

CROSS-BORDER BANK EXPOSURE NETWORK: A PRELIMINARY STUDY

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Abstract

In this paper we study the characteristics of the international banks' country risk exposures using the network approach and utilizing the Consolidated Banking Statistics (CBS) database provided by the Bank for International Settlements (BIS). International financial markets have been challenged during and after the recent financial crisis and as a result, several policy changes have been introduced to preserve the banking system from failure. A network perspective is a suitable framework to explore the connectedness of the world-wide banking system and to monitor potential threats to its stability. By calculation of several topological properties we are able to shed some light on interconnections among banking sectors on country-to-country level, although the applied methodology is also well-suited for the individual bank-to-bank exposure analysis. We extend the analysis by examining the cycles within the exposure networks, which correspond to the risk-sharing bank activities through the cross-border lending and borrowing at the same time.

Key words: bank exposure, networks, graph theory

JEL Code: F34, G15, G21

Introduction

After the last global crisis, a thorough analysis of financial sector seems to be requisite and has a direct implication for policy makers; as it turned out that regulatory framework was not adequate. From the recent financial crisis there are several studies addressing the “too-big-to-fail” conundrum (Thomson, 2009; Morrison, 2011; Patro et al., 2013, Oet et al., 2013 or Castro and Ferrari, 2014). One of the most important debates within the world-wide regulatory reform is that of “systemically important financial institutions” (SIFI) and/or “global systemically important banks” (G-SIBs). As noted by Thomson (2009), the definition of SIFIs is quite simple: “A firm is considered systemically important if its failure would have economically significant effects, if left unchecked, could destabilize the financial system and have negative impact on the real economy”. However, this definition is far from a workable

form and clearly cannot satisfy the needs of regulatory practice. The Basel Committee on Banking Supervision introduced the latest regulations (known as Basel III) that also specifically target SIFIs. Other institutions, like Financial Stability Board, International Monetary Fund and Bank for International Settlements (FSB/IMF/BIS, 2009) proposed using indicators for size, interconnectedness, and substitutability to measure the systemic importance of a firm. Thomson (2009) proposed to use size and the four C's (contagion, concentration, correlation, and conditions) as criteria to determine the systemic importance of a firm. Similarly, Patro et al. (2013) proposed stock return correlation as a useful indicator of systemic risk for markets as a whole.

In late 2009 investors and policy makers in Europe faced the possibility of a Greek default, an unprecedented situation which spread very quickly among other countries and may have tremendous effects on the entire European financial stability. In order to prevent contagious effects and their impact, various crisis resolution mechanisms have been introduced, such as temporary European Financial Stability Facility (EFSF) or permanent European Stability Mechanism (ESM). Along with an extensive stress-testing and systemic risk analyses, in November 2014 officially entered into operation the Single Supervisory Mechanism (SSM), the new system of financial supervision. Along with the European Banking Authority (EBA), established in January 2011 as a part of the European System of Financial Supervision (ESFS), European Union has established micro- and macro-prudential authorities in order to ensure complex financial supervision. All these changes, new mechanisms and institutions are leading to introducing the Banking Union.

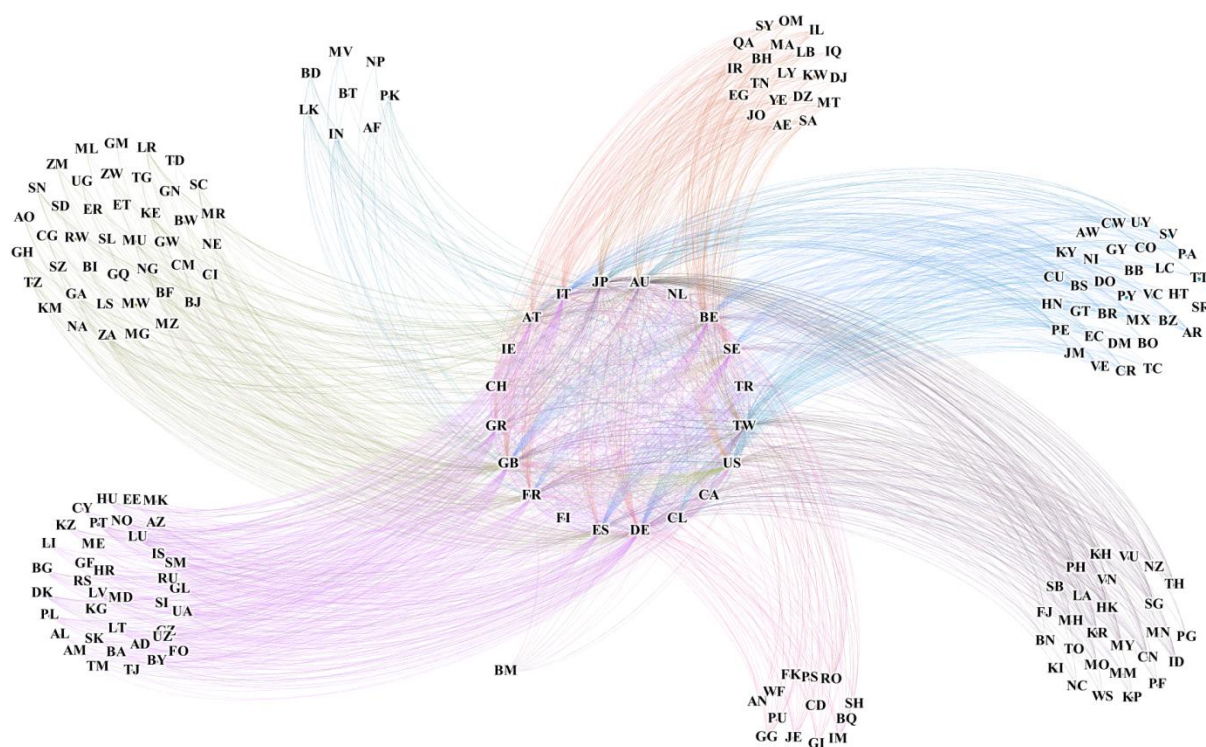
Estimating the systemic risk is crucial for early-warning systems and became a central interest of the regulatory authorities. Kano (2015) assess the analysis of theoretical network constructed of bilateral bank exposures (using data of the top 202 banks with more than \$50 billion in total assets) and showed, that G-SIBs play a central role in the global interbank market, as they may trigger contagious defaults. Black et al. (2016) proposed a systemic risk measure, so-called distress insurance premium, which accounts for characteristics as bank size, probability of failure (computed from credit default swaps), and correlation among equity returns.¹ According to this measure, European banks faced up a significant systemic risk with a peak in November 2011 (around €500 billion). Authors also identified Italian and Spanish banks as those with an increasing systemic importance.

¹ Note, that this measure is based on publicly available information. Other works on the topic of systemic risk analysis includes, among others, Borio (2011), Biais et al. (2012), Adrian and Brunnermeier (2014).

Network methodology appears to be the perfect choice for measuring and identifying SIFIs and other, not necessarily financial, systemically important firms (e.g. diversified global enterprises as General Motors). It is also well-suited for the examination of the banks' country risk exposures.

In this paper we apply the network approach to study international bank exposures at a country-to-country level. However, the same methodology can be used at individual bank-to-bank level, although such data on bilateral bank exposure are generally not easy to obtain.

Fig. 1: Full network consisting of reporting and non-reporting countries for 2010:Q4



Source: Authors' calculations based on the CBS database.

Note: Each group represent one of the following regions based on the World Bank's classification: "East Asia and Pacific", "Europe and Central Asia", "Latin America and Caribbean", "Middle East and North Africa", "North America", "South Asia", "Sub-Saharan Africa".

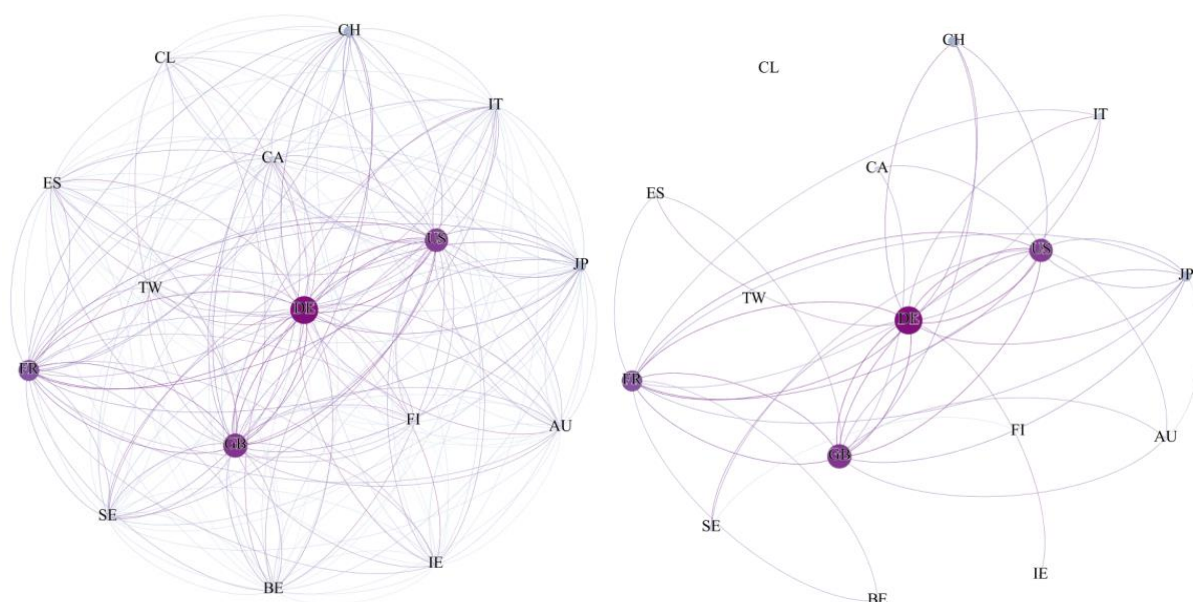
1 Consolidated banking statistics (CBS)

Dataset on banks' country exposures are obtained from The Bank for International Settlements (BIS). We are using consolidated banking sector total claims in millions of US dollars on an ultimate risk basis, for all instruments, all maturities, all currencies, for domestic banks excluding their domestic (intragroup) positions. Quarterly consolidated banking statistics are available for 26 reporting countries from the period from 2005:Q2 to 2015:Q3,

although the number of counterparties, as well as reporting countries may vary. This is actually the main disadvantage of the provided data, as an analysis of complex banks' country risk exposures is limited. This issue is demonstrated in Fig. 1.

In Fig. 1 we can see, that the path from the reporting country to non-reporting country has limited length as it ends in a non-reporting country. Thus, the topological properties of such network have only limited economic interpretation. For this reason in the following analysis we focus only on the exposures of all reporting countries. Due to discontinuities in data, the number of countries within our time span may vary².

Fig. 2: Exposure networks for 2010:Q4



Source: Authors' calculations based on the CBS database.

Note: Figure on the left represents the full network for 2010:Q4. Network on the right presents a subgraph with the least number of edges retaining 90% of the cumulative exposure of the full network. The size of a node corresponds to the amount of total claims of a given country.

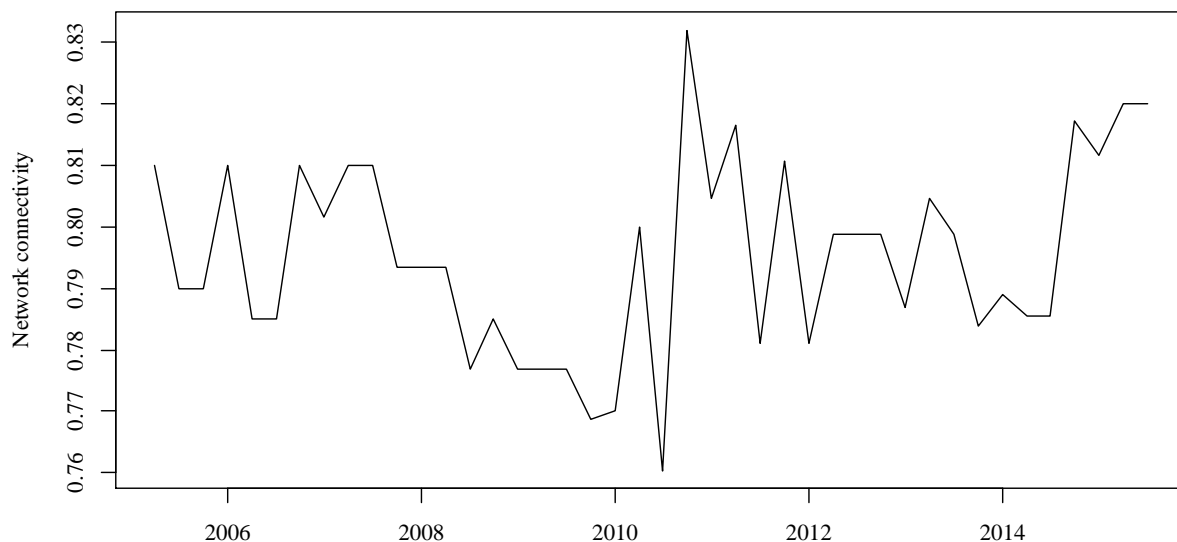
2 Exposure networks

We define an exposure network at period t as a graph $G_t(V_t, E_t)$, with the vertex set V_t consisting of all reporting banks within the period and a set of weighted edges $E_t \subseteq V_t \times V_t$ representing the exposure as reported in the CBS. Fig. 2 shows an example of such a network for the period of 2010:Q4, where the network density (measured as a percentage of edges to the number of possible edges, i.e. *connectivity*) was the highest. Fig. 3 depicts the evolution of the network connectivity over time. The two figures reveal, that exposure between reporting

² For further details please see the BIS website (breaks-in-series): <http://www.bis.org/statistics/>.

countries is: i) complex, in that around 80% of all possible relationships are actually present, ii) stable, as the connectivity remains within a 7% range within the whole sample.

Fig. 3: Network connectivity during the sample period



Source: Authors' calculations based on the CBS database.

Our first analysis focuses on the calculation of topological properties. As the networks are fairly dense, an analysis of centrality measures (degree, closeness, betweenness) shows similar dynamics as the overall connectivity (see Fig. 3). Also, other measures typically used to describe network dynamics, such as survival ratios are quite high³. Mathematically, this again follows from the high network density, but has economic rationale as well – as we are using quarterly data, this frequency might be too high for any dramatic changes to be recognizable within the network topology, given the possibly higher average maturity of instruments creating the overall exposure.

Next, we extract some basic statistics from the CBS database about the bank's exposures of the reporting countries, averaged over the sample period. Surprisingly, the most out-degrees (number of links from a given vertex) are on average found for South Korea, followed by Germany, Italy, Austria, and Canada. The most in-degrees (number of links to a given vertex) are for Germany, then Canada, Italy, Austria, and Spain.

We also reported the amount of average "Total lending" and "Total borrowing" in mil. US dollars, but the more interesting is to look at the relative variables "Total lending %" and "Total borrowing %", which depict the amounts of banks' country risk exposures in comparison to the total network exposure. Top four countries on both sides (lending and

³ Detailed results are available upon request.

borrowing) are Unites States, United Kingdom, France, and Germany. These findings led us to a further examination of the network cycles, as it is possible that the banks from these four countries are lending and/or borrowing to the banks with the same origin country.

Tab. 1: Averages of the selected variables (TOP 5 countries)

Out-degree	In-degree	Total lending	Total borrowing	Total lending %	Total borrowing %
KR 17.13	DE 16.89	FR 805690.8	US 636705.9	FR 0.21	US 0.30
DE 16.78	CA 16.60	GB 772587.6	GB 530100.9	GB 0.21	GB 0.24
IT 16.22	IT 15.00	DE 640080.1	FR 326906.9	US 0.17	FR 0.14
AT 15.25	AT 14.75	US 598627.9	DE 290496.2	DE 0.16	DE 0.11
CA 15.00	ES 13.41	CH 346233.5	JP 155060.1	CH 0.10	JP 0.07

Source: Authors' calculations based on the CBS database.

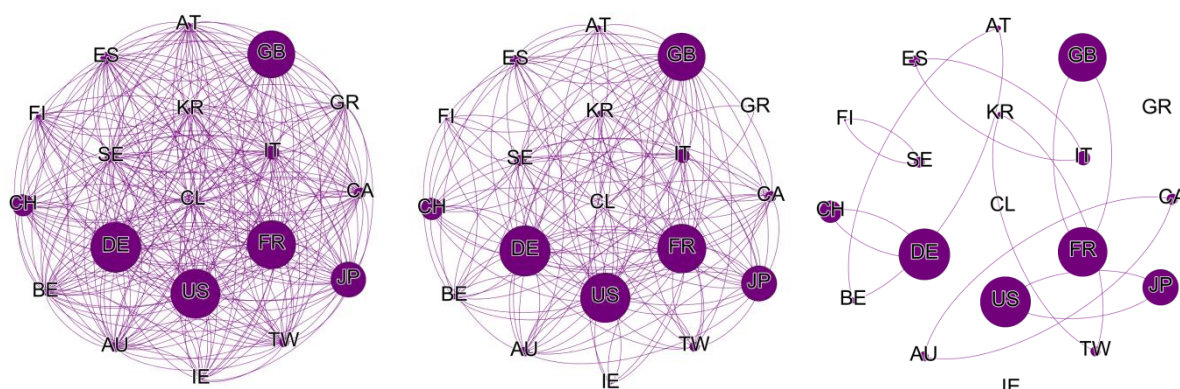
Note: The country abbreviations correspond to the ISO 3166-1 alpha-2 codes (i.e. KR – South Korea, DE – Germany, IT – Italy, AT – Austria, CA – Canada, ES – Spain, GB – United Kingdom, US – United States, CH – Switzerland, JP – Japan, FR – France). More detailed descriptive statistics are available upon request.

3 Cycles in exposure networks – interconnectedness

As the topological results are in line with expectations given the network density, we further focus on analysis of cycles.

Cycles present an interesting feature of the exposure network, as they corresponds to a situation in which banks in a local country prefer to lend abroad, but at the same time banks in other countries borrow to the local banks, completing the “loop”.

Fig. 4: Cycles in exposure networks for 2015:Q3



Source: Authors' calculations based on the CBS database.

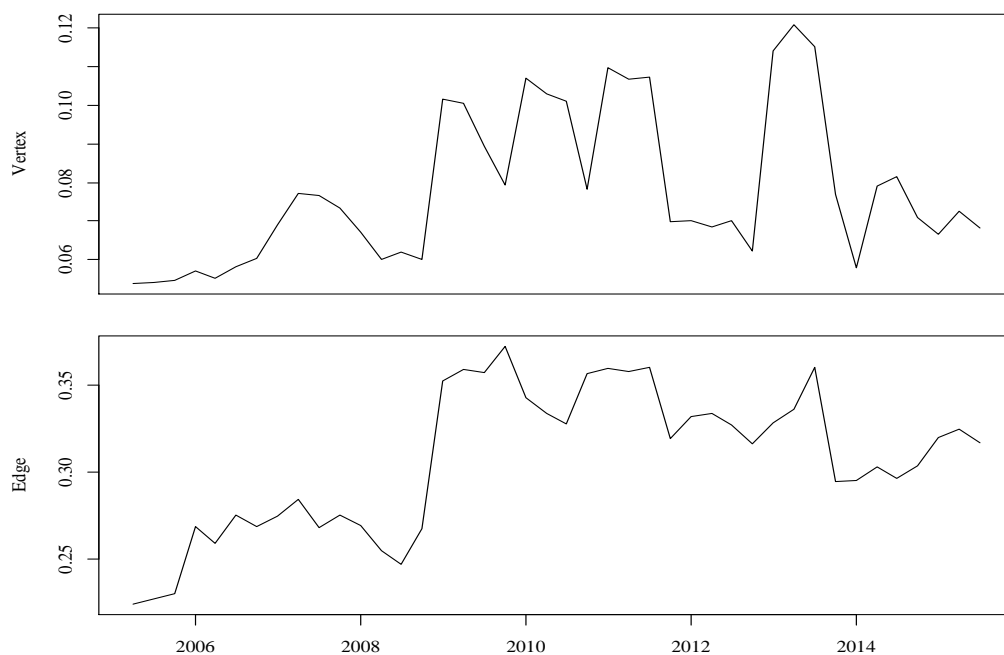
As an example, we have visualized in Fig. 4 three networks (for the last observation in our sample, i.e. 2015:Q3). The full network is visible on the left side of the Fig. 4. As there

are many cycles in the network, particularly a dense one such as in our case, one might wonder about the importance and frequency of this cycles occurring within the network. To put this into perspective, we calculated two kinds of subgraphs, focusing on the cycles.

The first type (“Type A”, depicted on the right in Fig. 4) follows an analogous algorithm, but replaces the edgewise disjoint condition with vertex disjoint constraint – no cycles shall share any of the vertices. This is clearly very restrictive. In this case, Greece and Ireland remained isolated. The non-existence of a cycle in this case means, that there is not a large bilateral exposure among these two countries and at the same time, the largest exposures exist among other reporting countries. From the size of the nodes it is apparent, that the banks which are borrowing/lending at the highest level among each other are operated in countries: United Kingdom – France, United States – Japan, and Germany – Switzerland.

Another strategy (“Type B”, showed in the middle of Fig. 4) is created by starting with a network with no edges, and then adding maximal cycles with respect to the minimum edge weight within the cycle. This corresponds to adding a cycle that allows for maximum possible flow. Further, maximal cycles are added, provided the cycles are edgewise disjoint – no two added cycles share any edges. The algorithm terminates, when either the network is a connected graph or we run out of cycles.

Fig. 5: Cycles as a % of total exposure for Type A (top) and Type B (bottom) networks



Source: Authors’ calculations based on the CBS database.

To generalize our findings regarding the cycles, we have plotted in Fig. 5 the percentages of the entire network exposure for our two types of restricted networks over the entire sample period:

Type A: Top panel of Fig. 5 – vertices can occur only once in any cycle (this corresponds to the network on the right of Fig. 4).

Type B: Bottom panel of Fig. 5 – cycles capturing all vertices, while edges are not repeated (this corresponds to the network in the middle of Fig. 4).

The most restrictive networks (Type A) containing only the largest bilateral exposures capture around 10% of the total exposure in a given network. The increase of these cycles is visible from the late 2008; while it is even more apparent for the Type B networks, where from the late 2008, the cycles represent more than 30% of a total network exposure. Banks' country risk exposures are thus quite large for a few countries.

Conclusion

In this paper we have exploited some possibilities of utilizing the CBS database provided by the Bank for International Settlements using the network approach. International banks' risk exposures became the center of interest for regulatory authorities after the recent financial crisis.

Our main finding is that the connectivity of bank exposure network is very high, particularly within the entire examined period. Around 80% of all possible relationships are actually present, which makes the banks' country risk exposure very high. Top four countries as both lenders and borrowers are United States, United Kingdom, France, and Germany. We further examined the network cycles, which present an interesting feature, as they correspond to a situation in which banks in a local country prefer to lend abroad, but at the same time, banks in other countries borrow to the local banks. These cycles are worth of further examination, as they are a nice example of a risk-sharing behavior among cross-country banks' exposures.

Only some preliminary results have been showed, as the CBS database has several limitations. It will be much more interesting, if individual exposures on a bank-to-bank level would be available and a complete bank exposure network may be constructed.

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