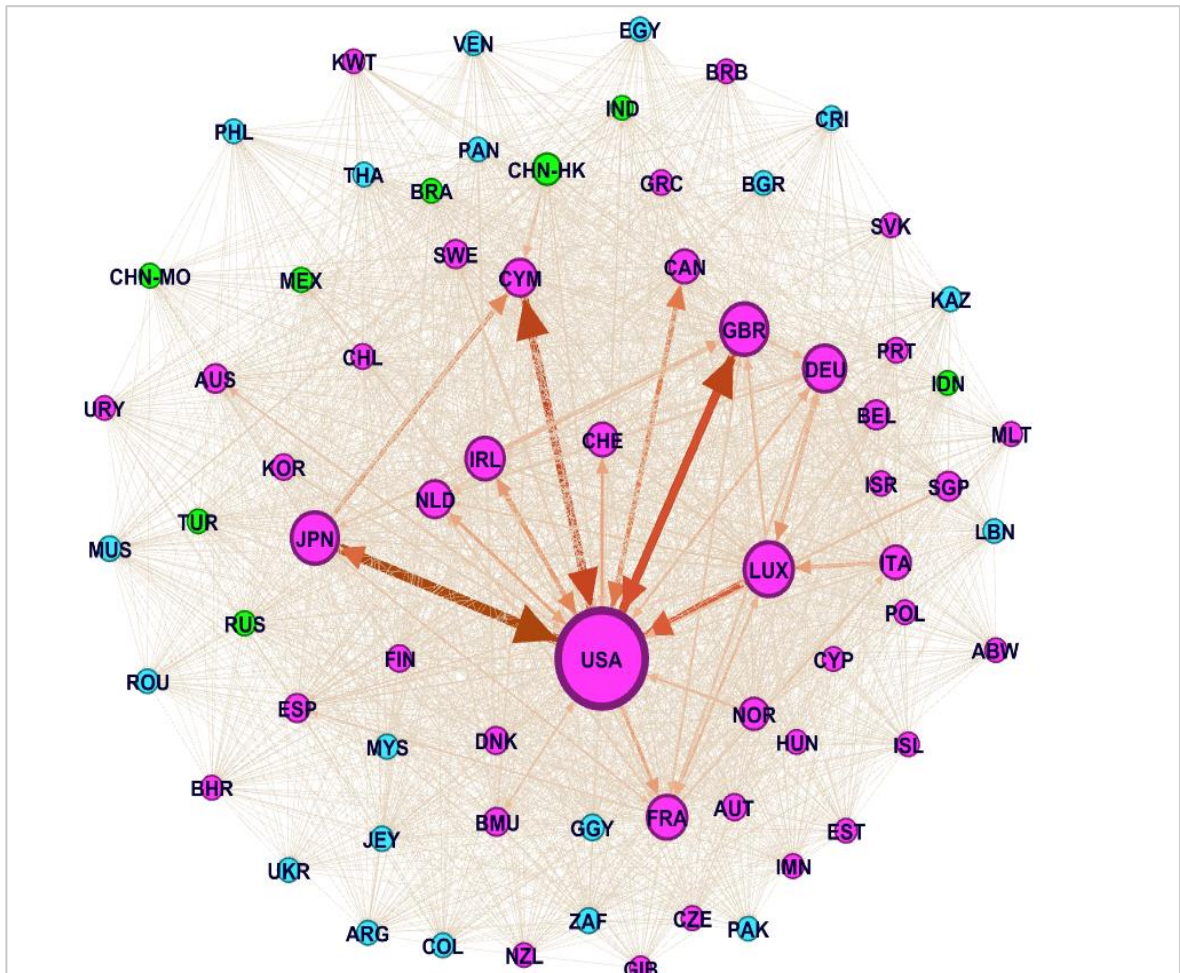
Graph 13: International Financial Network 2015

Source: Author's compilations (2017)

Graph 13, visualizing network for 2015 data, offers quite a similar picture as 2004, with the US maintaining a unique position in the network and the rest of countries establishing intensive relations with it. Different from 2004's network where only two countries (GBR and Japan) had intensive relations with the USA, in 2015 it seems like more and more countries are attracted by USA's assets and this country as well has obviously diversified its portfolio. As empirically discussed, position of small financial offshore Cayman Islands rapidly improved, especially in the aftermath of recent financial crises. As it can be noticed

graphically, this small offshore has strong financial ties with the USA, both as issuer and assets holder. Japan and China – Hong Kong as well appear to have relatively strong ties with Cayman Islands. In addition, compared to 2004, it looks like countries such as Ireland, Canada and Luxembourg have intensified their financial ties with the USA. Again, the network is fully dominated by developed economies and emerging countries, beside their improved position in international trade network, recorded insignificant change in their role and importance in the international financial network.

3.3. Discussion

3.3.1. Sub-Networks of Foreign Assets Holdings Financial Web

This thesis explores international financial integration, where as the main measures is level of foreign assets ownership. CPIS offers in separate data for equity portfolio and debt portfolio holdings. In addition, IMF further decomposes debt data in two categories, long and short-term debt holdings. The full analysis is performed for each category of assets and findings are available upon request. In principal, in many indicators there are no significant differences among assets classes in terms of countries' centrality measures. In most of the measures, leading country is the USA, followed by GBR, Luxembourg, Germany, Switzerland, France and Japan. Findings of this thesis are in line with Schiavo, Reyes & Fagiolo (2010: 398)'s conclusion, that 'no significant differences emerge in the structural properties of the networks made up by various types of assets. Still, provided that within the scope of this thesis financial network is considered as directed, obtained results capture in more details typology and evolutions of assets based financial networks compared to Schiavo, Reyes and Fagiolo (2010)'s analysis. Table 10 summarizes key differences among assets classes, compared to general result obtained from total assets holdings network analysis.

Table 9: Financial integration by assets category

Measure \ Assets	Total Equity	Total Debt	Long Term Debt	Short Term Debt
In-Degree	-‖-	-‖-	-‖-	-‖-
Out-degree	-‖-	-‖-	-‖-	≠
In-Strength	-‖-	-‖-	-‖-	-‖-
Out-Strength	-‖-	≠	≠	≠
Betweenness	-‖-	-‖-	-‖-	-‖-
In-Closeness	-‖-	-‖-	-‖-	-‖-
Out-Closeness	-‖-	-‖-	-‖-	-‖-
Hub	-‖-	≠	≠	≠
Authority	≠	-‖-	-‖-	-‖-

Source: Author's compilations (2017)

There is no substantial difference based on in-degree, in-strength, betweenness and closeness centrality measures meanwhile there are noticed difference out-degree, out-strength, hub and authorities' centrality. Different from other assets' categories where most diversified portfolios are held by countries such as USA, GBR, Luxembourg, Germany, Switzerland, etc., for short term debt network China foreign assets holdings result to be among most diversified ones for the whole considered period. In addition, small financial centers such as Guernsey, Isle of Man, Cayman Islands and Bermuda significantly increase their position in the short-term debt network in the aftermath of global and European financial crisis.

Considering degree centrality of weighted networks, again there are no substantial differences as per regarding to most prestigious issuers. On the other side, most influential countries (defined in terms of out-strength centrality) per assets based network differ in case of total debt and its two sub-categories. As earlier presented, for total assets network (the same for equity portfolio network), most influencing countries for the whole period are USA, GBR, Japan and France, with an absolute dominance of the USA for the whole period. In case of total debt network, Japan appears to be a highly influencing country, holding 1st (2004 & 2012) and 2nd (2008 & 2015) positions for the whole period. While most influencing countries in total debt network and long-term debt network are mainly USA, Japan and most industrialized European countries, in short term debt network, China

and Singapore seem to be well positioned in the aftermath of last financial crisis. In addition, leading country for the whole period is Ireland (with an exception in 2008 where Ireland is ranked 2nd and it is slightly overcomed by Luxembourg positioned as 1st in the network). Interesting is as well decrease in influence of some small but important financial offshores in the aftermath of last financial crisis (Bermuda, Jersey, Guernsey). The only tax haven to significantly increase its influence in the short-term debt network in the aftermath of European crisis is Cayman Islands, ranked in 5th position by 2015.

Hubs & authority's centrality offers different results for both equity portfolio and total debt networks. As per regarding to hub centrality (countries that point to countries with high authority (point by holding assets from these countries)), differences are noticed for total debt and its sub-categories networks. For both total debt and long-term debt most, central country pointing most authoritative countries is Japan ranked 1st for the whole period, having a hub value almost twice of hub index for the next in ranking country (GBR or Cayman Islands). In addition, interesting is the significant increase in hub centrality ranking of Cayman Islands. Short term debt network has as leading hub Ireland, followed by Luxembourg and USA. Again, hub centrality emphasizes increased importance of Cayman Islands as an important hub in the aftermath of European financial crisis. On the other side, authority centrality offers mixed results for different categories of assets. USA appears to be leading authority for almost the whole period followed by countries such as GBR, Japan, Germany and France. Equity portfolio network more than in composition of top-authority countries, it differs in the way these countries are ranked. Till 2012, most authoritative country in total equity portfolio is GBR followed by Japan, France and Cayman Islands. Surprisingly, by 2015 Cayman Islands rank as the most authoritative country followed by GBR, Japan and the USA.

In general, what can be noticed from this analysis is the dominance of small group of countries excessing intensive power and influence in the international financial network. Why global finances are in most of the cases leaded by countries such as USA, GBR, Germany, France, or Japan? Why are relatively small countries such as Luxembourg, Netherlands and Switzerland so important in the international financial networks? Why did small tax havens such as Cayman Islands, Isle of Man, Barbados or Bermuda became more

important in international finances in the aftermath of global and European financial crises? Why Asiatic region is becoming an important factor in international financial network? Many more questions may arise while studying patterns and evolution of international financial network.

3.3.2. Core-Periphery Structure of International Financial Network

In line with most prominent existing literature, this study finds that international financial integration has been on the rise since 2004, and this trendy was slightly affected by the recent global and European financial crises (Thakor, 2015; Caballero, 2015; Arribas, Pérez and Tortosa-Ausina, 2011; Minoiu and Reyes, 2010; IMF, 2011). Still, obtained results may sound surprisingly for several reasons. *First*, in 2007 world entered the most severe crisis since Great Depression, with an estimated cost more than $ 10 trillion. It emerged from US mortgage markets and quickly spread to national and international financial markets. Did this affect position of countries in international financial web? Very few changes were noticed in the aftermath of crisis. US, which was at the heart of meltdown, retained its position as most influential and prestigious country in the international financial web. *Second*, while world economy entered a sharp recession, emerging economies recoded positive growth rates. Still, little changed for these countries in terms of power they excess to international financial web. *Lastly*, international financial network has become denser over time with an increasing number of countries establishing bilateral financial relationships. Arguments behind core - periphery structure of global financial web lay on theory of financial integration determinants.

Theoretically there are several determinants indicating level of financial integration: degree of financial integration, political circumstances, geography and history, economic factors (GDP, income, etc.), financial development, market size, common currency and language, capital controls, institutional quality and governance, technological development, etc. (Almekinders et al., 2015, Kose et al., 2010, IMF, 2011, Lane and Milesi-Ferretti, 2017). In addition, Thakor (2015) argues that a country's level of international financial integration is determined by number and type of international financial institutions

operating in the country, central banks' regulatory measures to these institutions, etc. All core countries display superiority in most of these variables.

As earlier mentioned, core is composed of a small group of countries (US, GBR, Netherlands, Germany, France, Luxembourg, Switzerland, Japan). While US (New York), GBR (London) and Japan (Tokyo) are well recognized financial hubs, hosting a large number of foreign banks and other financial institutions, countries such as Germany, Netherlands and Switzerland are home for many banks and financial institutions responsible for huge amounts of transactions performed globally (Giudici and Spelta, 2013). Luxembourg is one of the largest financial centres in the world (in the same time, one of the most attractive financial offshore). It is as well host country for more than 100 foreign banks' branches and subsidiaries. In addition, most popular financial offshore is Netherlands, hosting subsidiaries of more than 250 world largest companies, followed by Bermuda and Cayman Islands (Phillips et al., 2017).

Already indicated in the results section, an increased role of financial offshores was noticed in the aftermath of global and European financial crises. Specifically, Cayman Islands managed to improve its position as issuer. At the same time, this small financial offshore hugely improved its position as assets holder or influencer in the network. From 33rd position ranked in 2012 it managed to move to 9th position by 2015. If we consider data for holders of assets issued in Cayman Islands, largest amount of assets is owned by US, followed by Japan, China, Luxembourg, GBR and Switzerland. In addition, Cayman Islands is a sophisticated tax haven jurisdiction, hosting about 40 out of 50 largest banks in the world. In total it hosts more than 220 banks, from which more than 2/3 are branches of large European, North American or Latin American banks. Other characteristics of this small financial offshore are: low barriers to entry for foreign banks, English based legal system, low country risk (politically and economically), good reputation, general tax neutrality system, strong banking tradition, etc. Cayman Island together with other small financial offshores are important financial intermediaries, but still their net position in the international prospect is insignificant (Lane & Milesi-Ferretti, 2017). As regard increased role of Asian countries in international finances, regional and global financial crises urged these countries to strengthen their macroeconomic policies and their position in

international financial markets. Positive trend of regional and international integration of Asian countries is expected to pursue in the future and continuous efforts are made in this direction (Almekinders et al., 2015).

Overall, global finances are governed by some of most industrialized economies, explained by their high levels of trade integration, favourable economic and political environment, strong tradition in providing financial services, highly sophisticated financial sector, few restrictions on capital mobility, technologically advanced and innovation oriented countries, etc. On the other side, both emerging and developing countries taken together count for a small share of foreign assets holdings (Lane and Milesi-Ferretti, 2017). By 2015, among emerging economies most influential country in international financial network is China, followed by Korea, Mexico and Brazil. Still, as financial network becomes denser, these countries as well display an increased role in the network as both issuer and holder. Nonetheless, mainly due to reasons already explained, it seems like there is a long way to go until they manage to join the core of most influential or prestigious countries in international finance.

Lastly, dominance of advanced economies and some of the most prominent financial offshores was reflected among all assets categories, similar to IMF (2011)' results. In addition, level of financial integration varies based on assets type (similar with Giorgio Fagiolo's finding) and the lowest was obtained for short-term debt. This is a logic results, since most of economies tend to finance their short-term needs for funding with domestic funds meanwhile for longer periods of investments, international financial markets may offer more attractive options.

CONCLUSIONS AND FUTURE RESEARCH

General Conclusions

There is a treasury of literature exploring international financial integration phenomenon from different perspectives. Since long ago, conventional wisdom has considerably relied in econometric models dealing mainly with numbers calculated under specific model assumptions. Used data sources and models vary a lot, consequently obtained results often contradict each-other and in most of cases these studies end up being inconclusive. It was not until the last international financial crisis that graph and network models gained currency as powerful tools to address several issues on international capital flows, unable to be captured by traditional models. Considering recent developments in this research area, this thesis was inspired by the existing gap in literature and possibility to contribute to a rapidly expanding research area.

There is no standard definition of financial integration, as well as there is no well-established glossary of used terminology. In addition, existing literature on both measures and possible implications of this process is inconclusive. Still there are some widely discussed measures and implications of financial globalization. Two main categories of measures used are de jure and de facto indicators. A third category may arise as a combination of first two measures. Most popular de jure measure is AREAER published by IMF. Regarding de facto measures, there are three main categories of these measures: price based measures, quantity based measures and hybrid measures. Network model falls under second category, quantity based measure.

Regarding presumed implications of financial integration, literatures widely discusses as potential benefits: encourage diversification, international risk sharing and consumption smoothing, more efficient capital re-allocation, spur economic growth, domestic investment and income convergence, encourage domestic financial sector development, impose greater discipline on governments and financial institutions, better macroeconomic policies, commitment to better economic policy, improved employability, product innovation, transfer of technological and managerial know-how, promotion of specialization, etc.

Opponents of integration argue that increased levels of cross-border capital mobility will trigger financial instability, greater exposure to crises and contagion effect.

This thesis has employed a complex network analysis to investigate typology and evolution of international financial network. Key variable used is total foreign assets portfolio, and separate analyses are performed for both equity portfolio and debt (long and short-term holdings). Main data source is CPIS database published by IMF. Analysis covers a sample composed of 70 countries and lies in a period from 2004 to 2015. Both country sample and time period are restricted due to data availability. Nonetheless, selected country sample covers most important economies, including emerging and small financial offshores. In addition, selected time period includes both global and European financial crises, considered as most important developments in international financial markets since Great Depression. Key network parameters discussed are: network density, clustering coefficient, degree centrality, betweenness centrality, closeness centrality, hubs & authorities centrality, and assortative mixing.

The contribution of this thesis is threefold. First, up to our knowledge, this is the first time CPIS data are employed in a directed weighted network analysis. Second, we were able to access only two previous works analysing separately each assets category, Schiavo, Reyes and Fagiolo (2010) and IMF (2011), nonetheless both of these works heavily rely in statistical measures, meanwhile this thesis is mainly based in network metrices. Decision to rely more in network measures rather than traditional statistical tools (such as ANOVA, t-test, etc.) is supported by Suerdem and Bicquelet (2014)'s argument of a non-random nature of social networks. Last, this thesis contributes to a rapidly expanding research area and covers relatively a long-time period based completely on CPIS data.

Summary of Results

In line with previous works, obtained results show an absolute dominance of a small group of countries, classified as core and the rest of the countries positioned in the periphery layers of the network (core-periphery network structure). Overall network has become denser and an increased role of financial offshore is noticed in the aftermath of recent global and European financial crises. For the whole period, countries classified as core of network are US, GBR, Japan, Germany, France, Netherlands, Luxembourg and

Switzerland. In the aftermath of recent crises small financial offshore, Cayman Islands, emerged as both influencing and prestigious country in the international financial network.

A summary of obtained results for each research question is presented on the following.

1 - How did recent financial crises affect level of international financial integration?

As the most straightforward network measure of integration, network density is calculated annually for total assets and for each of its sub-categories (equity portfolio, total debt, long-term and short-term debt). Overall, there is a general upward trend in all networks, with some noticeable breaks during both global and European financial crises. Drop in total debt integration during crises is slightly higher than the one occurred in equity network integration. Any downward trend noticed after 2012 is partially justified due to increased 'confidential' reporting in CPIS data. Integration in short-term debt network is an exception, being twice as low as integration in long-term debt and decline in density after 2014 can be partially interpreted as a real decrease in the level of integration in this network.

2 - What is the position of each country in the network and has it changed over time?

Position of each country in the network is analysed using four important network parameters: degree centrality, closeness centrality, betweenness centrality and hubs & authorities. As per regarding degree centrality, it is noticed that an increasing number of countries manage to issue assets to an increasing number of investors, with GBR and the USA as most prestigious countries for the whole period. Germany, Netherlands, France and Switzerland follow next as most prestigious countries in the financial network. Interesting is the increased influence of Asian countries such as Japan and Korea, and some key financial offshores (such as Cayman Islands). As regards strength centrality measure, an absolute dominance of USA (1st) followed by GBR (2nd) and France (4th) is noticed. These countries result to be highly prestigious in the network. Unlike first proposition of this thesis, gap in node strength between USA and following countries in ranking (Luxembourg, GBR and Japan) continuously increases in the aftermath of recent financial crises and almost triples by 2015.

Referring to closeness centrality results, GBR and the USA are ranked on the top as most closely related nodes with all other countries in the network, followed by Netherlands and Germany (position held until 2012). By 2015, 3rd and 4th are taken respectively by Cayman Islands and Luxembourg. Considering betweenness centrality output, leading country is GBR for the whole period followed by the USA (excepting 2012 where Netherlands ranks 2nd). Lastly, based on hubs & authorities centrality output USA and Japan (Japan ranks 1st only in 2008) are identified as top hubs for the whole period, followed by GBR, Luxembourg and Ireland. On the other side, top authorities in the network for the whole period are USA and GBR, followed by Germany, ranked 3rd for the first two years, and after in 5th (2012) and 6th positions (2015). France manages to maintain a stable position ranked as 3rd most authoritative country in the network. Lastly, impressive is the progress of small financial offshore Cayman Islands in the aftermath of European financial crises, being ranked 3rd most authoritative country in 2015 and ranks 5th in hub centrality.

3- Is there any preferential attachment in the international financial network?

Inter and intra group network density is considered as a direct measure of network homophily or tendency for preferential attachment in the international financial network. To explore for a possible location based preferential attachment, countries are separated in seven different regions based in their geographical location: North and Central America (6), South America (6), Europe (34), Asia (12), The Caribbean (4), Oceania (2) and Middle East and Africa (6). Most connected regions are North & Central America and South America in 2004, but by 2015 a decline in financial connectedness among South American countries is experienced meanwhile density of financial ties in North & Central America increased. Regarding financial ties among groups, it seems that assets issued in North & Central America countries are more attractive for the rest of the world. Holdings of other regions to North & Central America increase for three regions (Europe, Asia and The Caribbean). Considering income based preferential attachment, countries are classified in three main categories: developed economies (43), emerging economies (8) and the rest (19). Highest level of integration is achieved among developed countries and less among emerging economies or the rest of the world. In addition, assets holdings of developed economies issued in emerging countries or the rest of the world significantly increase by 2015.

4 - Is there any significant difference in the network of different classes of assets?

In principal, in many indicators there are no significant differences among assets classes in terms of countries' centrality measures. In most of the measures, leading country is the USA, followed by GBR, Luxembourg, Germany, Switzerland, France and Japan. There is no substantial difference based on in-degree, in-strength, betweenness and closeness centrality measures meanwhile there are noticed difference out-degree, out-strength, hub and authorities' centrality. Different from other assets' categories where most diversified portfolios are held by countries such as USA, GBR, Luxembourg, Germany, Switzerland, etc., for short term debt network China foreign assets holdings result to be among most diversified ones for the whole considered period. In addition, small financial centers such as Guernsey, Isle of Man, Cayman Islands and Bermuda significantly increase their position in the short-term debt network in the aftermath of global and European financial crisis. Considering node strength centrality, in case of total debt network, Japan appears to be a highly influencing country, holding 1st (2004 & 2012) and 2nd (2008 & 2015) positions for the whole period. While most influencing countries in total debt network and long-term debt network are mainly USA, Japan and most industrialized European countries, in short term debt network, China and Singapore seem to be well positioned in the aftermath of last financial crisis.

Considering hubs & authorities centrality measure, differences are noticed for total debt and its sub-categories networks. For both total debt and long-term debt most, central most authoritative countries are Japan, GBR and Cayman Islands. Meanwhile most important hub in short term debt network is Ireland followed by Luxembourg and USA. As regards authority measure, USA appears to be the most authoritative country followed by GBR, Japan, Germany and France. For total equity portfolio network, until 2012 most authoritative countries are GBR followed by Japan, France and Cayman Islands. By 2015, Cayman Islands rank as the most authoritative country followed by GBR, Japan and the USA.

Research Limitations and Future Work

Main limitation of studies employing network models in financial integration is data availability and reliability. Most common data sources offering bilateral data are CPIS and BIS locational data. Both these databases have some widely recognized limitations. CPIS offers data for a relatively limited number of countries and starting from 2001. On the other side, BIS' data cover a longer period of time but provides full data (in and out flows) for only 30 countries. In addition, availability of data for the USA is another limitation of BIS database. USA started to report for the first time in 1999, therefore any analysis prior this year would miss important information about the most important player in the international financial network.

Another limitation of network applications has to do with lack of standardization. Existing literature continuously borrows from other research areas and there is no well-established theoretical background of financial networks. What is the best way to define network's reciprocity (directed / undirected), …what are key measures that can offer useful information regarding network's patterns, … how should one way un-connected nodes in a directed network be considered, … are traditional statistical and econometric measures applicable in scale-free networks, … and many other questions like these would arise while working with financial networks. For these reasons, applying network analysis to financial relations becomes a challenging task; even so, gaps in the existing literature inspire ambitious scholars to further explore this research area.

There is a lot of space for future research employing graph and network models to analyse typology and evolutions of financial networks. *First*, introduction of new network parameters or increased country sample would increase the quality of research and enable a more complex consideration of financial networks. *Second*, CPIS provides separated data based on location, assets' category and sector. Future research may consider focusing only in specific sectors or geographical locations. *Third*, considering limitations of CPIS data (and other similar databases on bilateral financial relations), combining data from several resources may offer a deeper understanding of patterns of international financial web. *Last*, using more attributes to test network homophily, may provide useful information on what really triggers cross-border capital mobility.

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APPENDICES

Appendix 1: Country sample

	Country		L	I		Country		L	I
	Country		**L**	**I**		**Country**		**L**	**I**
1	ARG	Argentina	2	3	36	ITA	Italy	3	1
2	ABW	Aruba	5	1	37	JPN	Japan	4	1
3	AUS	Australia	6	1	38	JEY	Jersey	3	3
4	AUT	Austria	3	1	39	KAZ	Kazakhstan	4	3
5	BHR	Bahrain	7	1	40	KOR	Korea	4	1
6	BRB	Barbados	5	1	41	KWT	Kuwait	7	1
7	BEL	Belgium	3	1	42	LBN	Lebanon	7	3
8	BMU	Bermuda	1	1	43	LUX	Luxembourg	3	1
9	BRA	Brazil	2	2	44	MYS	Malaysia	4	3
10	BGR	Bulgaria	3	3	45	MLT	Malta	3	1
11	CAN	Canada	1	1	46	MUS	Mauritius	5	3
12	CYM	Cayman Islands	5	1	47	MEX	Mexico	1	2
13	CHL	Chile	2	1	48	NLD	Netherlands	3	1
14	CHN-HK	China, P.R.: Hong Kong	4	2	49	NZL	New Zealand	6	1
15	CHN-MO	China, P.R.: Macao	4	2	50	NOR	Norway	3	1
16	COL	Colombia	2	3	51	PAK	Pakistan	4	3
17	CRI	Costa Rica	1	3	52	PAN	Panama	1	3
18	CYP	Cyprus	3	1	53	PHL	Philippines	4	3
19	CZE	Czech Republic	3	1	54	POL	Poland	3	1
20	DNK	Denmark	3	1	55	PRT	Portugal	3	1
21	EGY	Egypt	7	3	56	ROU	Romania	3	3
22	EST	Estonia	3	1	57	RUS	Russian Federation	3	2
23	FIN	Finland	3	1	58	SGP	Singapore	4	1
24	FRA	France	3	1	59	SVK	Slovak Republic	3	1
25	DEU	Germany	3	7	60	ZAF	South Africa	7	3
26	GIB	Gibraltar	3	1	61	ESP	Spain	3	1
27	GRC	Greece	3	1	62	SWE	Sweden	3	1
28	GGY	Guernsey	3	3	63	CHE	Switzerland	3	1
29	HUN	Hungary	3	1	64	THA	Thailand	4	3
30	ISL	Iceland	3	1	65	TUR	Turkey	3	2
31	IND	India	4	2	66	UKR	Ukraine	3	3
32	IDN	Indonesia	4	2	67	GBR	United Kingdom	3	1
33	IRL	Ireland	3	1	68	USA	United States	1	1
34	IMN	Isle of Man	3	1	59	URY	Uruguay	2	1
35	ISR	Israel	7	1	70	VEN	Venezuela	2	3

L - Location
1 North & Central America
2 South America
3 Europe
4 Asia
5 The Caribbean
6 Oceania
7 Middle East & Africa

I - Income
1 Developed economies
2 Emerging economies
3 The Rest

Appendix 2: 'Confidential' Reporting 2004-2015

2004	2008	2012	2015
Australia (18) China: Hong Kong (4) Poland (17) GBR (4) USA (2)	Australia (18) China (7) Finland (4) Poland (15) Spain (32) GBR (1)	Australia (20) China: Hong Kong (1) Finland (4) New Zealand (1) Poland (11) Singapore (39) Spain (35) Romania (4)	Argentina (8) Australia (17) Bermuda (1) Bulgaria (1) China: Hong Kong (2) China: Macao (1) Costa Rica (1) Cyprus (1) Estonia (1) Finland (4) Isle of Man (1) Malta (26) New Zealand (24) Philippines (17) Poland (18) Romania (9) Russian Federation (22) Singapore (42) Spain (32) Thailand (1) Uruguay (2)

Appendix 3: Partial Binary Matrix (2015)

	ARG	ABW	AUS	AUT	BHR	BRB	BEL	...	RUS	SGP	SVK	ZAF	ESP	SWE	CHE	THA	TUR	UKR	GBR	USA	URY	VEN
ARG	*	0	1	0	0	0	0	...	1	0	0	1	1	0	1	0	0	0	1	1	1	0
ABW	0	*	1	1	0	0	1	...	1	1	0	1	1	1	1	1	1	0	1	1	0	0
AUS	1	0	*	1	0	0	1	...	1	1	1	1	1	1	1	1	1	0	1	1	1	0
AUT	1	1	1	*	1	1	1	...	1	1	1	1	1	1	1	1	1	1	1	1	1	1
BHR	1	0	1	1	*	0	1	...	1	1	0	1	1	1	1	1	1	1	1	1	1	0
BRB	1	1	1	1	0	*	1	...	1	1	0	1	1	1	1	1	1	0	1	1	0	1
BEL	1	0	1	1	1	1	*	...	1	1	1	1	1	1	1	1	1	1	1	1	1	1
...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
RUS	1	0	1	0	0	0	1	...	*	1	1	1	1	1	1	0	1	0	0	1	0	1
SGP	1	0	1	1	0	0	0	...	0	*	0	0	1	0	0	1	0	0	1	1	0	0
SVK	0	0	1	1	0	0	1	...	1	0	*	0	1	1	1	0	1	1	1	1	0	1
ZAF	1	0	1	1	1	0	1	...	1	1	0	*	1	1	1	1	1	0	1	1	0	0
ESP	0	0	1	1	0	0	1	...	1	1	0	0	*	1	1	0	1	0	1	1	0	0
SWE	1	0	1	1	1	1	1	...	1	1	1	1	1	*	1	1	1	1	1	1	1	1
CHE	1	1	1	1	1	1	1	...	1	1	1	1	1	1	*	1	1	1	1	1	1	1
THA	0	0	1	1	1	0	1	...	1	1	0	1	1	1	1	*	1	0	1	1	1	0
TUR	1	0	1	1	1	0	1	...	1	1	0	1	1	1	1	1	*	1	1	1	0	1
UKR	0	0	0	0	0	0	0	...	1	0	0	0	0	0	0	0	0	*	1	1	0	0
GBR	1	1	1	1	1	1	1	...	1	1	1	1	1	1	1	1	1	1	*	1	1	1
USA	1	1	1	1	1	1	1	...	1	1	1	1	1	1	1	1	1	1	1	*	1	1
URY	1	0	1	1	1	1	1	...	1	0	0	1	1	1	1	0	1	1	1	1	*	1
VEN	0	0	0	0	0	0	0	...	0	0	0	0	0	0	1	0	0	0	1	1	0	*

Appendix 4: Degree Centrality

Out – Degree				In – Degree			
2004	**2008**	**2012**	**2015**	**2004**	**2008**	**2012**	**2015**
LUX	GBR	GBR	GBR	GBR	GBR	USA	USA
DEU	LUX	JPN	LUX	USA	USA	GBR	GBR
CHE	CHE	LUX	USA	DEU	DEU	DEU	LUX
USA	ITA	IRL	CYM	NLD	FRA	NLD	CYM
GBR	AUT	DEU	NLD	CHE	NLD	JPN	NLD
ITA	DEU	CHE	CHE	ITA	LUX	LUX	CHE
FRA	FRA	DNK	FRA	FRA	IRL	FRA	FRA
BEL	IRL	NLD	JPN	AUS	CHE	CHE	IRL
AUT	DNK	FRA	IRL	SWE	CAN	AUS	DEU
GGY	USA	ITA	DEU	LUX	CYM	IRL	CAN
NLD	NLD	AUT	CAN	BEL	BEL	CAN	BRA
IRL	BEL	GGY	SWE	CAN	ITA	ESP	ESP
CHN-HK	NOR	USA	ITA	IRL	JPN	ITA	SWE
CAN	GGY	KOR	NOR	JPN	AUS	BEL	BEL
ESP	JPN	BEL	DNK	CYM	ESP	SWE	KOR
JEY	CYP	NOR	AUT	FIN	AUT	CYM	JPN
CYP	CHN -HK	SWE	GGY	ESP	SWE	KOR	BMU
DNK	KOR	JEY	BEL	AUT	NOR	BRA	AUS
JPN	JEY	CAN	BMU	DNK	FIN	FIN	ITA
BMU	SWE	BMU	KOR	CHN-HK	RUS	NOR	FIN
NOR	CAN	CHN -HK	FIN	BMU	CHN -HK	BMU	CHN - HK
SWE	BMU	CZE	JEY	NOR	BRA	MEX	TUR
GRC	HUN	BRA	CHL	BRA	DNK	DNK	MEX
IMN	CZE	BHR	CHN - HK	KOR	GRC	CHN -HK	NOR
KOR	MUS	CYP	CYP	RUS	MEX	TUR	RUS
CZE	BRA	LBN	LBN	ARG	BMU	AUT	ZAF
CHN-MO	IMN	ABW	BRA	MEX	KOR	ZAF	DNK
SVK	CYM	HUN	CZE	SGP	TUR	JEY	AUT
LBN	LBN	URY	IMN	GRC	IND	RUS	PRT
BRA	GRC	RUS	HUN	PRT	JEY	IND	IND
CHL	SVK	GRC	EST	ZAF	ZAF	POL	SGP
SGP	MYS	CHL	BHR	PHL	SGP	SGP	JEY
HUN	CHL	THA	ZAF	POL	GGY	ARG	ISR
FIN	FIN	IMN	MYS	IND	PRT	GGY	GRC
ZAF	THA	MUS	MUS	PAN	POL	GRC	IDN
MYS	URY	CYM	THA	TUR	THA	PRT	GGY
CYM	EST	MYS	URY	THA	ISR	HUN	POL
URY	CHN -MO	ISL	AUS	MYS	ISL	ISR	CHL
EGY	SGP	ZAF	PAN	ISR	NZL	CHL	NZL
MUS	PRT	SVK	BGR	VEN	PAN	THA	MYS
EST	BHR	AUS	SVK	NZL	IDN	MYS	ARG
PHL	AUS	FIN	BRB	CHL	HUN	KAZ	HUN
AUS	ZAF	BGR	CHN -MO	HUN	MYS	NZL	COL
PRT	ISR	ISR	TUR	COL	PHL	CYP	CYP
PAN	KAZ	KAZ	PRT	JEY	CHL	IDN	PAN
ISR	ISL	EST	ISR	IDN	KAZ	PAN	THA
BHR	BRB	GIB	ABW	UKR	ARG	VEN	VEN
TUR	POL	CHN -MO	GRC	GGY	VEN	COL	CZE
KAZ	KWT	IDN	IDN	CYP	CYP	PHL	IMN
COL	PAN	BRB	ISL	CZE	CZE	CZE	PHL
ISL	BGR	TUR	KAZ	URY	UKR	IMN	KAZ
KWT	ABW	IND	POL	ISL	COL	EGY	ROU
BGR	CRI	CRI	ESP	EGY	EGY	UKR	ISL
ARG	RUS	POL	ROU	KAZ	IMN	ROU	MLT
BRB	GIB	PAN	CRI	MUS	MUS	MUS	EGY
RUS	ESP	PRT	GIB	BGR	URY	ISL	MUS
CRI	ARG	KWT	COL	EST	BHR	SVK	UKR
NZL	EGY	ESP	MLT	ROU	PAK	BHR	BGR
MLT	COL	COL	IND	SVK	BGR	BGR	SVK
POL	TUR	MLT	PHL	LBN	ROU	URY	CRI
THA	IND	ROU	MEX	CRI	GIB	MLT	BHR
IDN	IDN	MEX	RUS	ABW	SVK	EST	PAK
MEX	MLT	EGY	KWT	PAK	BRB	PAK	EST
VEN	MEX	SGP	SGP	BHR	KWT	LBN	URY
IND	VEN	ARG	EGY	IMN	MLT	GIB	KWT
GIB	ROU	PAK	ARG	KWT	EST	BRB	LBN
ROU	NZL	PHL	PAK	BRB	LBN	CRI	BRB
PAK	PHL	NZL	VEN	GIB	CRI	KWT	GIB
ABW	PAK	VEN	NZL	MLT	ABW	ABW	CHN -MO
UKR	UKR	UKR	UKR	CHN-MO	CHN -MO	CHN -MO	ABW

Appendix 5: Node Strength Centrality

Out – Strength				In – Strength			
2004	**2008**	**2012**	**2015**	**2004**	**2008**	**2012**	**2015**
USA	USA	USA	USA	USA	USA	USA	USA
GBR	FRA	JPN	LUX	GBR	GBR	GBR	GBR
JPN	JPN	GBR	GBR	DEU	DEU	DEU	LUX
FRA	GBR	LUX	JPN	FRA	FRA	FRA	FRA
LUX	DEU	DEU	DEU	NLD	LUX	LUX	CYM
DEU	LUX	FRA	FRA	ITA	NLD	CYM	DEU
NLD	IRL	IRL	IRL	LUX	ITA	NLD	NLD
IRL	NLD	NLD	NLD	CYM	CYM	ITA	JPN
ITA	ITA	ITA	CYM	JPN	ESP	IRL	IRL
CHE	CHE	CHE	CAN	ESP	JPN	JPN	ITA
BEL	BEL	CAN	CHE	CAN	IRL	CAN	CAN
ESP	NOR	NOR	ITA	IRL	CAN	AUS	ESP
CAN	ESP	CHN-HK	NOR	CHE	AUS	ESP	CHE
CHN-HK	CAN	BEL	CHN-HK	SWE	CHE	CHE	AUS
BMU	CHN-HK	SGP	BEL	BEL	AUT	SWE	SWE
SWE	BMU	AUS	SGP	BMU	SWE	BRA	BEL
AUT	SGP	SWE	AUS	AUT	BEL	KOR	BMU
NOR	SWE	BMU	SWE	AUS	BMU	BEL	KOR
SGP	AUT	DNK	ESP	GRC	JEY	BMU	IND
DNK	AUS	ESP	BMU	FIN	GRC	AUT	CHN-HK
AUS	DNK	AUT	FIN	KOR	PRT	CHN-HK	DNK
FIN	FIN	FIN	AUT	JEY	KOR	NOR	AUT
GGY	PRT	GGY	GGY	DNK	IND	IND	MEX
PRT	GGY	ZAF	ZAF	PRT	FIN	MEX	BRA
JEY	JEY	PRT	KOR	BRA	BRA	DNK	NOR
CYM	MUS	KOR	ZAF	CHN-HK	DNK	FIN	FIN
ZAF	GRC	GRC	CHL	MEX	NOR	JEY	JEY
GRC	KOR	CHL	PRT	NOR	CHN-HK	SGP	SGP
MUS	ZAF	MUS	GRC	IND	MEX	RUS	ZAF
KOR	CHL	JEY	MUS	SGP	SGP	PRT	IDN
NZL	CYM	ISR	ISR	RUS	RUS	ZAF	PRT
BHR	CYP	KAZ	JEY	ZAF	POL	TUR	TUR
CHL	ISR	CYM	MYS	MYS	ZAF	POL	POL
CZE	KAZ	MEX	KAZ	POL	TUR	MYS	ISR
ISR	BHR	MYS	RUS	HUN	ISR	IDN	MYS
BRB	KWT	RUS	MEX	ISR	GGY	GGY	GGY
CYP	CZE	CYP	THA	TUR	MYS	THA	RUS
KWT	RUS	NZL	MLT	NZL	HUN	ISR	THA
IMN	BRB	BHR	CZE	GGY	IDN	PHL	PHL
MLT	NZL	SVK	COL	PAN	NZL	HUN	NZL
RUS	ARG	THA	CHN-MO	THA	THA	GRC	CHL
CHN-MO	IMN	CZE	POL	IDN	CZE	CHL	GRC
MEX	MYS	MLT	BRA	ARG	PHL	NZL	HUN
POL	THA	KWT	ARG	ISL	PAN	CZE	COL
ISL	MLT	ARG	SVK	PHL	CYP	COL	PAN
KAZ	BRA	CHN-MO	IMN	CHL	CHL	PAN	CZE
PHL	VEN	BRA	PAN	VEN	ISL	VEN	ARG
BRA	POL	BRB	CYP	CZE	COL	SVK	MUS
PAN	COL	IMN	PHL	COL	ARG	MUS	SVK
MYS	MEX	COL	KWT	CYP	SVK	ARG	ROU
VEN	HUN	POL	HUN	SVK	EGY	UKR	CYP
SVK	ISL	HUN	BHR	ROU	BHR	CYP	VEN
COL	CHN-MO	ISL	BRB	BGR	VEN	ROU	UKR
URY	PAN	PAN	ISL	UKR	MUS	KAZ	KAZ
EST	SVK	GIB	EST	EST	UKR	MLT	IMN
LBN	IDN	PHL	IDN	GIB	KAZ	IMN	URY
HUN	EST	BGR	NZL	EGY	URY	EGY	MLT
THA	LBN	LBN	URY	URY	ROU	ISL	EGY
IDN	PHL	EST	BGR	BHR	IMN	URY	ISL
TUR	URY	IDN	LBN	IMN	ABW	BHR	PAK
EGY	TUR	VEN	VEN	MUS	KWT	BGR	BHR
ROU	GIB	URY	ROU	KWT	EST	PAK	CRI
BGR	ROU	ROU	TUR	LBN	MLT	BRB	BRB
GIB	IND	EGY	IND	CRI	BGR	LBN	BGR
ABW	EGY	IND	EGY	KAZ	PAK	KWT	LBN
IND	BGR	TUR	CRI	ABW	LBN	CHN-MO	KWT
ARG	CRI	CRI	GIB	BRB	BRB	GIB	CHN-MO
UKR	ABW	ABW	ABW	MLT	GIB	EST	EST
CRI	UKR	UKR	UKR	PAK	CRI	CRI	GIB
PAK	PAK	PAK	PAK	CHN-MO	CHN-MO	ABW	ABW

Appendix 6: Betweenness Centrality 2004-2015

2004		2008		2012		2015	
GBR	182.272	GBR	189.921	GBR	87.04	GBR	81.932
USA	127.598	USA	89.423	NLD	77.219	USA	80.108
LUX	124.839	NLD	79.396	USA	62.044	CYM	68.462
DEU	100.853	DEU	75.298	JPN	60.519	NLD	55.088
CHE	99.985	FRA	74.736	FRA	60.151	CHE	54.042
NLD	98.845	CHE	70.247	LUX	60.006	LUX	52.025
FRA	93.356	LUX	68.406	CHE	59.971	IRL	50.804
ITA	89.927	IRL	68.264	DEU	59.499	ITA	47.1
CHN-HK	83.581	BEL	60.683	IRL	53.602	FRA	44.353
BEL	83.399	CHN-HK	59.789	KOR	45.796	DEU	42.1
JPN	69.978	JPN	56.15	ITA	44.48	JPN	39.639
AUT	64.798	ITA	55.546	CAN	37.806	CAN	38.965
IRL	64.695	AUT	51.564	BEL	37.692	FIN	37.863
CAN	63.14	NOR	45.946	DNK	37.148	BMU	36.932
ESP	58.488	CAN	45.644	BMU	36.465	SWE	34.846
SWE	52.427	DNK	41.406	SWE	35.697	KOR	34.282
DNK	44.511	SWE	35.253	NOR	35.177	BEL	33.221
BMU	36.23	CYM	34.621	BRA	34.255	BRA	32.055
NOR	33.654	BMU	33.477	AUT	33.158	NOR	29.423
KOR	26.111	KOR	31.136	CHN-HK	30.556	AUT	28.112
JEY	23.729	BRA	29.718	CYP	29.327	DNK	27.72
CYM	23.322	GGY	29.405	CYM	27.199	CYP	27.597
BRA	22.409	JEY	28.474	JEY	26.85	CHN-HK	27.078
FIN	22.101	PRT	22.927	GGY	25.756	GGY	23.367
GRC	21.456	GRC	20.22	AUS	23.707	JEY	20.975
RUS	19.819	FIN	19.624	RUS	18.1	CHL	19.248
AUS	19.79	CYP	18.91	FIN	17.464	TUR	17.137
GGY	19.544	AUS	17.688	ZAF	15.461	ZAF	17.118
CYP	18.903	THA	15.523	THA	15.258	AUS	16.035
MYS	13.155	MUS	14.311	MYS	14.855	MYS	15.235
SGP	12.987	RUS	12.947	IND	14.855	PAN	15.161
CHL	11.523	HUN	12.354	CHL	14.849	RUS	14.132
MUS	10.317	SGP	12.047	TUR	14.18	IDN	13.125
ZAF	10.131	MYS	11.07	CZE	12.892	HUN	10.93
PHL	10.022	POL	10.156	GRC	12.366	PRT	10.806
PAN	9.054	CZE	10.094	IDN	11.691	CZE	10.281
PRT	8.042	CHL	9.981	HUN	11.295	THA	9.273
HUN	7.051	ESP	9.388	IMN	10.174	GRC	9.141
TUR	6.946	PAN	9.277	MUS	10.135	MUS	9.076
ARG	6.89	BHR	8.962	BHR	10.045	IMN	8.652
KWT	5.821	ZAF	8.312	URY	9.627	ISR	8.578
EGY	5.335	TUR	8.299	POL	9.62	ESP	8.488
CZE	4.862	IMN	5.617	PAN	9.34	MEX	7.729
LBN	4.821	URY	5.428	ESP	9.069	BHR	7.301
URY	4.448	ISR	5.288	KAZ	8.248	SGP	6.652
COL	3.418	IND	5.042	PRT	6.879	POL	6.65
ISR	3.332	IDN	4.535	ISR	6.77	IND	5.67
IMN	3.109	ARG	4.494	ISL	6.04	LBN	5.61
BHR	3.061	KAZ	4.247	MEX	5.513	BGR	5.498
VEN	2.629	ISL	3.733	SVK	5.178	COL	5.249
IND	2.338	BGR	3.103	SGP	5.025	SVK	4.203
MEX	2.305	LBN	2.945	COL	4.57	EST	3.699
KAZ	2.101	EGY	2.837	LBN	4.374	URY	3.42
EST	2.024	COL	2.643	EGY	4.34	EGY	3.265
THA	1.884	MEX	2.532	ARG	3.752	KAZ	3.147
POL	1.797	SVK	2.493	BGR	2.574	ISL	2.802
SVK	1.669	EST	1.903	MLT	2.301	MLT	2.777
IDN	1.511	KWT	1.814	VEN	2.024	CHN-MO	2.482
NZL	1.467	BRB	1.456	ABW	1.95	ARG	2.299
BGR	1.379	VEN	1.293	EST	1.943	ROU	1.688
CRI	0.903	GIB	1.039	KWT	1.866	PHL	1.687
PAK	0.725	CRI	0.988	ROU	1.809	KWT	1.56
ISL	0.535	NZL	0.681	BRB	1.565	CRI	1.324
MLT	0.235	PAK	0.661	CHN-MO	1.529	BRB	1.202
BRB	0.174	ABW	0.524	PAK	1.026	PAK	0.809
CHN-MO	0.097	PHL	0.299	GIB	1.021	VEN	0.669
ABW	0.071	CHN-MO	0.28	CRI	0.799	GIB	0.462
ROU	0.038	MLT	0.272	NZL	0.702	ABW	0.287
GIB	0.033	ROU	0.262	PHL	0.672	NZL	0.273
UKR	0	UKR	0	UKR	0.135	UKR	0.082

Appendix 7: Closeness Centrality 2004-2015

In-Closeness				Out-Closeness			
2004	**2008**	**2012**	**2015**	**2004**	**2008**	**2012**	**2015**
GBR	GBR	USA	USA	LUX	GBR	GBR	GBR
USA	USA	GBR	GBR	DEU	LUX	LUX	LUX
DEU	DEU	DEU	LUX	CHE	CHE	JPN	USA
NLD	FRA	NLD	CYM	USA	AUT	IRL	CYM
CHE	NLD	LUX	NLD	GBR	DEU	DEU	NLD
ITA	LUX	JPN	CHE	ITA	FRA	CHE	CHE
FRA	IRL	FRA	FRA	FRA	IRL	DNK	FRA
AUS	CHE	CHE	IRL	BEL	DNK	NLD	JPN
SWE	CAN	AUS	DEU	AUT	USA	FRA	IRL
LUX	CYM	IRL	CAN	GGY	NLD	ITA	DEU
BEL	BEL	CAN	BRA	NLD	BEL	AUT	CAN
CAN	ITA	ESP	ESP	IRL	NOR	GGY	SWE
IRL	JPN	ITA	SWE	CHN-HK	GGY	USA	ITA
JPN	AUS	BEL	BEL	CAN	JPN	KOR	NOR
CYM	ESP	SWE	KOR	ESP	CYP	BEL	DNK
FIN	AUT	CYM	JPN	JEY	CHN-HK	NOR	AUT
ESP	SWE	KOR	BMU	CYP	KOR	SWE	GGY
AUT	NOR	BRA	AUS	DNK	JEY	JEY	BEL
DNK	FIN	FIN	ITA	JPN	SWE	CAN	BMU
CHN-HK	RUS	NOR	FIN	BMU	CAN	BMU	KOR
BMU	CHN-HK	BMU	CHN-HK	NOR	BMU	CHN-HK	FIN
NOR	BRA	MEX	TUR	SWE	HUN	CZE	JEY
BRA	DNK	DNK	MEX	GRC	CZE	BRA	CHL
KOR	GRC	CHN-HK	NOR	IMN	MUS	BHR	CHN-HK
RUS	MEX	TUR	RUS	CZE	BRA	CYP	CYP
ARG	BMU	ZAF	ZAF	CHN-MO	IMN	LBN	LBN
MEX	KOR	JEY	DNK	SVK	CYM	ABW	BRA
SGP	TUR	RUS	AUT	LBN	LBN	HUN	CZE
GRC	IND	IND	PRT	BRA	GRC	URY	IMN
PRT	JEY	POL	IND	CHL	SVK	RUS	HUN
ZAF	ZAF	SGP	SGP	SGP	MYS	GRC	EST
PHL	SGP	ARG	JEY	HUN	CHL	CHL	BHR
POL	GGY	GGY	ISR	FIN	FIN	THA	ZAF
IND	PRT	GRC	GRC	ZAF	THA	IMN	MYS
PAN	POL	PRT	IDN	MYS	URY	MUS	MUS
TUR	THA	HUN	GGY	CYM	EST	CYM	THA
THA	ISR	ISR	POL	EGY	CHN-MO	MYS	URY
MYS	ISL	CHL	CHL	URY	SGP	ISL	AUS
ISR	NZL	THA	NZL	MUS	PRT	ZAF	PAN
VEN	PAN	MYS	MYS	EST	BHR	SVK	SVK
NZL	IDN	KAZ	ARG	PHL	AUS	AUS	BGR
CHL	HUN	NZL	HUN	AUS	ZAF	FIN	BRB
HUN	MYS	COL	COL	PRT	ISR	BGR	CHN-MO
COL	PHL	CYP	CYP	PAN	KAZ	ISR	TUR
JEY	CHL	IDN	PAN	ISR	ISL	EST	PRT
IDN	KAZ	PAN	THA	BHR	BRB	KAZ	ISR
UKR	ARG	VEN	VEN	TUR	POL	GIB	ABW
GGY	VEN	COL	CZE	KAZ	KWT	CHN-MO	GRC
CYP	CYP	PHL	IMN	COL	PAN	IDN	IDN
CZE	CZE	CZE	PHL	ISL	BGR	BRB	ISL
ISL	UKR	IMN	KAZ	KWT	ABW	TUR	KAZ
EGY	COL	EGY	ROU	BGR	CRI	IND	POL
URY	EGY	UKR	ISL	ARG	RUS	CRI	ESP
KAZ	IMN	ROU	MLT	BRB	GIB	POL	ROU
MUS	MUS	MUS	EGY	RUS	ESP	PAN	CRI
BGR	URY	ISL	MUS	NZL	ARG	PRT	GIB
EST	BHR	SVK	UKR	CRI	EGY	KWT	COL
ROU	PAK	BHR	SVK	MLT	COL	ESP	MLT
SVK	BGR	BGR	BGR	POL	TUR	COL	IND
LBN	ROU	URY	CRI	THA	IND	MLT	PHL
CRI	GIB	MLT	BHR	IDN	IDN	ROU	MEX
ABW	SVK	EST	PAK	MEX	MLT	MEX	RUS
PAK	BRB	PAK	EST	IND	MEX	EGY	KWT
IMN	KWT	LBN	URY	VEN	VEN	SGP	SGP
BHR	MLT	GIB	KWT	GIB	ROU	ARG	EGY
KWT	EST	BRB	LBN	ROU	NZL	PAK	ARG
BRB	LBN	CRI	BRB	PAK	PHL	PHL	PAK
GIB	CRI	KWT	GIB	ABW	PAK	NZL	VEN
MLT	ABW	ABW	CHN-MO	UKR	UKR	VEN	NZL
CHN-MO	CHN-MO	CHN-MO	ABW			UKR	UKR

Appendix 7: Hubs and Authorities 2004-2015

Hubs				Authority			
2004	2008	2012	2015	2004	2008	2012	2015
USA	JPN	USA	USA	USA	USA	USA	USA
JPN	USA	JPN	JPN	GBR	GBR	GBR	GBR
GBR	GBR	GBR	LUX	DEU	DEU	CYM	CYM
FRA	IRL	LUX	GBR	FRA	FRA	FRA	FRA
LUX	LUX	IRL	CYM	NLD	CYM	DEU	JPN
IRL	FRA	DEU	IRL	CYM	NLD	CAN	DEU
NLD	DEU	FRA	CAN	ITA	ITA	NLD	NLD
DEU	NLD	NLD	DEU	JPN	JPN	JPN	IRL
ITA	ITA	CAN	FRA	CAN	LUX	LUX	CAN
CHE	CAN	CHE	NLD	LUX	ESP	AUS	LUX
CAN	CHE	NOR	CHE	ESP	IRL	IRL	CHE
BMU	BMU	ITA	NOR	IRL	CAN	ITA	ITA
ESP	BEL	AUS	CHN-HK	CHE	CHE	CHE	AUS
BEL	NOR	CHN-HK	SGP	AUS	AUS	BRA	ESP
CHN-HK	ESP	BMU	BMU	BMU	BMU	ESP	SWE
SWE	CHN-HK	SGP	AUS	SWE	SWE	SWE	BMU
NOR	AUS	BEL	ITA	BEL	BEL	KOR	KOR
AUS	SWE	SWE	SWE	AUT	AUT	BMU	BEL
SGP	SGP	DNK	DNK	KOR	JEY	CHN-HK	CHN-HK
AUT	AUT	ESP	BEL	FIN	PRT	MEX	MEX
DNK	DNK	AUT	ESP	GRC	GRC	BEL	BRA
GGY	GGY	FIN	KOR	MEX	BRA	NOR	IND
FIN	JEY	GGY	FIN	BRA	KOR	AUT	DNK
CYM	FIN	ZAF	GGY	CHN-HK	NOR	IND	JEY
JEY	PRT	CHL	AUT	DNK	CHN-HK	JEY	SGP
PRT	GRC	KOR	CHL	JEY	FIN	ZAF	NOR
ZAF	KOR	ISR	ISR	NOR	DNK	SGP	AUT
KOR	CYM	GRC	ZAF	PRT	MEX	DNK	FIN
GRC	ZAF	MEX	MEX	SGP	SGP	RUS	ZAF
NZL	CHL	PRT	KAZ	ZAF	IND	FIN	ISR
ARG	ISR	JEY	JEY	ISR	ZAF	TUR	IDN
BHR	KAZ	KAZ	PRT	RUS	ISR	MYS	GGY
ISR	ARG	CYM	GRC	IND	RUS	POL	MYS
BRB	BHR	ARG	MYS	PAN	POL	IDN	RUS
CHL	BRB	MYS	ARG	POL	GGY	ISR	TUR
CZE	CYP	NZL	COL	NZL	TUR	PRT	POL
IMN	NZL	BRB	BRA	HUN	MYS	THA	PRT
KAZ	COL	BRA	MUS	TUR	HUN	GGY	THA
KWT	KWT	COL	RUS	GGY	NZL	PHL	CHL
MEX	RUS	RUS	BHR	ARG	IDN	CHL	PHL
PHL	VEN	BHR	CHN-MO	THA	PAN	HUN	NZL
RUS	CZE	CYP	IMN	CHL	THA	NZL	COL
BRA	IMN	IMN	PAN	PHL	CHL	COL	PAN
CHN-MO	MYS	KWT	POL	VEN	CZE	PAN	HUN
COL	MUS	MUS	THA	IDN	PHL	VEN	GRC
CYP	MEX	SVK	BRB	ISL	ARG	GRC	ARG
ISL	BRA	THA	CYP	CZE	COL	CZE	MUS
MLT	CHN-MO	CHN-MO	CZE	COL	VEN	MUS	CZE
MUS	HUN	CZE	HUN	CYP	ISL	ARG	VEN
PAN	ISL	GIB	ISL	ABW	EGY	UKR	ROU
POL	LBN	HUN	KWT	BGR	KAZ	KAZ	UKR
VEN	MLT	ISL	MLT	EGY	CYP	CYP	KAZ
ABW	PAN	LBN	PHL	EST	IMN	IMN	IMN
BGR	PHL	MLT	SVK	GIB	MUS	SVK	BRB
CRI	POL	PAN	URY	ROU	SVK	ISL	CYP
EGY	SVK	PHL	VEN	SVK	URY	MLT	ISL
EST	THA	POL	ABW	UKR	ABW	URY	SVK
GIB	URY	URY	BGR	URY	UKR	EGY	URY
HUN	ABW	VEN	CRI	BHR	BHR	ROU	EGY
IND	BGR	ABW	EGY	BRB	BRB	BRB	PAK
IDN	CRI	BGR	EST	IMN	KWT	BHR	BHR
LBN	EGY	CRI	GIB	KAZ	CHN-MO	KWT	CHN-MO
MYS	EST	EGY	IND	KWT	LBN	CHN-MO	KWT
PAK	GIB	EST	IDN	CHN-MO	MLT	GIB	MLT
ROU	IND	IND	LBN	MLT	BGR	LBN	ABW
SVK	IDN	IDN	NZL	MUS	CRI	ABW	BGR
THA	PAK	PAK	PAK	CRI	EST	BGR	CRI
TUR	ROU	ROU	ROU	LBN	GIB	CRI	EST
UKR	TUR	TUR	TUR	PAK	PAK	EST	GIB
URY	UKR	UKR	UKR		ROU	PAK	LBN

Appendix 8: Total Assets – Centrality Descriptive Statistics

	Mean	Std. Dev	Variance	Min	Max
2004					
Out-Degree	41.143	18.071	326.551	2	69
In-Degree	41.143	16.133	260.265	2	69
Out-Strength	$2.85 *10^{11}$	$6.1 * 10^{11}$	$3.73 * 10^{23}$	$1.65 * 10^7$	$3.53 * 10^{12}$
In-Strength	$2.85 *10^{11}$	$5.99 * 10^{11}$	$3.6 * 10^{23}$	$1.265 * 10^8$	$3.674 * 10^8$
Betweenness	27.971	38.715	1498	0	182.272
In-Closeness	73.244	12.574	158.099	48.936	100
Out-Closeness	73.764	14.048	197.358	49.286	100
2008					
Out-Degree	45.114	17.164	294.616	1	68
In- Degree	45.114	15.149	229.501	3	69
Out-Strength	$3.676 *10^{11}$	$7.554 *10^{11}$	$5.706 *10^{23}$	$4.091 *10^{11}$	$2.4 *10^8$
In-Strength	$3676*10^{11}$	$7.474 *10^{11}$	$5.586 *10^{23}$	$4.07 *10^{12}$	$4.62 *10^{12}$
Betweenness	23.9	31.404	986.225	0	189.921
In – Closeness	76.248	12.249	150.037	51.111	100
Out– Closeness	76.787	13.836	191.433	50	98.571
2012					
Out – Degree	48.357	15.785	249.172	3	69
In – Degree	48.357	14.209	201.887	18	68
Out – Strength	$5.095 * 10^{11}$	$1.151 * 10^{12}$	$1.325 * 10^{24}$	$1.21* 10^8$	$7.446 * 10^{12}$
In – Strength	$5.095 * 10^{11}$	$1.01* 10^{12}$	$1.02 * 10^{24}$	$1.14 * 10^9$	$6.473 * 10^{12}$
Betweenness	20.643	21.029	442.208	0.135	87.040
In – Closeness	78.853	11.984	143.615	57.500	51.111
Out– Closeness	79.264	13.240	175.301	98.571	100
2015					
Out – Degree	49.729	16.748	280.483	4	69
In – Degree	49.729	13.197	174.169	16	68
Out–Strength	$5.934 * 10^{11}$	$1.33 * 10^{12}$	$1.76 * 10^{24}$	$1.525 * 10^8$	$8.91 * 10^{12}$
In–Strength	$5.934 * 10^{11}$	$1.32 * 10^{12}$	$1.741* 10^{24}$	$3.477 * 10^8$	$9.31 * 10^{12}$
Betweenness	19.271	19.865	394.612	0.082	81.932
In – Closeness	79.815	11.129	123.849	56.557	98.571
Out– Closeness	80.760	13.906	193.380	51.493	100

Appendix 9: Assortative Mixing – Location

	N & C America	South America	Europe	Asia	Caribbean	Oceania	ME & Africa
2004							
Total Assets Density	0.900	0.738	0.776	0.682	0.250	1.000	0.600
Equity Density	0.733	0.381	0.647	0.561	0.167	1.000	0.600
Total Debt Density	0.800	0.643	0.712	0.485	0.250	1.000	0.350
Long Term Debt Density	0.800	0.643	0.696	0.462	0.167	0.500	0.200
Short Term Debt Density	0.433	0.143	0.365	0.227	0.083	0.000	0.100
2008							
Total Assets Density	0.833	0.786	0.843	0.667	0.417	1.000	0.600
Equity Density	0.733	0.429	0.743	0.621	0.250	1.000	0.550
Total Debt Density	0.767	0.738	0.769	0.561	0.333	1.000	0.550
Long Term Debt Density	0.767	0.714	0.750	0.545	0.333	0.500	0.500
Short Term Debt Density	0.400	0.214	0.402	0.326	0.167	0.500	0.350
2012							
Total Assets Density	0.900	0.810	0.881	0.803	0.583	1.000	0.550
Equity Density	0.800	0.548	0.775	0.659	0.250	1.000	0.500
Total Debt Density	0.900	0.738	0.769	0.727	0.500	0.500	0.500
Long Term Debt Density	0.900	0.690	0.763	0.682	0.500	0.000	0.400
Short Term Debt Density	0.500	0.310	0.405	0.402	0.083	0.000	0.250
2015							
Total Assets Density	0.967	0.738	0.886	0.826	0.667	0.500	0.550
Equity Density	0.900	0.548	0.789	0.697	0.417	1.000	0.500
Total Debt Density	0.867	0.667	0.798	0.735	0.667	0.500	0.500
Long Term Debt Density	0.867	0.667	0.772	0.735	0.667	0.500	0.500
Short Term Debt Density	0.433	0.357	0.359	0.333	0.250	0.000	0.250

Appendix 10: Assortative Mixing – Income

	Developed Economies	Emerging Economies	The Rest
2004			
Total Density	0.746	0.500	0.304
Equity Density	0.631	0.375	0.193
Total Debt Density	0.670	0.321	0.222
Long Term Debt Density	0.641	0.304	0.211
Short Term Debt Density	0.326	0.161	0.094
2008			
Total Density	0.800	0.589	0.351
Equity Density	0.687	0.446	0.243
Total Debt Density	0.707	0.375	0.272
Long Term Debt Density	0.679	0.357	0.266
Short Term Debt Density	0.358	0.161	0.053
2012			
Total Density	0.813	0.768	0.421
Equity Density	0.696	0.554	0.304
Total Debt Density	0.718	0.625	0.319
Long Term Debt Density	0.711	0.536	0.307
Short Term Debt Density	0.369	0.375	0.094
2015			
Total Density	0.832	0.714	0.418
Equity Density	0.729	0.554	0.301
Total Debt Density	0.754	0.554	0.330
Long Term Debt Density	0.741	0.571	0.322
Short Term Debt Density	0.368	0.232	0.085

Appendix 11: Total Equity Portfolio Network 2004 – 2015
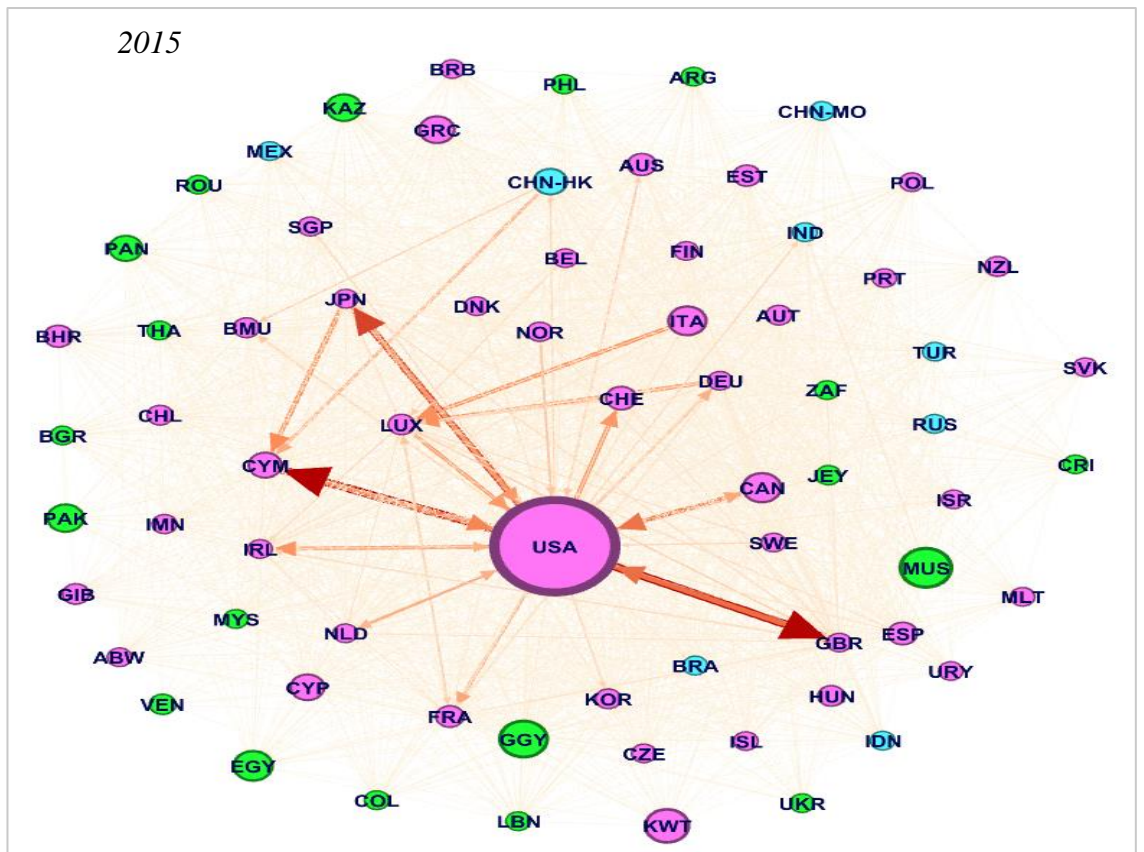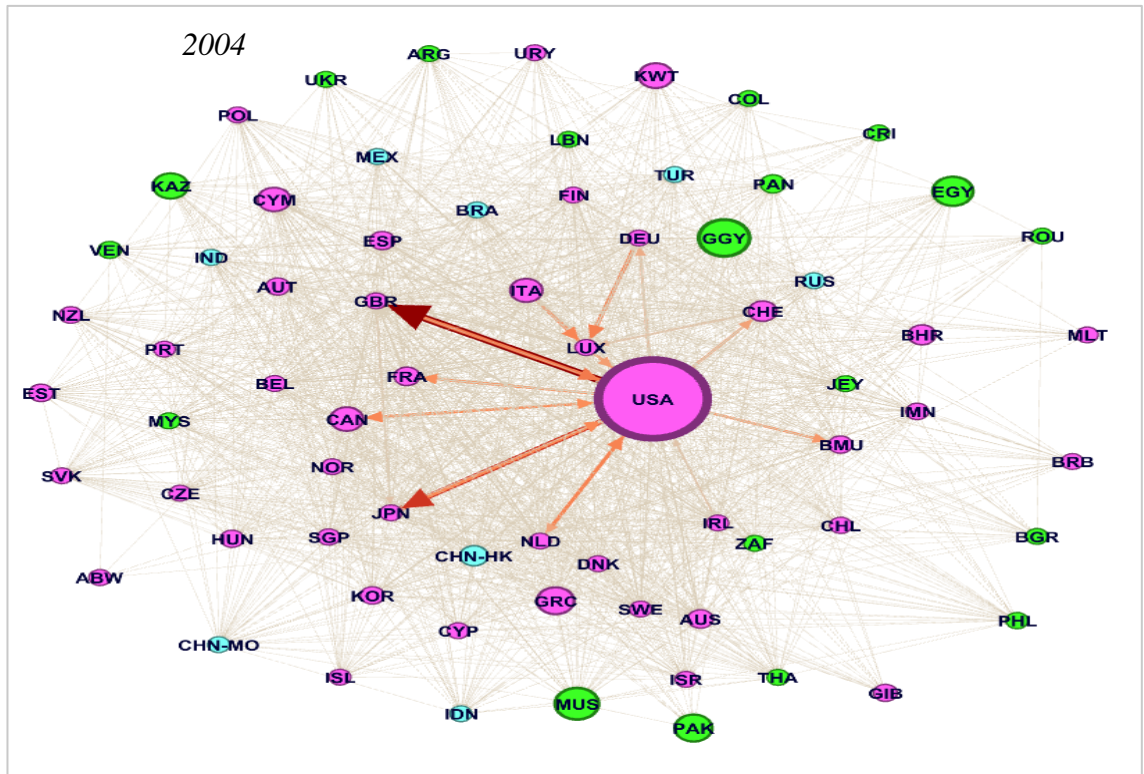
Appendix 12: Total Debt Network 2004 – 2015

2004

2015
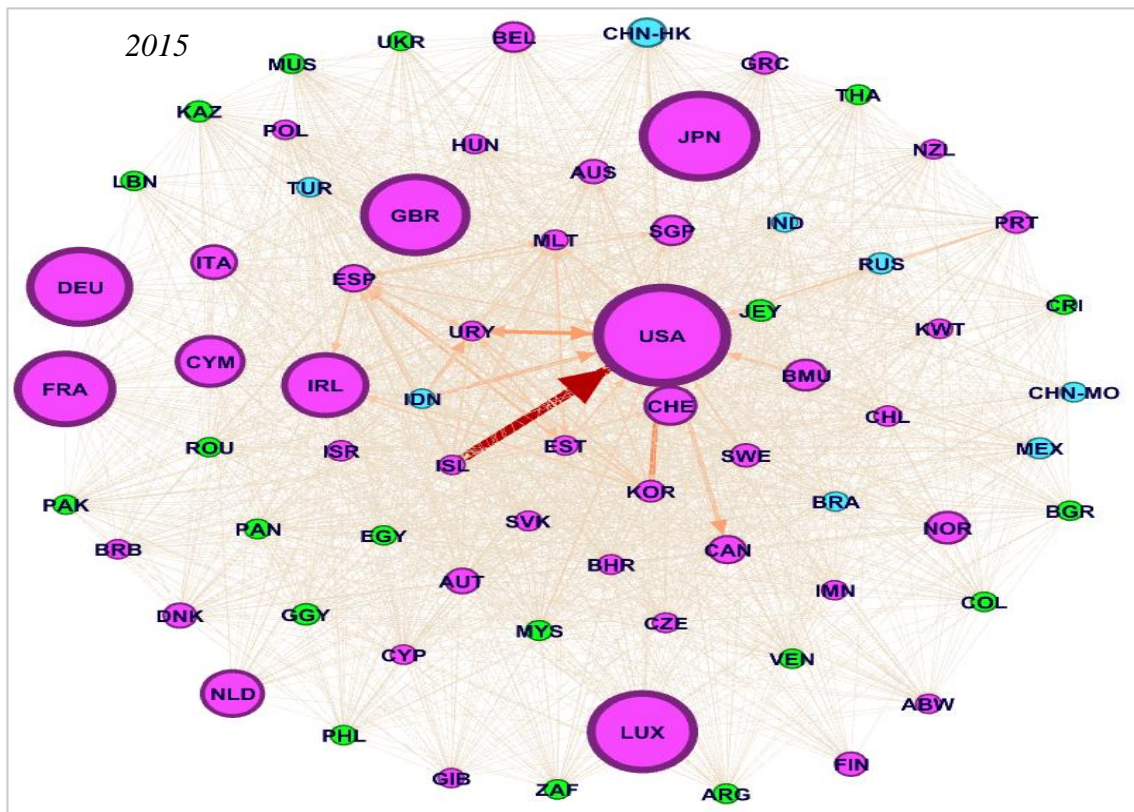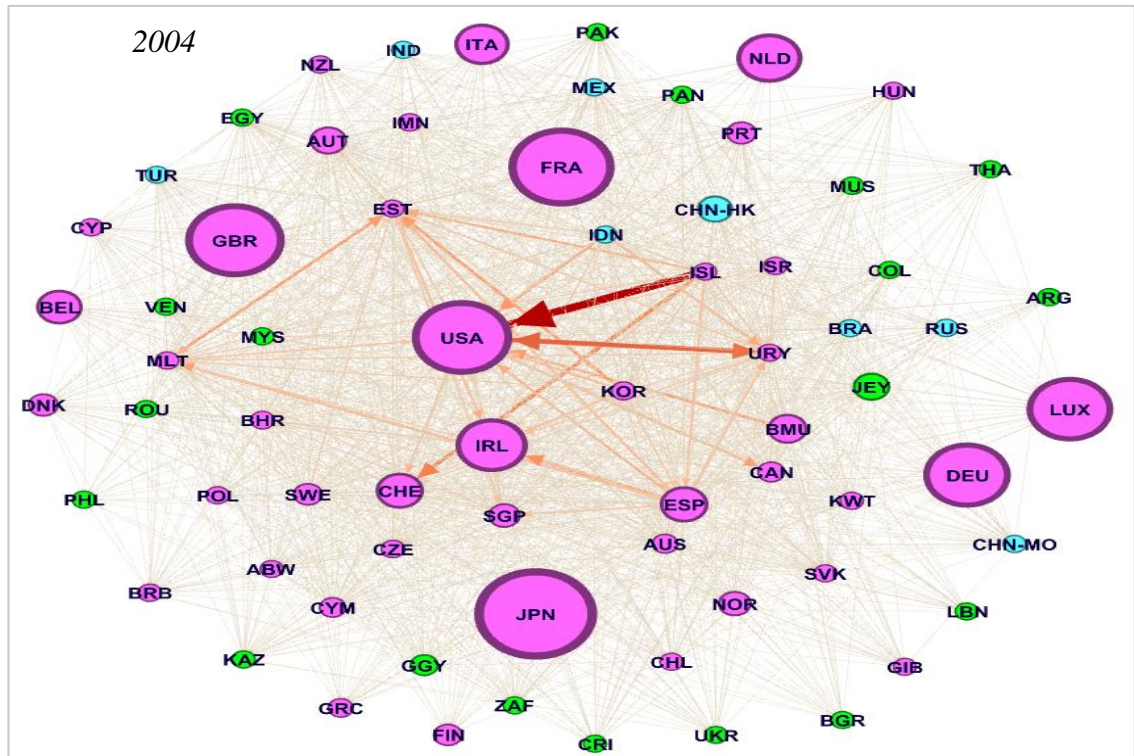
BIOGRAPHY

Ornela Valdi was born and grew up in Albania. She holds a double bachelor degree in Finance - Accounting and Business Management. She as well received a MBA in Management of Information Systems from Canadian Institute of Technology. In 2014 Ornela was awarded Turkish Government Scholarship Program and moved to Turkey to continue her master studies at Sakarya University, International Trade program. During her studies in Turkey, she was awarded Erasmus+ Traineeship Grant and had a valuable experience as Junior Project Officer at International Institute of Social Studies / Erasmus University Rotterdam in The Hague, Netherlands.