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Math 168: Introduction to Networks
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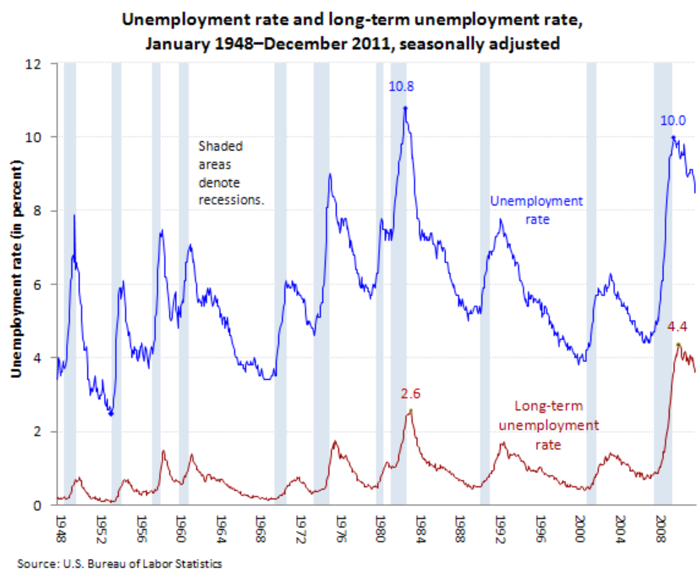
Review of Pathways Towards Instability in Financial Networks

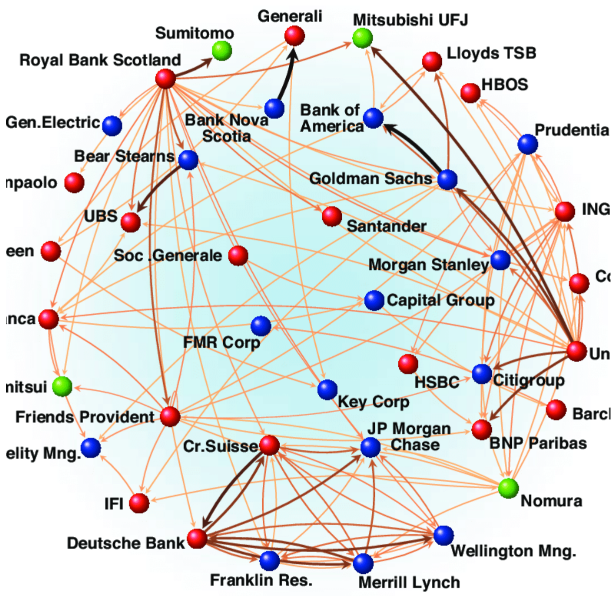
Motivation and Introduction

On 15 September 2008, the Lehman Brothers filed for bankruptcy, in culmination of the 2007-2008 financial crisis and began an international banking crisis. Just in the United States, more than 8 million people lost their jobs (Jones). The effects were as far-reaching as to the other side of the world: India reported "decline of gross domestic product by more than 2 percentage points in the fiscal year 2008–2009" (Kumar and Vashisht 2009). The impact was overarching across all sectors: my father working in the telecommunications industry in India lost his job. Thus, the effects of the Great Recession hit hard at home.



Unemployment Rate in the United States (1948 - 2010)
Source: U.S. Bureau of Labor Statistics

Understanding the factors that contribute to financial instability is key to preventing such a global economic catastrophe. The paper "Pathways Toward Instability In Financial Networks" presents ideas to decipher the complex web of financial entities' (banks in this case) relationships, unveiling how increased network complexity and interconnectedness, often perceived as strengths, can paradoxically sow the seeds of systemic vulnerability. In this analysis, the banks are considered as nodes, and the directed edges between them represent the interactions. The below figure can be used to gain a basic understanding of the financial network discussed in this paper.

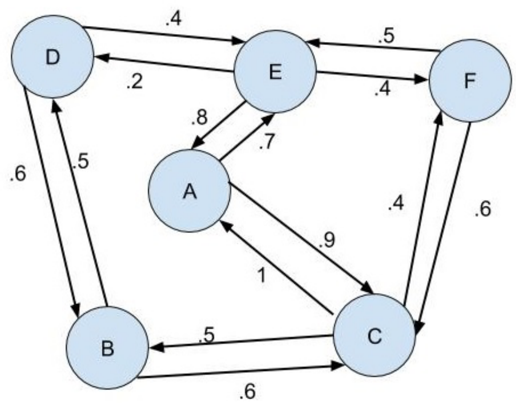


Directed Network of Banks
Source: Medium, Analytics Vidhya

Core Concepts and Methods in the Paper

Until the 1970s, it was believed that increasing complexity provides stability to networks. However, in May's analysis "a class of network models indicated that networks with a larger number of interactions (at fixed interaction strengths) were less stable" (Bardoscia et al.). Applying this to financial networks, the paper delves into the systemic risk in financial networks, highlighting how the greater interconnectedness of various financial entities such as banks, investment firms, and insurance companies and diversification of risk can contradictorily contribute to instability. The study pinpoints two primary mechanisms through which financial distress spreads: (i) illiquidity contagion, where banks withdrawing funds from their counterparts due to anticipation of loss and default trigger a domino effect, and (ii) deterioration of interbank assets, where mark-to-market practices leading to asset devaluation and subsequent losses that ripple through the network. Additionally, the paper highlights the crucial role of cyclical structures within networks, and the concept of 'pathways to instability,' demonstrating how financial networks can transition from stable to unstable states without any change in average interbank leverage.

The methods employed attempt to provide a comprehensive approach to understanding financial networks. Direct weighted networks model the interactions between different financial entities, offering a detailed perspective on the relationships and the extent of their interconnectedness. A significant methodological tool is the eigenvalue analysis of the interbank leverage matrix (leverage is the ratio between total assets and equity of a bank and the elements of the leverage matrix represent each entity with respect to each specific asset class or counterparty), which plays a pivotal role in determining the financial system's stability by pinpointing specific conditions for systemic shocks. Additionally, the paper delves into the exploration of various network topologies, including regular random graphs, scale-free graphs, and core-periphery graphs. This exploration is crucial in understanding how different structural configurations of the network influence its stability. Given the sensitive nature of interbank exposures, the study applies techniques like the RAS algorithm for reconstructing these exposures from the limited public data available. Another crucial aspect of the study is scenario analysis, where different network scenarios are simulated. This analysis observes the effects of changes in the network's topology and the integration of new entities or contracts, providing insights into the overall stability of the financial system.



Basic Directed Weighted Network
Source: Bookdown.org

Theoretical Contributions of the Paper

The paper offers significant theoretical insights into the dynamics of financial systems through the lens of network theory and systemic risk. It establishes a compelling analogy between the complexities of financial systems and ecological networks, underscoring how the similarities between networks and how structure influences the propagation of instability. A key contribution is shifting the focus from individual risk to the greater network for vulnerability to instability. The paper challenges the traditional belief that market integration and diversification inherently stabilize financial systems and goes to illustrate how they can instead cause financial instability in the system. A novel theoretical concept introduced is the 'pathways towards instability', demonstrating that increasing the number of entities or contracts in a financial network can destabilize an otherwise stable system, regardless of the risk profiles of individual entities.

Applied Contributions of the Paper

The paper provides applied contributions for banks and policymakers to avoid an economic recession:
(i) Policymakers: The concept of 'pathways towards instability' gives policymakers a valuable quantifiable tool to identify and monitor potential scenarios where market integration and diversification could lead to increased systemic risk. This understanding is crucial for developing more effective macroprudential policies that can preempt and mitigate the risk of financial crises.

(ii) Banks: The eigenvalue analysis of the interbank leverage matrix, developed in the paper, provides a novel approach to assess their exposure to systemic risk. By understanding their position within the network and how different network configurations can impact stability, banks can make more informed decisions regarding their investments, risk diversification, and interbank relationships.

Limitations or Challenges of the Paper

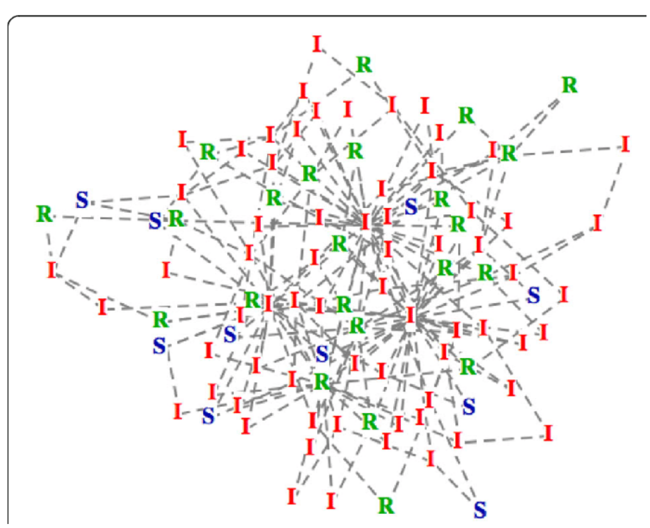
A primary limitation of the paper lies in the models used to simulate financial networks, which might oversimplify the complexities inherent in real-world financial systems, especially under atypical or crisis conditions. This raises concerns about the applicability and robustness of the findings in diverse financial scenarios. Another challenge is the reliance on accurate and comprehensive financial data, which can be difficult to obtain, particularly in less transparent or regulated markets. This dependence on data quality and availability could potentially impact the validity of the study's conclusions. The paper also overlooks the dynamic nature of financial markets, influenced by other factors such as regulatory changes, technological innovations, and macroeconomic trends, which could limit the long-term applicability of its models. Moreover, the paper introduces several open questions, particularly regarding the resilience of financial networks to different types of shocks and the influence of emerging financial technologies and non-banking financial institutions on systemic risk. While the insights are most pertinent to risk management and financial regulation, their application to more micro-level financial issues such as individual credit risk or specific investment strategies appears limited.

Feedback

The paper's technical depth, while impressive, may pose comprehension challenges for a broader audience. Key economic concepts such as "mark-to-market" require more detailed explanations to enhance accessibility and understanding for readers beyond specialized fields. Furthermore, the paper's model, predominantly focused on just one aspect of the economic structure, could benefit from incorporating a wider range of economic participants, including individuals, government entities, and the impacts of regulatory changes, technological innovations, and global political dynamics. Such an expansion would not only make the model more comprehensive but also provide more actionable insights for policymakers. Currently, the model demands significant further research and refinement before its application in real-world economic scenarios. Additionally, integrating an interdisciplinary approach that melds machine learning, political theory, economics, and finance could offer a more holistic and nuanced perspective on financial networks, enriching the paper's analytical depth and practical relevance.

Advances since the Paper and Open Questions in the Field

Since the publication of "Pathways towards Instability in Financial Networks," the landscape of financial network research has evolved with changes in political climate and technological innovation. A critical area of progress is in the refinement of network models to consider more factors, interdisciplinary approaches, and further topological analysis to draw conclusions. One of the papers, Epidemics of liquidity shortages in interbank markets, embraces a more creative approach in modeling financial networks instability likening it to that of epidemics. It assumes "that the liquidity shocks propagate as an epidemic disease over the market, [and] adapt[s] the well-known SIR (Susceptible–Infected–Removed) model [[47], [48], [49]] to the specific context of liquidity shocks interbank networks" (Brandi et al.). This paper further analyzes the topological structure of the network and the placement of the nodes to understand the financial contagion and susceptibility to bankruptcy and subsequently causing financial instability.



SIR Model

Source: *researchgate.net*

Another significant advancement is the integration of environmental, social, and governance (ESG) factors into financial network analysis. Recent research such as that by Roconi et al. (2021) represents a growing recognition of the importance of sustainability risks in financial stability, indicating a broadening scope that extends beyond traditional financial metrics to include environmental and social factors. This research underscores the relationship of climate risks with financial instability and the need for a holistic approach to risk assessment.

The rise of cryptocurrency platforms and decentralized finance (DeFi) has introduced new dimensions to financial network research. Studies such as those by Carlo Campajola et al. (2022) investigate the centralization tendencies in cryptocurrency systems, marking a shift in focus towards understanding the stability implications of these emerging financial technologies.

However, several open questions remain in the field. The resilience of financial networks to various shocks, especially those from non-financial sources such as geopolitical events or global health crises remains an area of active investigation. Additionally, the impact of technologies like fintech and blockchain on the stability of financial networks is an area of ongoing research. Another important question revolves around the role of non-banking financial institutions in systemic risk and how these entities can be effectively integrated into existing models. A key focus of current research is also to translate the theoretical findings to actionable recommendations for policymakers and help improve the stability of financial systems. Continued research and understanding of financial networks are imperative for accurately predicting and averting future financial instabilities, thereby safeguarding against another catastrophic event akin to the Great Recession.

Bibliography:

1. Jones, C. (n.d.). Trump’s Job Losses Will Exceed The Great Recession’s. Forbes. Retrieved November 18, 2023, from https://www.forbes.com/sites/chuckjones/2020/04/04/trumps-job-losses-will-exceed-the-great-recessions/?sh=51ff3f97d372

2. Kumar, R., and P. Vashisht. 2009. The Global Economic Crisis: Impact on India and Policy Responses. ADBI Working Paper 164. Tokyo: Asian Development Bank Institute. Available: http://www.adbi.org/working-paper/2009/11/12/3367.global.economic.crisis.india/

3. Bardoscia, Marco, et al. “Pathways towards Instability in Financial Networks.” Nature Communications, vol. 8, no. 1, Feb. 2017, https://doi.org/10.1038/ncomms14416.

4. Brandi, Giuseppe, et al. Epidemics of Liquidity Shortages in Interbank Markets. Oct. 2018, pp. 255–67, https://doi.org/10.1016/j.physa.2018.05.104. Accessed 18 May 2023.

5. Campajola, Carlo, et al. “The Evolution of Centralisation on Cryptocurrency Platforms.” ArXiv:2206.05081 [Physics, Q-Fin], June 2022, arxiv.org/abs/2206.05081.

6. Roncoroni, Alan, et al. “Climate Risk and Financial Stability in the Network of Banks and Investment Funds.” Journal of Financial Stability, vol. 54, June 2021, p. 100870, https://doi.org/10.1016/j.jfs.2021.100870.