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The topology of cross-border exposures: Beyond the minimal spanning tree approach

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ABSTRACT

The recent financial crisis has stressed the need to understand financial systems as networks of interdependent countries, where cross-border financial linkages play the fundamental role. It has also been emphasized that the relevance of these networks relies on the representation of changes follow on the occurrence of stress events. Here, from series of interbank liabilities and claims over different time periods, we have developed networks of positions (net claims) between countries. Besides the Minimal Spanning Tree analysis of the time-constrained networks, a coefficient of residuality is defined to capture the structural evolution of the network of cross-border financial linkages. Because some structural changes seem to be related to the role that countries play in the financial context, networks of debtor and creditor countries are also developed. Empirical results allows to relate the network structure that emerges in the last years to the globally turbulent period that has characterized financial systems since the latest nineties. The residuality coefficient highlights an important modification acting in the financial linkages across countries in the period 1997–2011, and situates the recent financial crises as replica of a larger structural change going on since 1997.

1. Introduction

Despite the conventional wisdom that national economies are interdependent there is less evidence on the contribution of economic crises to the reinforcement of cross-border financial interdependencies. The recent financial crisis has stressed the need to understand financial systems as networks of countries where cross-border financial linkages play the fundamental role. Furthermore, it has become clear that the relevance of these networks relies on the representation of changes follow on the occurrence of stress events.

The adoption of an evolving network approach is recommended not only because of the proper emphasis on the financial interdependencies but also due to the possibility of describing how the structure of these interdependencies evolves in time. In so doing, we are able to address the role that an existing network structure plays in the spread of shocks and conversely, the effectiveness of stress events and their impact on the structure of the network.

In August 2007, the crisis of the subprime mortgage industry stormed the financial systems of several countries. As a response, hundreds of billions of dollars were injected by the authorities into the market. Nevertheless, this was not enough to avoid the second wave of a financial crisis.

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Since the end of 2009, the downgrading of Greek debt has been followed by several debt crises in the EU member states. As many of these countries cope with a decline in growth prospects and an increase in debt loads, the spread of the shocks seems to lead the EU to an unsustainable macro situation [1].

Deriving macro (global) situations from micro (local) scenarios has been a recurrent topic in economics. The way to link the macro and the micro levels hinges on graph theory, which has been recently introduced in economics to study formally the generation and stability of economic interactions among agents [2,3]. Even though basic geometric and topologic structures have already been used by Helpman and Krugman [4] to explain international trade relations, the knowledge on the complex structure of financial networks is far from being sufficient to realize the potential of the topological approaches.

Several authors have reported the opportuneness of describing financial linkages through a network approach. Some papers have favored the study of interdependencies between credit banks [5], or focused on the analysis of shocks storming the financial systems of several countries [6]. The topological properties of national interbank markets have also been studied by Soramaky and co-workers [7] as they analyzed the network topology of the interbank payments transferred between commercial banks over the Fedwire Funds Services [8]. In the same context, Fuijwara and collaborators explored the credit relationships between commercial banks and a set of Japanese companies [9].

The adoption of a network approach on empirical data has also been conducted in the characterization of the Italian [10] and the Austrian [11] interbank markets. More recently, Kubelec and collaborators [12] as well as Garratt and co-workers [13] used the Bank for International Settlements (BIS) consolidated banking statistics to develop cross-border banking networks. McGuire and co-workers [14] studied the international banking system while focussing in the cross-border financial trade. A similar approach was adopted by Minoiu and co-workers [15] in their study of global banking networks. For several extreme phenomena taking place at the global economic level, they found enough evidence of incoming instabilities in the network regime.

There has been much effort expended recently to study economic and financial crises through the characterization of rare events [16–19]. In this context, there are at least two important and complementary research branches: (i) the investigation on the underlying stochastic process that generates the rare events and (ii) research on time series analysis and modeling in order to predict the future of a measurement series on the basis of its past, where correlation based measures play the central role. While the first branch comprises the pioneering work of Mandelbrot [20] on the shape of a probability distribution function; the second branch of research has been stressing on cross-correlations based distances, which includes both Time-lag Cross Correlations [17] approaches and Random Matrix theory [16]. In trying to characterize and predict the occurrence of rare events, both branches have been concerned with the estimation of systemic risk [18] and its association with financial crises.

Here, also starting from a statistical setting, our approach is driven by a geometrical and topological perspective. Later on the paper we shall argue that, as the distances between countries are related to the covariances of their net positions, much of what we discuss could be carried out in a purely statistical setting. However, the fact that those distances are properly defined distances gives a meaning to geometrical and topological tools in the study of the interbank market.

Topological coefficients have been the object of growing attention ever since some network regimes were identified as the underlying structures of important phenomena found in many different fields. However, as most of these coefficients apply to graph structures that are connected and sparse, when analyzing systems whose topological signature is a complete (fully-connected) network, there is a need to find out the corresponding representation of the system where sparseness replaces completeness in a suitable way. It has been often accomplished [21–24] through the construction of a Minimal Spanning Tree (MST).

In the present paper we have explored an equivalent approach to construct a sparse and connected network of financial linkages across countries. From time series of interbank liabilities and claims conducted through the international banking system, we have developed networks of countries' positions (net claims). The networks are built for the last 28 years and for two chronologically successive branches of 14 years.

In this context, besides the MST analysis of the cross-country networks, a coefficient of residuality is defined to capture the structural changes occurring on the network along the last 28 years. In so doing, this measure not only captures changes in the threshold that insures connectivity of the whole network, but allows for measuring modifications in the relative amounts of strong and weak ties.

Because some structural changes seem to be related to the role that countries play in the financial context, networks of debtor and creditor countries are also developed. Empirical results allow to relate the network structure that emerges in the last years to the globally turbulent period that has characterized financial systems since the latest nineties. The residuality coefficient highlights an important modification acting in the financial linkages in the period 1997–2011, and situates the turbulent period that has been characterizing the global financial system since the Summer 2007 as a replica of a larger structural change going on for a decade. This occurs in such a systematic fashion that it may not be a statistical accident.

The paper is organized as follows: Section 2 briefly presents the set of empirical data we work with. Section 3 is targeted at presenting the method and the first results obtained from its application. The main contributions of the paper are presented in Sections 4 and 5: the coefficient of residuality and its application to the evaluation of the structural evolution of some specific networks as those that result from the identification of debtor and creditor countries. The paper ends with appropriate conclusions and outline of future work.