European Banking Network in Light of the Single Supervisory Mechanism from the Network Analysis Perspective

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Abstract: *In this paper we discuss the topological properties of the European banking network and its evolution over time based on the BIS consolidated banking statistics data exploiting information from complex network analysis. Our conclusions are discussed in light of the soon-to-be-launched Single Supervisory Mechanism that takes into account, among other things, the significance of cross-border activity as a precondition for specifying the systemically important European credit institutions. According to our results, the banking network of the EU13 economic space can be characterized as highly asymmetric with a tendency to create clusters based on geographic distance and cultural and social similarities. Additionally, the highly exposed countries are usually dependent on a small number of major creditors while creditor countries tend to spread their power over dependent countries more equally. We advocate that the presence of heterogeneity and asymmetry in the network and a decrease in the level of foreign banking across Europe could be mitigated by the introduction of SSM, and from this perspective it should be viewed as a positive step towards greater financial stability.*

Keywords: *Single Supervisory Mechanism, network analysis, directed weighted network, too-interconnected-to-fail*

JEL codes: *G18, G21, G28*

Introduction

The financial crisis has highlighted the need for analysis of complex economic structures in order to assess systemic risk in a more accurate way.

At the outset of the financial crisis in 2008 the Too-Big-Too-Fail (TBTF) concept rose to prominence promoting discussion of the financial institutions whose fall could not only bring down the entire financial system but from which consequent problems would cascade social costs over the real sector that would be significantly higher than the costs incurred by their rescue. By Bernanke (2010): "A too-big to fail firm is one whose size, complexity, interconnectedness, and critical functions are such that, should the firm go unexpectedly into liquidation, the rest of the financial system and the economy would face severe adverse consequences." In other words, the negative externalities generated in the

process are large and undesirable as they affect not only the financial system but also the real sector. There is no clear definition of what the TBTF concept means (Hurley, 2010) partially due to the often vaguely defined threshold between institutions allowed to fail and those who are not.

The four criteria for becoming a TBTF institution named by Bernanke (size, complexity, interconnectedness, critical function) are not mutually conditioned. Relatively small financial institutions in terms of their assets and size might become TBTF if serving as a financial hub for many other players in the network and vice versa.[1] As the network analysis focuses on studying the interconnectedness of nodes in a network along with its characteristics we will prefer using the Too-Interconnected-Too-Fail (TITF) term throughout the text in order to stress the role of connections in systemic risk of the banking network.

The network analysis used in this paper is, in general, able to address two types of questions (Allen and Babus, 2008): (1) network effects of the particular network structure (resilience of a network towards systemic or idiosyncratic shock and related contagion effects); (2) network formation as a response to the external or internal shocks (how links between nodes are formed and destroyed). The topology of a network affects its functionality and stability (Albert and Barabasi, 2002; Newman, 2004). Scale-free networks (i.e. networks with a power law distribution of degrees) are extremely vulnerable to intentional attacks on their hubs (Albert et al., 2000) as well as to epidemics (Barthélemy et al., 2005).

In finance, most of the theoretical economic literature concentrates on the first question using network analysis to assess systemic risk and risk of contagion with respect to a particular network structure. The seminal paper in this area by Allen and Gale (2000) shows that better connected networks are more resilient to contagion and in the case of a completely connected structure the system is fully resilient to contagious effects. Gai and Kapadia (2007) develop a model of contagion in financial networks using literature on spreading disease in epidemiological literature. While greater connectivity reduces the likelihood of widespread default, the shocks may have a greater impact on entire system when they occur as in the case of less connected network. The resilience of a more connected network is highly dependent on shocks hitting fragile points associated with structural liabilities (financial hubs). On top of that, the financial system tends to be fragile by its very nature whereby the behavior of one agent within a

[1] The Long-Term Capital Management (LTCM) hedge fund defaulted in 1998. At that time the size of the assets approached 4 bil. USD and daily VaR was 400 mil. USD. The asset size for Amaranth Advisors LLC hedge fund was approximately 9 bil. USD at its peak in 2006, thus more than two times bigger than the LTCM fund. While the default of the Amaranth Advisors did not induce any response from the FED, the default of the LTCM threatened the stability of the entire US financial system due to the singificant interlinkages at home and abroad and FED was called to step in.

network may induce further distress to other agents (Cifuentes et al., 2005). The trade-off between improvement in risk sharing (shock absorption) and threats posed by higher contagion effects (shock diffusion) goes hand by hand with increasing network interconnectedness.

Empirically, network analysis is widely used for studying the structure of the domestic interbank system (Cocco et al., 2009; Furfine, 2003; Iori et al., 2008), global banking network (Minoiu and Reyes, 2010; Hattori and Suda, 2007), international financial network (Cetorelli and Peristiani, 2009; Kubelec and Sa, 2010), global financial derivatives network (Markose, 2012) and other sectors of financial system. For a more detailed overview of the network analysis and its current stance see Allen and Babus (2008). In general, empirical studies report the existence of four basic features that can characterize most of the existing financial networks: (1) robust yet fragile structure,[2] (2) strength of weak ties,[3] (3) homophily,[4] (4) small world phenomenon.[5] Any of these four characteristics may pose a significant threat to systemic stability of any financial network and as such should be properly addressed by regulatory bodies. As we argue later in the text, the Single Supervisory Mechanism represents a tool that might help to mitigate some of the negative consequences of the features of the European banking network from the systemic risk point of view.

This study uses network analysis for investigation of the topological structure of the European banking network in terms of foreign claims, thus exposure toward country risk. In this sense, we focus on a systematic part of the financial system risk. As argued in Minoiu and Reyes (2010) the analysis of gross exposures can be a useful indicator of the contagion potential, thus a measure of systemic risk while the cross-border flows of financial capital reflect liquidity conditions in international markets and as such can be an informative source of financial distress. In that sense, our study expands research done by Allen et al. (2011) and Schoenmaker and Wagner (2013).

We restrict our study to national datasets for 13 countries available in the Bank for International Settlements database. While regulation of the banking sector in

[2] Many low-degree nodes that can be added to or removed from a network without disturbing the overall robustness of this network. Yet, when a hub is hit by a directed shock the network is fragile in a sense that the shock disseminates across the network and contagion spreads over.

[3] In social sciences the „strength of weak ties" concept was firstly introduced by Granovetter (1973). It describes the observation that rather then strong connections the weak ties enable transmission of information to large number of nodes over longer distances.

[4] Certain attributes tend to set up clusters of nodes, i. e. agents tend to associate disproportionately with those having similar traits.

[5] Network paths tend to be short or get shorter due to current trends in world economy (globalization, internationalization, economic integration etc.).

the European Union is harmonized to some extent[6], the supervision over the domestic banking sector (and financial sector) has been so far left to the decisions of particular member states.[7] The introduction of the Single Supervisory Mechanism will radically change this situation as part of the supervision power will be taken from the national supervisory bodies and transferred to the European central bank. As a result of the regulatory and supervisory architecture existing in the European Union before the outburst of the financial crisis the banking groups operating in various member states had been subject to different supervisory bodies and not supervised on an international level. As we would like to capture this dichotomy we focus on the country level data and not micro level data from individual banking institutions as some other authors do.

Additionally, the regulatory capital charges implemented in the Basel framework have been so far focusing mainly on the risk related to the individual institution's exposures in trading and loan books and do not take into account losses incurred as a result of high interconnectedness of a particular institution. On top of that, institutions whose fall may bring about the fall of the entire financial network (financial hubs, TITF banking groups etc.) are not penalized or charged in any other way for their incremental contribution to the risk of other institutions connected to them and any potential costs from network failure must be borne by the government and, ultimately, tax payers. Recent research tries to address this issue with various regulatory propositions (Adrian and Brunnermeier, 2009; Tarashev et al., 2009; Chan-Lau, 2010 and others). While those propositions basically aim to regulate the single institutions, the supervisory initiatives adopted at the international level aim to direct the TITF issue from the top level. The newly created Single Supervisory Mechanism, legally binding for all member states, might be in this sense understood as a tool for mitigating the systemic risk in the highly interconnected banking network in Europe. The implications of the banking network structure for the Single Supervisory Mechanism will be discussed in the next sections of this paper.

The key objective of this paper is to investigate the structure of the banking network in Europe from the network analysis perspective. The final results describing the characteristics of the banking network will be discussed in light of the Single Supervisory Mechanism (SSM) introduction. We advocate that the presence of heterogeneity and asymmetry in the network and a decrease in the level of foreign banking across Europe could be mitigated by the SSM introduction

[6] Traditionally, the EU regulation of the banking sector have been predominantely in form of EU directives that are not legally binding untill implemented by provisions of national law. Some of the measures, however, do have direct regulatory impact if present in a form of official EU regulations.

[7] Until 2011 the Committe of European Banking Supervisors operated on the Level 3 of the Lamfalussy approach serving as a place for co-ordination the supervision of cross-border institutions, thus operating as an advisory not supervisory body.

and from this perspective should be viewed as a positive step towards greater financial stability.

The paper is structured as follows. In the first section we present topological network measurements that are used to characterize the banking network of the EU13 economic space. The results are discussed in the second section of this paper. The third sections discuss the Single Supervisory Mechanism in light of our empirical results. Conclusions summarize our key findings.

1 Methodology and Data

Network analysis allows one to investigate the complex structure of various economic relationships among different economic agents. In our terms, the sovereign countries represent single economic agents that are connected to each other through foreign claims. Such a financial system can by visualized by a graph that consists from a list of nodes $\{1,2,\ldots,N\}$, where N stands for number of countries included into analysis, and a set of links with directed arrows connecting any two nodes. From the mathematical point of view, the financial network is represented by the $N \times N$ adjacency matrix $\mathbf{A}$, where $a_{ij} = 1$ indicates the existence of a link between nodes (countries) i and j, $a_{ij} = 0$ otherwise and with zeros on the main diagonal as the self-interactions are not allowed (not economically sensible).

A weighted network allows one to attach a positive number (weight) to each connection in the network that typically captures the strength of interaction between two economic agents represented by network nodes. By the nature of the foreign banking claims we are able to create two weighted matrices, $\mathbf{W}^O$ for outward investments (foreign claims) and $\mathbf{W}^I$ for inwards investments (foreign liabilities). Any non-zero entry w_{ij}^O measures the share of foreign claims originating in country i and being transferred to country j on total financial assets of the financial corporations sector of country j. Any non-zero entry w_{ij}^I measures the share of foreign liabilities in country i toward country j on total financial assets of the financial corporations sector of country i. The matrix of outward investments $\mathbf{W}^O$ is transpose of the weighted matrix of inward investments $\mathbf{W}^I$. Mathematically, the following must hold:

$$\mathbf{W}^I = \left(\mathbf{W}^O\right)^T \tag{1}$$

1.1 Topological Measures of the Banking Network

In our paper we deal with a complete directed weighted network. There is a variety of possible network characteristics that can be computed for different networks. The reasons behind our specific collection are discussed in the following text while presenting the mathematical formula for each one.

The ***in-strength (out-strength) degree*** of a node i measures total strength of dependency and is given by the following expression:

$$s_i^I = \sum_{j \in \forall i} w_{ij}^I \ , \ s_i^O = \sum_{j \in \forall i} w_{ij}^O \tag{2}$$

Economically speaking, with the in-strength degree we measure the portion of domestic financial assets that is owned by foreign counterparties no matter their domicile. The value of the in-strength degree might vary from zero (absolute autarky, i. e. foreign parties do not have any claims toward domestic agents) to any positive number (absolute openness, i. e. the higher the number the higher the involvement of foreign parties in domestic financial sector).[8] Conversely, the out-strength degree measures the absolute level of involvement of the domestic banking sector into the financial sector of all other network members. The value of the out-strength degree might vary from zero (absolute autarky, i. e. absolutely no involvement) to any positive number (absolute openness, i. e. the higher the number the higher the involvement of domestic banking sector into business of financial sector of other network players).[9]

The weights of edges linked to a particular node can either be of the same magnitude or they can be heterogeneously distributed with some edges dominating the others. The measurement of this heterogeneity is sometimes called as the ***participation rate ratio*** or disparity measure, but in reality is nothing else as the widely used Herfindahl-Hirschmann index. Participation ratio

[8] As discussed in the next section the data collected by the BIS does not only include international claims but also claims made by bank offices owned by foreign investors located in a domestic economy denominated in domestic currency. Theoretically, the total in-strength degree might exceed one in various extreme cases – international claims exceed total domestic financial assets of financial corporations or all domestic financial assets are in form of credit provided by the bank offices owned by foreign investors that have some foreing claims too, to name some of them.

[9] The proper interpretation of the out-strenght degree might be an intriguing one. Let us suppose that a country X ownes the only bank operating in the country Y, has no other international claims against country Y and no other involvement in any other network members‘ financial sector. The out-strength degree for that country would be 1 no matter the total value of the financial assets of country Y. Other network members might have much higher value of claims in absolute terms than the total value of assets owned by country X but their out-strength degree will be lower if they invest in countries with relatively big domestic financial sector owned by domestic subjects.

close to unity indicates preferential relationships between nodes and is calculated as follows:

$$h_i^W = \sum_{j \in \forall i} \left(\frac{w_{ij}}{\sum_{j \in \forall i} w_{ij}} \right)^2 = \sum_{j \in \forall i} \left(\frac{w_{ij}^O}{s_i^O} \right)^2 \quad (3)$$

Higher scores in the participation rate ratio are to be found for network nodes that concentrate their economic activity to smaller number of subject in terms of the total exposure. In our case (subjects are countries), higher score in the participation rate ratio points towards a preferential relationship among particular countries and goes hand by hand with possible clustering occurring in the network. Secondly, high score in the participation rate ratio might suggest inefficient allocation of resources of the domestic banking sector towards foreign partners ("do not put all eggs into one basket" rule).[10]

As the existence of directed and weighted networks brings along a more complicated and convoluted analysis, researchers tend to symmetrize the network (i. e. making in undirected) and then apply standard procedures for undirected network analysis. However, possible symmetry of our weighted matrices $\mathbf{W}^{O(I)}$ brings also many interesting economic insights into the nature of the international banking relationships among European countries.

We use the symmetry index proposed by Fagiolo (2006) in order to check for symmetry of a weighted matrix $\mathbf{W}^{O(I)}$ to reject or confirm the hypothesis, that the banking sectors of the chosen EU28 member states in terms of country risk exposure is highly skewed. In the case of a more or less symmetric network there is no "master-servant" relationship present and countries are equal in their relative power towards each other.

We use the „master-servant" term without implying any negative connotations related to it but just to label the situation when the relative exposure of the domestic banking sector towards a particular foreign partner heavily exceeds claims of domestic subjects against a foreign partner in relative terms. Many studies have confirmed the existence of positive externalities coming from the presence of foreign banks in the domestic banking sector. These include: increase in domestic competition, access to financial services, enhanced financial and

[10] In order to measure inefficiency in terms of excessive exposure of the domestic banking sector towards a smaller group of partners it would be necessary to compare the current distribution of exposures with a theoretical optimal distribution. In line with Markowitz portfolio theory measurements of country risk (e. g. country rating) and return (e. g. government bond interest rate) should be included. This we leave for a future research.

economic performance that all lead to greater financial stability (Claessens and van Horen, 2012). However, since the onset of the financial crisis possible negative consequences of foreign banking for domestic banking sector have often been discussed. By de Haas et al. (2011) and Popov and Udell (2010) shows that a decrease in lending due to the crisis in emerging European countries by foreign subsidiaries was higher than that by domestically owned banks. Countries with high relative exposure towards foreign banking institutions might consequently suffer a much higher drop in banking operations than those without it. As always, the costs might exceed the benefits even in international banking and we should ask where the threshold lies.[11]

The symmetry index of the directed matrix $\mathbf{W}^O$ is calculated in the following way:

$$S(\mathbf{W}^O) = \frac{\frac{N+1}{N-1}\tilde{S}(\mathbf{W}^O) - m_W(N)}{s_W(N)} \tag{4}$$

where the $N = 28$ for EU28 member states, $m_w(N)$ is given by the expression $m_w(N) = 0.25 - \exp\{-1.767551 - 0.937586 \ln N\}$, $s_w(N)$ is given by the expression $s_w(N) = \exp\{-0.913297 - 0.982570 \ln N\}$.

The value of the non-standardized symmetry index $\tilde{S}(\mathbf{W}^O)$ used in [1] is calculated in the following way:

$$\tilde{S}(\mathbf{W}^O) = \frac{\left\| \mathbf{W}^O - \left(\mathbf{W}^O\right)^T \right\|_F^2}{\left\| \mathbf{W}^O \right\|_F^2 + \left\| \left(\mathbf{W}^O\right)^T \right\|_F^2} = \frac{1}{2}\left[\frac{\left\| \mathbf{W}^O - \left(\mathbf{W}^O\right)^T \right\|_F}{\left\| \mathbf{W}^O \right\|_F} \right]^2 \tag{5}$$

where $\left\| \mathbf{W}^O \right\|_F^2$ is given by the square of the Frobenius (or Hilber-Schmidt) norm calculated as $\left\| \mathbf{W}^O \right\|_F^2 = \sum_i \sum_j w_{ij}^2 = N + \sum_i \sum_{j \neq i} w_{ij}^2$.

[11] For a deeper discussion regarding the costs and benefits of international banking and computation of a possible threshold see Schoenmaker and Wagner (2013).

In general, if the $S(\mathbf{W}^O) < 0$, then the network can be considered as the undirected one and the analysis of the undirected weighted network can be applied and vice versa.[12]

After testing for the symmetry of a network we compute the difference between out-and in-strength degree of a link ij to capture the strength of the "master-servant" relationship. For the measurement of the dependency between foreign and domestic banking sector in general we will calculate the ***dependency measure*** in the following way:

$$d_i = \sum_{j \in \forall i} \left(w_{ij}^O - w_{ji}^O \right)^2 = \sum_{j \in \forall i} \left(w_{ji}^I - w_{ij}^I \right)^2 = \sum_{j \in \forall i} l_{ij}^2 \qquad (6)$$

The value of the dependency measure is always positive with no upper bound, thus it is not be possible, per se, to say what direction does the "master-servant" relationship take, only to confirm its existence. By computation of the dependency measure we finally create a weighted undirected network serving as an illustration of the distribution of power across European banking network.

1.2 Dataset Description

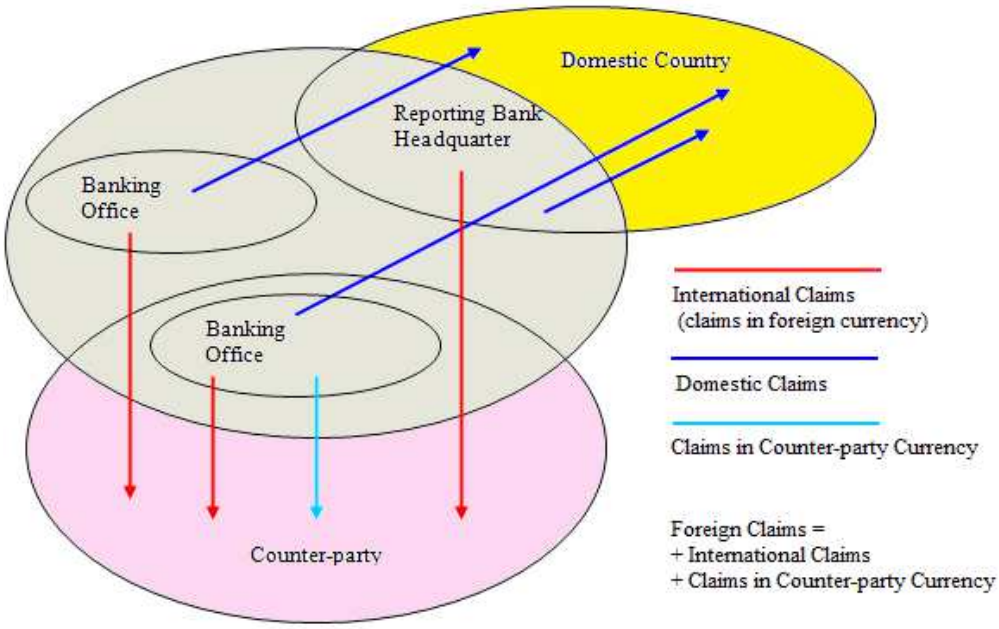
The dataset used in our analysis spans from year 2007 to the end of 2012 and observations are collected on yearly basis. Data are taken from the Bank for International Settlements (BIS) database for consolidated banking statistics on bilateral basis for 13 member states of the European Union for which we have complete data on bilateral foreign claim linkages.[13,14]

[12] This rule is used in Fagiolo (2007) and represents the situation when the value of the standardized symmetry index $S(\mathbf{W}^O) < 0$, i.e. is lower than the mean of the normal distribution $N(0,1)$ from which the $S(\mathbf{W}^O)$ is taken. In general, one can set the threshold to be any real number $x \in R$ and conclude that the graph is undirected if $S(\mathbf{W}^O) < x$ and vice versa.

[13] Austria, Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain, Sweden, United Kingdom.

[14] The BIS statistics provides data on foreign claims provided by 25 reporting countries from which only 13 countries belong to the EU28 economic region. Even though the creation of the bilateral matrix for 28 EU member state would be in theory possible the matrix would be incomplete. The paper by Allen et al. (2011, p.63) replaces the missing values for the rest of the 15 countries by zeros stating that: "Finland and Luxembourg, (…), as well as the new member states do not have any large banks that do sizeable business abroad." We do not follow their approach for the sake of data consistency.

Figure 1 Structure of the BIS consolidated banking statistics data



Source: Author's visualization

According to the BIS guidelines for reporting the BIS international banking statistics (BIS, 2014, p. 54), the foreign claims are defined as: "financial claims on residents of countries other than the reporting country, i. e. claims on non-residents of the reporting country. In the consolidated banking statistic, foreign claims are calculated as the sum of cross-border claims and local claims (in all currencies) of reporting banks' foreign affiliates, or equivalently of international claims and local claims denominated in local currencies." In comparison, the international claims are defined as (BIS, 2014, p. 55): "sum of cross-border claims in any currency and local claims of foreign affiliates denominated in non-local currencies." As we focus on exposure of domestic (reporting) banking sector to total country risk we will take data on foreign claims that includes both domestic as well as foreign claims of foreign affiliates of domestic banking sector. To illustrate the structure of the BIS consolidated banking statistics see Figure 1.

The total foreign claims of a reporting country against the receiving country will be divided by the total financial assets of the financial corporations[15] sector on a consolidated basis as reported by the Eurostat in local currency converted to the

[15] By the definition provided by Eurostat the financial corporations sector comprises all private and public entities engaged in financial intermediation such as monetary financial institutions (broadly equivalent to banks), investment funds, insurance corporations and pension funds.

US dollars by the end of period exchange rate. Basically, this is in line with procedure used in Allen et al. (2011) and Schoenmaker and Wagner (2011) for calculation of the outward and inward integration index.

2 Results and Discussion

In this section we discuss the results of the network analysis based on the data for EU13 countries in terms of claims of their banks' foreign claims, i.e. country exposure and measurement of systemic risk. Before discussing the topological properties of the EU13 banking network let us briefly comment on the role of foreign claims in total financial assets of the domestic financial corporations sector measured by inward integration index (in-strength degree). If in 2007 the index values varied from 11 percent (United Kingdom) to 31 percent (Greece), the financial and consequently the debt crisis has caused a drop of its value to a minimum level of 5 percent (United Kingdom) and a maximum of 22 percent (Belgium). Apparently, even after the crisis the level of foreign exposure in the domestic banking sector of some countries represents a significant factor for assessment of its stability and supports the need for assessment of the systemic risk present in the entire EU13 banking network.[16]

Table 1 reports the standardized Fagiolo Index values for period 2007 to 2012. In all years the computed indices are way over the zero threshold suggested by Fagiolo (2006) indicating that the matrix is directed, thus highly asymmetric. In economic terms, the high level of foreign claims floating from country i toward country j as is not reciprocated by backward flows in the form of foreign liabilities originating in country j measured as a proportion of domestic financial assets.

Table 1 Fagiolo Symmetry Measure of the EU13 Banking Network

	2007	2008	2009	2010	2011	2012
Fagiolo Index	18.479	20.316	22.083	20.524	20.864	20.181

Source: Author's computation

Turning to the development over time, the highest level of asymmetry was achieved in year 2009 with a subsequent decrease. Yet, the changes in the Fagiolo index over this relatively short period cannot be considered significant and are barely able to cover the fact that the relationship between domestic banking sectors in EU13 is highly asymmetric in terms of creditor-debtor position.

Table 2 and Table 3 provide the summary of the in- and out-strength degree of the banking sectors in the EU13 banking network. The countries with the highest influence over the banking sector of their network partners are France and

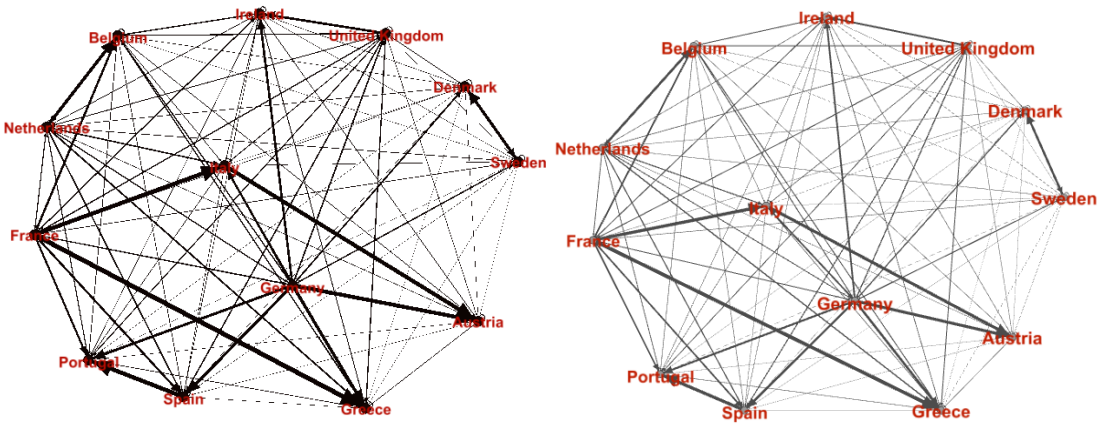
[16] Dependency on foreign financing is even more visible in the case of new EU28 members, such as the Slovak or Czech Republic. Initial calculations suggest that the value of inward integration index for those countries fluctuates around 60 percent.

Germany followed by Netherland and UK (out-strength degree). On the other side stand countries such as Portugal, Belgium and Austria (in-strength degree) that play the role of the most exposed countries toward their foreign partners. Regarding the evolution over time, the significant drop in the in- as well as out-strength degree signalizes substantial closing out of the foreign positions of network members. This tendency is the most visible in case of the PIIGS countries, such as Greece, Ireland or Italy (in-strength degree) where the debt crisis has led to fall in their dependency on the foreign banking sector, on one hand, but resulted in higher dependency on the international institutions ("Troika") on the other hand.

Belgium, as the representative country of the Western developed economies, proves to be a special case due to the problems of domestic banking sector caused by the financial crisis in 2008. While the dependency of the domestic banking sector had increased to unprecedented levels (in-strength degree, 2009), the foreign creditor position of the domestic banking sector was hit severely and reached its bottom (out-strength degree, 2012).

The visualization of these tendencies is provided by Figure 2. As apparent from the directed networks for years 2007 and 2012 the overall structure of the network remains almost untouched by the financial crisis; it is the overall strength of connections that was hit the most severely by the crisis and not the distribution.

Figure 2 EU13 Banking Network by Out-Strength Degree in Year 2007 (left figure) and in Year 2012 (right figure) in directed weighted network



Source: Author's computation

Note: The darker the color of the connecting edge between two nodes the stronger the connection between those nodes in comparison to the strength of the other edges. It is not possible to compare the strength of a particular connecting edge between the same two nodes (e.g. France and Italy) for different years (2007 and 2012) as both figures were

adjusted in a way to make the strongest connections visible while keeping the appropriate relative distances.

Another piece of the EU13 banking network puzzle is visually presented by Figure 2. The banking system is not only centralized but also highly asymmetric with some countries serving as leaders and some as followers. This leads to the structure characterized by one almost separated cluster (Denmark -> Sweden), one chainlike hybrid serving as a central hub of the entire financial structure (Netherlands -> Belgium <- France; France -> Italy -> Austria) one highly interlinked cluster-like structure (Netherlands -> Belgium) connected to the central hub, three countries connected predominantly in one-way direction to the central hub (Portugal, Spain, Greece) and the United Kingdom loosely connected to Ireland, then to other countries. As the overall structure of the network shows the geographical distances linked to other cultural and social factors clearly play a significant role in determining the strength of the linkages in the EU13 banking network.

Let us now focus our attention on the properties of the EU13 banking network in terms of its heterogeneity. Even though the absolute changes in the in- and out-strength degrees, thus the foreign exposure, are substantial the distribution of power remains relatively constant with slow upward trend towards more concentration in both in- and out-strength degree. For this reason we do not report the evolution of the HHI indices over time but only their 6-year averages.[17] As apparent from the results presented in Table 5, to countries with highest concentration of their dependency (in-strength degree) or their power (out-strength degree) belong Sweden, Denmark, Spain and Italy followed by Austria and Belgium. Countries that are able to distribute their foreign exposure the most heterogeneously are Germany, UK, Ireland and France.

[17] One exception to this rule is Denmark where the concentration in the in-strength degree has almost doubled to 0.567 over the last six years.

Table 2 In-Strength Degree of the EU13 Banking Network Nodes

	Austria	Belgium	Denmark	France	Germany	Greece	Ireland	Italy	Netherland	Portugal	Spain	Sweden	UK
2007	24.729	19.396	14.068	9.224	9.608	31.712	18.993	22.264	11.140	27.394	20.653	10.295	10.846
2008	24.009	19.550	11.637	8.071	9.080	28.001	17.872	20.373	8.617	27.185	19.943	11.000	7.298
2009	21.263	27.151	13.375	6.887	8.403	25.649	15.195	18.526	7.457	27.346	18.148	9.927	7.268
2010	18.353	22.236	13.105	6.709	8.234	18.686	11.304	14.569	7.353	22.731	14.924	8.204	6.074
2011	17.654	21.965	13.114	6.850	7.271	16.876	9.967	12.152	7.170	21.872	12.390	7.670	5.129
2012	17.328	21.910	12.983	5.954	7.437	8.098	7.960	11.080	7.516	18.823	10.631	7.978	5.156

Source: Author's computation

Table 3 Out-Strength Degree of the EU13 Banking Network Nodes

	Austria	Belgium	Denmark	France	Germany	Greece	Ireland	Italy	Netherland	Portugal	Spain	Sweden	UK
2007	3.660	16.019	5.754	46.257	54.746	0.158	8.716	18.347	26.961	2.578	15.726	8.758	22.641
2008	3.126	11.324	6.837	46.057	49.878	0.122	7.005	19.169	21.837	2.688	15.316	7.691	21.588
2009	3.222	5.102	5.127	56.777	45.961	0.296	6.155	15.352	19.166	3.154	15.540	9.126	21.615
2010	2.375	4.063	4.511	42.012	38.911	0.237	3.157	13.472	14.649	3.128	14.488	10.068	21.416
2011	1.955	2.993	4.176	38.314	34.424	0.222	0.928	13.032	14.089	2.651	14.659	11.426	21.212
2012	1.389	2.069	4.174	31.579	30.779	0.262	0.755	11.932	13.632	2.252	14.281	11.049	18.703

Source: Author's computation

Table 4 Dependency Measure of the EU13 Banking Network Nodes (average, 2007-2012)

	Austria	Belgium	Denmark	France	Germany	Greece	Ireland	Italy	Netherland	Portugal	Spain	Sweden	UK
Austria	0.00	0.16	0.02	2.49	**51.03**	0.40	0.16	**74.37**	0.31	0.04	0.05	0.00	0.38
Belgium	:	0.00	0.02	**107.53**	3.14	1.44	1.78	0.07	**34.40**	0.43	0.07	0.01	1.52
Denmark	:	:	0.00	0.79	4.80	0.00	0.11	0.02	0.22	0.01	0.01	*21.39*	0.26
France	:	:	:	0.00	0.08	**77.55**	1.99	**61.36**	0.85	*13.68*	*12.28*	0.78	1.72
Germany	:	:	:	:	0.00	**33.33**	*13.30*	2.06	0.88	*23.77*	*21.58*	3.33	1.02
Greece	:	:	:	:	:	0.00	0.92	0.84	3.19	1.61	0.02	0.01	3.66
Ireland	:	:	:	:	:	:	0.00	0.10	0.39	0.16	0.05	0.03	*12.73*
Italy	:	:	:	:	:	:	:	0.00	1.42	0.36	0.03	0.01	1.24
Netherlands	:	:	:	:	:	:	:	:	0.00	1.27	3.92	0.17	1.39
Portugal	:	:	:	:	:	:	:	:	:	0.00	**90.80**	0.00	6.80
Spain	:	:	:	:	:	:	:	:	:	:	0.00	0.00	1.27
Sweden	:	:	:	:	:	:	:	:	:	:	:	0.00	0.69
UK	:	:	:	:	:	:	:	:	:	:	:	:	0.00

Source: Author's computation

Note: The light-grey highlighted cells are assigned to the countries listed in the rows that are in a strong ***servant*** position of the "master-servant" relationship. The black highlighted cells are assigned to the countries listed in the rows that are in a strong ***master*** position of the "master-servant" relationship.

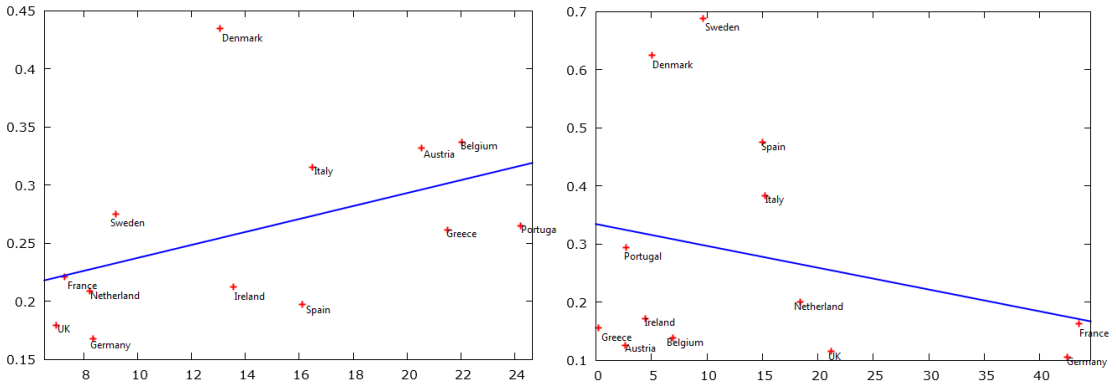
Table 5 HHI Index for the In-Strength Degree and Out-Strength Degree of the EU13 Banking Network Nodes (average, 2007-2012)

	Austria	Belgium	Denmark	France	Germany	Greece	Ireland
In-Strength Degree	0.332	0.337	0.435	0.221	0.168	0.261	0.212
Out-Strength Degree	0.126	0.139	0.625	0.163	0.105	0.156	0.172
	Italy	**Netherland**	**Portugal**	**Spain**	**Sweden**	**UK**	
In-Strength Degree	0.315	0.209	0.265	0.197	0.275	0.179	
Out-Strength Degree	0.383	0.200	0.294	0.475	0.689	0.115	

Source: Author's computation

Interestingly, the countries with a highest in-strength degree are generally those countries that report the highest concentration of their foreign exposures, with Denmark as an exception due to its mutual interdependence with the Swedish banking system. On the other hand, the more powerful the domestic banking sector in terms of higher value of out-strength degree the more equally distributed its foreign claims across the dependent countries, in general. Thus, the highly exposed countries are usually dependent on a small number of major creditors while creditor countries tend to spread their power over dependent countries more equally (Figure 1).

Figure 1 Relationship between HHI index (y-axis) and in-strength (left figure) or out-strength degree (right figure), average 2007-2012

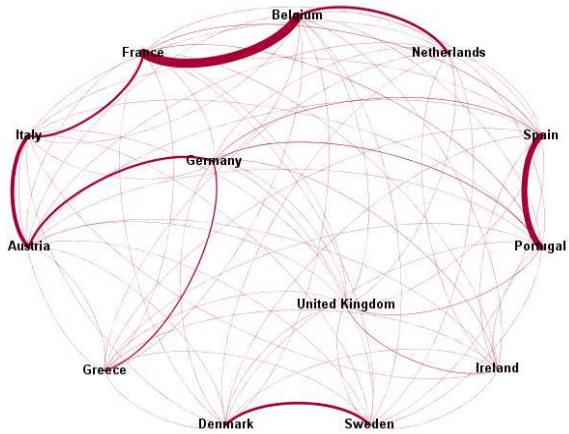


Source: Author's computation

Theoretically, this particular structure of the network might lead to the following scenario in case of a directed attack on some of the financial hubs – the greater equality in distribution in countries with high out-strength degree means that the shock is being transmitted to all links connected to the hub more or less equally

(risk-sharing). The countries entering the network in the "servant" position connected to the hub directed by an attack, on the other hand, serve as a receiver of their portion of risk, which, in relative terms, might cripple their domestic system if their exposure toward foreign partners is high.

Figure 3 EU13 Banking Network by Dependency Measure in Year 2012



Source: Author's computation

The structure of the network in terms of the dependency ratio is presented in Table 4 and Figure 3. The most uneven relationship between countries is visible between following partners: Denmark -> Sweden, Spain -> Portugal; Netherlands -> Belgium <- France, France -> Italy -> Austria; Germany -> Greece <- France. The potential implications of this uneven relationship will be discussed in the following part of the paper.

To sum our results up, at this point the existing structure of the EU13 banking network shows signs of robust, yet fragile characteristics with "master-servant" relationships present. Additionally, homophily (i.e. clustering on common characteristics) tends to be present as countries similar in cultural characteristics and close to each other in geographical terms are likely to form cluster-like structure.

2.1 European Single Supervisory Mechanism (SSM)

As one part of the solution to the European financial and debt crisis, the European Commission's proposal from 12 September, 2012 assigns the European Central Bank (ECB) new banking supervision tasks over the eurozone area's bank network. The Single Supervisory Mechanism represents the first pillar of the European Banking Union's three-pillar system that creates supranational supervisory architecture for common bank supervision in the EU, with ECB given the final supervisory power and national supervisors providing supporting roles.

Five basic conditions are given as the borderline between national and supranational jurisdiction: (1) the value of bank assets exceeds € 30 billions (the size criterion), (2) the value of bank assets exceeds both € 5 billions and 20% of the GDP of the member state in which it is located (the *economic importance criterion*), (3) the bank has large cross-border activities (*cross-border activities criterion*), (4) the bank receives assistance from a eurozone bailout fund (*direct public financial assistance criterion*), (5) the bank is among the three most significant banks of the country in which is located. These conditions are non-excludable and the bank can assume role of supervised entity under the ECB supervision on the basis of ***any*** of the conditions (ECB, 2014, Article 39).

Only the member states of the eurozone are obliged to follow the SSM scheme and become the members of the newly established European Banking Union. The non-eurozone member countries may enter and freely exit "close cooperation agreement" procedure. In that case the countries will act as full members of the SSM and will be obliged to all rights and responsibilities.

As our paper predominantly deals with the issue of bank cross-border exposures in the following text we discuss the criterion (3) in a more detailed way.

By the Article 59 (ECB, 2014, §1-3) the supervised group may be considered significant by the ECB on the basis of cross-border activities only when parent undertaking of a supervised group has established subsidiaries, which are themselves credit institutions, in more than one other participating Member State.

The supervised group is defined as a group (ECB, 2014, Article 6, §21: (a) whose parent undertaking is a credit institution or financial holding company that has its head office in a participating Member State; (b) a group whose parent undertaking is a mixed financial holding company that has its head office in a participating Member State, provided that the coordinator of the financial conglomerate, within the meaning of Directive 2002/87/EC of the European Parliament and Regulation (EU) No 648/2012 of the European Parliament and of the Council of 4 July 2012 on OTC derivatives, central counterparties and trade repositories (OJ L 201, 27.7.2012, p. 1) of the Council, is an authority competent for the supervision of credit institutions and is also the coordinator in its function as supervisor of credit institutions; (c) supervised entities each with their head office in the same participating Member State provided that they are permanently affiliated to a central body which supervises them under the conditions laid down in Article 10 of Regulation (EU) No 575/2013 and which is established in the same participating Member State.

A supervised group may be considered significant by the ECB on the basis of its cross-border activities only if the total value of its assets exceeds EUR 5 billion

and: (a) the ratio of its cross-border assets to its total assets is above 20 %; or (b) the ratio of its cross-border liabilities to its total liabilities is above 20 %.

The definition of the cross-border assets and liabilities are specified in Article 60 (ECB, 2014, §1-2). Cross-border assets', in the context of a supervised group, means the part of the total assets in respect of which the counterparty is a credit institution or other legal or natural person located in a participating Member State other than the Member State in which the parent undertaking of the relevant supervised group has its head office. Cross-border liabilities', in the context of a supervised group, means the part of the total liabilities in respect of which the counterparty is a credit institution or other legal or natural person located in a participating Member State other than the Member State in which the parent undertaking of the relevant supervised group has its head office.

The third criterion in the SSM mechanism is related to the cross-border activity of a banking entity that is subject to international jurisdiction. As we show the cross-border banking in a narrower sense and foreign banking in a broader sense represent an integral part of the European banking network which is reflected by inclusion of the cross-border activity criterion into the assessment of systemically important banking institutions (groups).

From the perspective of the EU13 banking network the network can be characterized by a higher level of clustering on a country level that may have a potential impact on the systemic risk of the banking sector on an international level. The one country from the EU13 group that is likely to stay outside of the SSM mechanism is the United Kingdom. This decision is understandable once we recall that the UK scores very low in in-strength degree which only reflects the low exposure of the UK banking system towards the other members of the EU13 in relative terms. Additionally, the UK banking system is the one with the most heterogeneously distributed claims and liabilities against the EU13 banking network which is likely to positively affect its robustness. The costs related to the single supervisory mechanism imposed by the ECB are thus likely to be considered inappropriate from the perspective of the UK policy makers. Interestingly, as the UK banking system is marked by the relative high out-strength degree which, economically speaking, means that the UK banks own a relatively significant portion of the EU13 banking network, the establishment of the SSM mechanism might increase the safety of the UK exposure without bearing the costs associated with the regulatory change.

Sweden is the second country after the UK that does not plan to enter the SSM mechanism. Once again as in the case of the United Kingdom the Swedish banking system is primarily oriented on investing in its closest neighbor – Denmark and its exposure towards other countries is relatively low. By Denmark

entering the SSM mechanism[18] the Swedish banking system might indirectly profit from common supervision without giving up national supervisory power.[19]

The highly asymmetric EU13 banking network supports the need for a common supervisory mechanism procedure as the domestic banking sectors of highly dependent countries are likely to be hit most severely once a liquidity shortage occurs on international level. In order to avoid the "cut and run" behavior of the owners of foreign capital (Allen et al., 2011) the Single Supervisory Mechanism can serve as a stabilizing component to prevent such behavior.

Lastly, due to the uncertain times ruling over the last five years foreign banking has been significantly reduced, as our numbers suggest. Allen et al. (2011) and Schoenmaker and Wagner (2013) argue that cross-border banking can yield significant gains from international diversification. The SSM procedure can indirectly affect decisions of the banking institutions to reestablish channels of international capital flows that have been previously closed due to the financial crisis or to create the new ones which could lead to a more stable and less asymmetric banking network.

Conclusions

This paper investigates the properties of the EU13 banking network in terms of foreign claims exposures in light of the currently established Single Supervisory Mechanism.

The banking network of the EU13 economic space can be characterized as highly asymmetric with tendency to create clusters based on geographic distance and cultural and social similarities. Too-interconnected-to-fail issue is also present in the EU13 economic space that forms the network structure characterized by some countries serving as the financial hubs and others as the dependent entities. Additionally, countries with a highest in-strength degree (Portugal, Belgium, Austria) report the highest concentration of their foreign exposures, in general. On the other hand, the more powerful the domestic banking sector in terms of higher value of out-strength degree (France and Germany) the more equally distributed its foreign claims across the dependent countries. Thus, the highly exposed countries are usually dependent on a small number of major creditors

[18] Even though Denmark does not belong to the Eurozone which means it is not obliged to participate on the SSM scheme some statements of official authorities might indicate that the country is actively considering its joining. Currently, Denmark is expected to become a next "close-cooperating" country along with Romania and Bulgaria.

[19] Assuming that the SSM will increase safety of the banking system of those countries included into this mechanism. Some authors argue that staying out of the SSM system might bring competitive disadvantage for the domestic banking sector and branches of banks not under the SSM supervision. If supervision by the ECB is considered as an important guarantee of soundness of banks, staying out might imply higher financing costs (Darvas and Wolff 2013).

while creditor countries tend to spread their power over dependent countries more equally. Due to the financial and debt crisis in Europe, the total exposure measured by the share of foreign claims on total domestic financial asset of financial corporations sector has significantly decreased.

One supervisory initiative adopted at the international level directing the TITF issue from the top level is the Single Supervisory Mechanism. From the network analysis perspective, the Single Supervisory Mechanism can serve as a stabilizing mechanism that ensures that the countries in dependent position will be less exposed to the possible "cut and run" behavior. Two countries from our dataset have so far adopted "wait and see" policy while rejecting the joining of the SSM system, namely United Kingdom and Sweden. From the European banking network perspective, this decision might be justifiable looking at the level and distribution of exposure of their domestic banking system towards participating countries. While not bearing the administrative costs related to the active participation in the SSM and not suffering the loss of supervision authority over the domestic banking sector, these countries might enjoy positive externalities coming from the decrease in systemic risk embedded in the banking sector network of their key partner countries. On top of that the Single Supervisory Mechanism could encourage the banking sector to restore foreign financing lost due to the financial and debt crisis in order to earn possible benefits from international diversification.

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References

Adrian, T. and Brunnermeier, M. (2009). CoVaR. Mimeo, Federal Reserve Bank of New York.

Albert, R., Jeong, H. and Barabási, A. L. (2000). Error and attack tolerance of complex networks. *Nature*, 406(6794), pp. 378-382.

Albert, R. and Barabási, A. L. (2002). Statistical Mechanics of Complex Networks, Reviews of Modern Physics, 74, pp. 47-97.

Allen, F. and Gale, D. (2000). Financial Contagion. *Journal of Political Economy*, 108(1), pp. 1-33.

Allen, F. and Babus, A. (2008). Networks in Finance. *Working Paper 08-07*, Wharton Financial Institutions Center.

Allen, F., Beck, T., Carletti, E., Lane, P. R., Schoenmaker, D. and Wagner, W. (2011). *Cross-Border Banking in Europe: Implications for Financial Stability and Macroeconomic Policies*. London: Centre for Economic Policy Research.

Barthélemy, M., Barrat, A., Pastor-Satorras, R. and Vespignani, A. (2005). Characterization and Modeling of Weighted Networks. *Physica A*, 346(1-2), pp. 34-43.

Bernanke, B. (2010). *Causes of the Recent Financial and Economic Crisis. Before the Financial Crisis Inquiry Commission*, Washington, D. C.

BIS (2014). *Guidelines for reporting the BIS international banking statistics*, update 14 March 2014. Available at: http://www.bis.org/statistics/bankstats guide_proprev2014.pdf.

Cetorelli, N. and Peristiani, S. (2009). Prestigious Stock Exchanges: A Network Analysis of International Financial Centers. *Staff Report no. 384*, Federal Reserve Bank of New York.

Chan-Lau, J. A. (2010). Regulatory Capital Charges for Too-Connected-to-Fail Institutions: A Practical Proposal. *IMF Working Paper WP/10/98.*

Cifuentes , R., Ferrucci, G. and Shin, H. S. (2005). Liquidity Risk and Contagion. *Journal of the European Economic Association,* 3(2–3), pp. 556–566.

Claessens, S., van Horen, N. (2012). Foreign Banks: Trends, Impact and Financial Stability. *IMF Working Paper WP/12/10*.

Cocco, J., Gomes, F. and Martins, N. (2009). Lending relationships in the interbank market. *Journal of Financial Intermediation,* 18(1), pp. 24–48.

Darvas, Z. and Wolff, G. B. (2013). Should non-euro area countries join the Single supervisory mechanism? *Bruegel Policy Contribution*, (06), pp. 1-15.

De Haas, R., Korniyenko, Y., Loukoianova, E. and Pivovarsk, A. (2011). *Foreign Banks During the Crisis: Sinners or Saints?* Mimeo, European Bank for Reconstruction and Development.

ECB (2014). *Regulation of the European Central Bank of 16 April 2014 establishing the framework for cooperation within the Single Supervisory Mechanism between the European Central Bank and national competent authorities and with national designated authorities*, European Central Bank, ECB/2014/17, 2014.

Fagiolo, G. (2006). Directed or Undirected? A New Index to Check for Directionality of Relations in Socio-Economic Networks. *Economics Bulletin*, 3(34), pp. 1-12.

Furfine, C. (2003). Interbank exposures: quantifying the risk of contagion. *Journal of Money, Credit and Banking,* 35(1), pp. 111-128.

Gai, P. and Kapadia, S. (2010). Contagion in Financial networks. *Working Paper 383*, Bank of England.

Granovetter, M. S. (1973). The Strength of Weak Ties. *American Journal of Sociology*, 78(6), pp. 1360-1380.

Hattori, M. and Suda, Y. (2007). Developments in a Cross-Border Bank Exposure Network. *CGFS Papers Chapters*, Bank for International Settlements.

Hurley, C. (2010). Paying the Price for Too Big to Fail. *Entrepreneurial Business Law Journal*, 4(2), pp. 351-389.

Iori, G., De Masi, G., Precup, O. V., Gabbi, G. and Caldarelli, G. (2008). A network analysis of the Italian overnight money market. *Journal of Economic Dynamics and Control*, 32(1), p. 259-278.

Kubelec, C. and Sa, F. (2010). The geographical composition of national external balance sheets: 1980-2005. *Bank of England Working Paper Number 384*, Bank of England.

Markose, S. M. (2012). Systemic Risk from Global Financial Derivatives: A Network Analysis of Contagion and Its Mitigation with Super-Spreader Tax. *IMF WP/12/282*, International Monetary Fund.

Minoiu, C. and Reyes, J. A. (2010). A network analysis of global banking: 1978-2009. *WP/11/74,* International Monetary Fund.

Newman, M. E. J. (2004). Analysis of weighted networks. *Physical Review E*, 70(5), pp. 613.

Popov, A. and Udell, G. (2010). Cross-Border Banking and the International Transmission and Financial Distress during the Crisis of 2007-2008. *ECB Working Paper No. 1203*, European Central Bank.

Schoenmaker, D. and Wagner, W. (2013). Cross-Border Banking in Europe and Financial Stability. *International Finance*, 16(1), pp. 1-22.

Tarashev, N., Borio, C. and Tsatsaronis, K. (2009). The Systemic Importance of Financial Institutions. *BIS Quarterly Review*, pp. 75-87.