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Macro-Networks: An application to euro area financial accounts ☆

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ABSTRACT

This paper develops a financial network, designated the "Macro-Network", that depicts the connections between the main financial and non-financial sectors of the economy in the various financial instruments of the euro area. The Macro-Network comprises of linkages across financial and non-financial sectors in each country. These country-level sector networks are then connected by the cross-border links between the individual banking sectors. Using the Macro-Network to simulate financial shocks, we find that the propagation effects depend on the underlying network structure, which evolves over time. After the financial crisis, bilateral linkages contracted sharply, reflecting the surge in counterparty risk and the de-leveraging processes. Nonetheless, our analysis suggests that even after this process, vulnerabilities remained in the euro area financial system, while a more diversified portfolio of cross-border exposures might mitigate the shock effects. We identify sectors which are most relevant for the propagation of financial shocks in the Macro-Network.

1. Introduction

The financial crisis that erupted in August 2007 generated global peacetime economic losses that had not been experienced since the Great Depression of the 1930s. The crisis, which originated from a relatively minor segment of the US housing market, spread across sectors and countries via financial markets and balance sheet exposures. The subsequent large-scale government support measures for the financial sectors, combined with an economic downturn, stretched government balance sheets and caused a sharp deterioration in public finances in most advanced economies. These losses were particularly acute in the euro area, where the size of the banking sectors are large relative to the GDP, and government financial positions face constraints due to the fiscal rules outlined in the Maastricht Treaty. Furthermore, faced with sudden losses in their asset values, banks stepped back from their lending exposures to the domestic and foreign non-financial sectors. Banks also sharply scaled back their cross-border wholesale financing exposures to counter the unforeseen counterparty risk exposures. This de-leveraging process acted as a financial accelerator and added to the losses faced by the banks' borrowers, governments and, as a result of the deteriorating debtor credit quality, the banks themselves. The end result was a malicious feedback loop between the financial and non-financial sectors and a marked deterioration in financial integration in the euro area and globally (see European Central Bank, 2012).

Dudley (2009) and Stiglitz (2008) discuss the potential for systemic risk in financially interdependent economies. They note that the speed and scope at which losses may propagate in the global financial system is partly facilitated by the growing interconnectedness of the balance sheets of firms, households, financial institutions and governments both at the national and at the cross-border level. Our paper focuses on these balance sheet interconnections and applies techniques from financial network analy-

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sis to study how the financial linkages between the institutional sectors have developed since the launch of the single European currency in 1999 and how they have reacted to the financial crisis. We estimate stylised networks of the sectors at the euro area–country level that capture the financial exposures both between the financial and non-financial sectors. These country-level networks are then connected by a cross-border network of national banking sectors. The resulting "Macro-Network" allows us to perform simulations of shock propagation and to analyse the static and dynamic features of the financial interconnections at the euro area level. Our findings suggest that despite the deleveraging process that followed the first round of the financial crisis in 2007–2008, the contagion risks did not meaningfully decrease.

Network analysis has recently emerged as an appealing approach to analyse financial contagion and systemic risk. However, despite the obvious usefulness of network tools in modelling interconnections, the financial applications are still relatively limited. A key reason is that a network representation requires detailed data on counterparty exposures, which are still rarely available, at least from public sources. To address the data limitation issues, previous empirical studies have often based the analysis on estimated linkages. For instance, estimated bilateral exposures have been used to depict the networks of national interbank payment systems (e.g., Upper and Worms, 2004; Degryse and Nguyen, 2007; Mistrulli, 2011). Another strand of the literature has adopted methods applied in epidemiology and biology to construct financial networks using mathematical methods. In this vein, Nier et al. (2007) exploit a banking system network to study contagious defaults and banking sectors resilience to systemic risk. Gai and Kapadia (2010) investigate the effects of the failures of individual institutions and how the likelihood of contagion risk depends on the market conditions and the network structures. In Gai et al. (2011), numerical simulations are used to study the interbank market and derive policy implications. Other papers construct credit networks and study the static and dynamic properties of financial propagation effects (Eisenberg and Noe, 2001; Battiston et al., 2012; Co-Pierre, 2013).

Our chosen methodology relates to both these strands of literature. However, our approach differs substantially from previous applications in that we develop networks at a more aggregated level or macro-level. Extending the work by Castrén and Kavonius (2013),[2] our starting point is the balance sheets of the main institutional sectors of the economy that form the nodes of the estimated networks. While linkages among the sectors at the country level need to be estimated from the balance sheets, the linkages at the cross-border level are observed for the banking sector. The resulting networks, which are constructed separately for the different instrument categories, connect the individual sectors of the 11 countries of the euro area. This representation is necessarily stylized: The macro data do not allow us to capture the complexity and interconnections that are present in the euro area financial system.

This notwithstanding, our approach provides certain advantages. First, it paints a broad picture of the financial linkages at the euro area level and collects the financial exposures of the various sectors in a unique setting. Second, it makes a useful framework for the shock propagation simulations, both across sectors within the countries and across the countries. The main methodological novelties of the present paper are to include some of the cross-border elements that exist within the euro area and to exploit recent advances in estimating the sector level networks. Regarding the latter, we analyse the complexity of the system in term of not only the direct bilateral linkages but also the indirect connections between sectors. In this way, we are able to identify the important structural heterogeneity in the interconnections across sectors and countries.

[2] They use sector balance sheets at the euro-area aggregate level.

We find that the euro area Macro-Network provides a suitable platform for simulating contagion and shock propagation. Thus far, the analyses of the economy-wide contagion effects via balance sheets (interlinked claims and obligations) and the liquidity spiral effects from asset fire sales and de-leveraging have for the most part been limited to theory models with limited empirical data (see e.g. Kiyotaki and Moore, 1997; Adrian and Shin, 2010; Shin, 2008). The recent empirical work by Degryse et al. (2010) use gross bilateral exposures at the banking system level to investigate the transmission of shocks over the period 1999-2006. For our setting, we are interested in understanding how the shocks propagate both domestically and across the borders in the euro area financial system and the extent of the financial losses that may be generated in these processes. In this sense, our work complements the theoretical studies that analyse how shocks propagate in the system as a function of the network architecture (Allen and Gale, 2000; Elliott et al., 2013; Cabrales et al., 2013). In particular, Elliott et al. (2013) and Cabrales et al. (2013) model the networks of firms linked by cross-holding positions and study the resulting contagion effects.

Our main findings are as follows. First, the global economic impact of a shock of a given magnitude strongly depends on its initial location, in terms of the financial instrument, economic sector and country of origin. In this way, we are able to identify the specific sectors in particular countries that are the most prominent in terms of the potential of generating system-wide losses in the euro area. Second, we uncover the large differences in the post-propagation losses not only in quantitative but also in qualitative terms. The country-specific structures of the linkages between the domestic sectors and to foreign countries are the key drivers of the propagation mechanisms, the speed of contagion and the iterative feedbacks in the model. Third, we find that the network structures and the propagation losses are strongly time-variant. We perform simulations quarter-by-quarter throughout the years 2003–2012, covering also the recent financial crisis. We observe a general increase in the potential economic losses caused by a standardised shock between 2003 and 2007, owing to the increase in volume of the bilateral linkages in the Macro-Network throughout this time period. After the financial crisis, the volumes of the bilateral linkages contracted sharply, due to the reduction in counterparty exposures and the de-leveraging processes that ensued as endogenous and procyclical responses to the financial crisis. Nevertheless, in terms of the propagation of shocks, vulnerabilities were not meaningfully reduced in the euro area financial system. Fourth, we demonstrate that network statistics may provide useful predictions of the ways shocks propagate in the system and, more generally, of the sensitivity and resilience of different types of financial systems to shocks. Fifth, considering a different network configuration we show that under a diversified structure of cross-border exposures, the post-propagation losses can be reduced.

Overall, our findings confirm the importance of understanding the pattern of interconnectedness in the financial systems. The multiple channels through which the financial shocks may spread between sectors underlines the potential for the systemic financial stability risks what are latent in closely integrated economies. We conclude that the trade-off between efficiency and stability in the financial networks is an important element to be considered in any welfare analysis of financial integration. In addition, by shedding light on the more remote links and connections in the financial system, the analysis provides new insights for counterparty risk management at the aggregated level.

The remainder of the paper is organised as follows. Section 2 presents the data and the methodology. Section 3 provides the key definitions and describes the constructed network and its topological properties, considering in detail certain methodological aspects. Section 4 contains the simulation analyses and the shock propagation exercises, and formulates financial stability