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Structure and dynamics of the global financial network

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ABSTRACT

In this paper, we study the evolution of the network topology for the global financial market. We evaluate the level of diversification and participation of developed and emerging economies in cross-border exposures and find that the gross exposure network is dense, the vulnerability matrix is sparse, and the network's fragility changes over time. Prior to the financial crisis in 2008, the network was relatively fragile, whereas it became more resilient afterwards, showing a reduction in financial institutions' risk appetite. Our results suggest that financial regulators should track down the network evolution in their systemic risk assessment.

1. Introduction

One of the main lessons of the 2008 crisis is that we live in an interconnected world. Financial systems, markets and instruments are not an exception. Since then, we have witnessed a crisis with unprecedented contagion that has had tremendous consequences in almost every corner of the world. Financial interconnectedness is at the top of the research agenda worldwide.

Understanding how to evaluate the potential for contagion due to financial interconnectedness is quite relevant for a variety of reasons. First, it allows for assessing the financial fragility of the current financial environment. Second, it is useful in the development of stress tests as one can include feedback effects in the analysis. Third, it can help regulators to assess potential vulnerabilities and their risk sources. Finally, it helps in designing better and more appropriate regulation frameworks.

Although research on global financial interconnectedness has a tremendous relevance for the discussion of a more comprehensive approach for financial regulation, most papers have focused on domestic networks in specific countries, such as in Brazil [2,13,21], the US [18], Mexico [8], Italy [6], the Netherlands [22], Turkey [7], among others.

This paper has a different perspective in the sense that it evaluates financial interconnectedness for a variety of countries using cross-border exposure data provided by the BIS. Therefore, our work permits us to evaluate which countries are systemically important and how their importance evolves over time in the global financial network.

The paper contributes to the literature in two ways. In the first, we investigate how the network topology of the global financial network from 2005 to 2014 evolves by employing network measurements borrowed from the complex network theory. We give clear financial interpretations for the evaluated measures. In the second, we investigate how the network dynamics behaves by assessing

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the persistence of financial operations over different time frames.

We relate the degree and strength measures to the level of diversification and participation of the countries, respectively. We find that the USA has the most diversified investment and funding portfolios. While its investment portfolio remains constant over time, the diversification of its funding portfolio increases from 2005 to 2014. We also observe that Oceanian and Asian countries tend to assume more diversified investment positions, but European and Latin American countries and Canada, on average, seem to reduce the diversification of their investment portfolios along the same period. We also see that all of the reporting countries, on average, show increasing participation in the international market, except for European countries, whose total investment amounts significantly decrease after the global financial crisis of 2007–2008.

Contrasting to domestic networks that are very sparse, we find that the gross exposure network of the global financial network is very dense. Moreover, we observe that the vulnerability network is perceptibly sparse. In special, we see that the network is potentially more fragile in-between 2007 and 2008, period that coincides with the global financial crisis. We also observe that, from March 2005 to the onset of the global financial crisis in 2008, the trajectory of the vulnerability network density assumes a consistent upward trend. After 2008, it rapidly drops down, suggesting that banks were less willing to accept risky positions.

We also find that the global financial network presents weak traces of disassortative mixing pattern. This feature contrasts with several works that analyze domestic interbank networks and conclude for the existence of strong disassortative patterns [11,13,19]. The difference might arise because of the nature of the financial systems: while the global network has dense topological structures due to the high activity of its members (G10 and emergent countries), those domestic networks are very sparse, with a significant number of entities connected to a few money centers. A high network density increases the chances of pairs of countries with similar degree to connect to each other, thus incrementing the network assortativity.

We interpret the clustering coefficient as a measure of the level of substitutability of countries in normal times. When the clustering coefficient of a country is large, its counterparties tend to be densely interconnected. In this way, these counterparties can substitute that country to one of those counterparties easily, because they already maintain financial operations with them. We find that the USA and European countries tend to become less substitutable in the borrowing side, but more easily substitutable in the lending side. In contrast, the level of substitutability of Latin American, Oceanian, Asian countries and Canada, on average, does not seem to change significantly in the studied period.

We also analyze the dominance as a network measure that indicates the relative importance of a reference country as a lender or borrower to its neighbors. We find that the dominance of the USA as a lender largely increases after 2010 due to the large outflow of investments performed by the USA after the failure of the Lehman Brothers. In contrast, European countries, on average, seem to lose importance as lenders in the studied period, while Oceanian and Asian countries have increasing dominance values in the lending perspective.

We investigate the existence of link reciprocity in the global financial network. We find that a large part of connections in the gross exposure network of the global financial market is mutual. Moreover, the link reciprocity seems to consistently increase from 2005 to 2014. We also study link reciprocity in the risk domain, i.e., in the vulnerability network. The occurrence of reciprocity in the risk domain contributes to increasing the speed of contagion because mutual links imply extended neighborhoods. In the risk dimension, we observe two behaviors in the link reciprocity of the vulnerability network. First, we see a large buildup in the link reciprocity before the global financial crisis. Following that event, just after the default of the Lehman Brothers, we observe a large decrease in the number of reciprocal links in the vulnerability domain.

We evaluate the network dynamics by analyzing how the observed link states change over time. In financial networks, the existence of persistent links between pairs of institutions may indicate preference attachment due to relationship lending or better contractual conditions in relation to the current market conditions. Unstableness may arise due to reclassification of the counterparty; external events, such as defaults that may force market players to perform reallocation strategies; among others. We find a large investment persistence in the network. In the risk domain, we see a consistent increase in the persistence of links that can potentially lead to default, suggesting that, even though banks were very exposed to others in relation to their capability of absorbing losses, due to the optimistic global scenario, they kept maintaining these risky financial operations in the network. This scenario drastically changed after the global financial crisis onset, when the persistence of vulnerable links largely dropped. This fact suggests that banks were attempting to avoid long-term risky positions in the global market.

1.1. Notation

In order to analyze the network, we extract some network measurements from the graph $\mathbf{G} = (\mathcal{V}, \mathcal{E})$ constructed from the active international borrowing and lending relationships between reporting countries of the BIS. To build up such network, let $\mathcal{V}$ denote the set of vertices (reporting country) and $\mathcal{E}$, the set of edges (active operations). The cardinality of $\mathcal{V}$, $N = |\mathcal{V}|$, represents the number of vertices or reporting countries in the network. The matrix $\mathbf{A}$ represents the assets matrix (weighted adjacency matrix), in which the (i, j)th entry represents the exposure of country i towards j. We construct the set of edges $\mathcal{E}$ using the filter over $\mathbf{A}$: $\mathcal{E} = \{\mathbf{A}_{ij} > 0 : (i, j) \in \mathcal{V}^2\}$. In our analysis, there is no netting between i and j. As such, if an arbitrary pair of countries owe to each other, then two directed independent edges linking each other in opposed directions will emerge. An interesting property of maintaining the gross exposures in the network is that, if a country defaults, its debtors remain liable for their debts. We also define