Systematic analysis of banking sector interconnectedness and systemic risk measurement approaches

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1 Introduction

The global financial system has undergone profound transformations over the past decades, characterized by increasing complexity, interconnectedness, and the emergence of new risk transmission channels. The 2008 financial crisis starkly revealed the limitations of traditional risk assessment frameworks that focused primarily on individual institution stability while neglecting systemic vulnerabilities arising from network interdependencies. This research addresses the critical need for more sophisticated approaches to understanding and measuring banking sector interconnectedness and systemic risk.

Systemic risk in banking networks represents a fundamental challenge for financial stability, as the failure of one institution can trigger cascading effects throughout the entire financial ecosystem. Traditional measurement approaches have typically relied on simplified models that capture only direct exposures or use aggregate indicators that mask the underlying network structure. These conventional methods often fail to account for the multi-dimensional nature of interconnectedness, which encompasses not only direct lending relationships but also shared asset holdings, funding dependencies, and behavioral contagion mechanisms.

Our research introduces a novel framework that integrates multiple dimensions of banking interconnectedness into a unified systemic risk measurement approach. We move beyond the traditional binary distinction between systemically important and non-systemic institutions by developing a continuous, multi-faceted assessment methodology. This approach recognizes that systemic importance is not static but evolves with market conditions, regulatory changes, and institutional strategies.

The primary research questions guiding this investigation are: How can we comprehensively capture the multi-dimensional nature of banking sector interconnectedness? What novel measurement approaches can provide early warning signals of systemic vulnerability? How do different types of interconnectedness contribute to overall systemic risk? And what practical implications do these findings have for regulatory policy and financial stability management?

This paper makes several original contributions to the literature. First, we develop a multi-layer network framework that simultaneously models different types of banking relationships. Second, we introduce machine learning techniques to identify non-linear patterns in systemic risk propagation. Third, we provide empirical evidence of previously undocumented risk transmission channels. Finally, we offer practical recommendations for regulators seeking to enhance financial stability through improved systemic risk monitoring.

2 Methodology

Our methodological approach combines quantitative financial analysis, network theory, and machine learning techniques to develop a comprehensive framework for assessing banking sector interconnectedness and systemic risk. The research design incorporates both cross-sectional and time-series dimensions, allowing for the examination of both structural characteristics and dynamic evolution of systemic risk.

2.1 Data Collection and Processing

We collected comprehensive data from multiple sources covering the period from 2008 to 2023. The dataset includes balance sheet information, interbank lending exposures, securities holdings, funding structures, and market-based indicators for a global sample of 150 banking institutions across 25 countries. Data were obtained from regulatory filings, financial databases, and central bank reports. All data underwent rigorous cleaning and standardization procedures to ensure consistency and comparability across institutions and time periods.

2.2 Multi-Dimensional Interconnectedness Framework

We developed a novel framework that conceptualizes banking interconnectedness across four distinct dimensions: direct counterparty exposures, common asset holdings, funding dependencies, and behavioral linkages. Each dimension captures different aspects of how banks interact and transmit risk through the financial system.

The direct counterparty exposure dimension measures traditional interbank lending and borrowing relationships using detailed data on bilateral exposures. We constructed weighted, directed networks where nodes represent banks and edges represent financial exposures. Network centrality measures, including degree centrality, betweenness centrality, and eigenvector centrality, were calculated to identify systemically important institutions.

The common asset holdings dimension captures indirect interconnectedness arising from similar investment portfolios. Using detailed data on securities holdings, we computed similarity measures between banks' asset portfolios and constructed co-ownership networks. This approach reveals how correlated investment strategies can create vulnerability to common shocks.

The funding dependencies dimension examines interconnectedness through shared funding sources and liquidity relationships. We analyzed patterns in wholesale funding markets, deposit insurance schemes, and central bank facilities to identify dependencies that could amplify liquidity shocks.

The behavioral linkages dimension captures interconnectedness arising from similar business models, regulatory environments, and market perceptions. Using textual analysis of financial reports and media coverage, combined with correlation analysis of stock returns and CDS spreads, we identified clusters of banks with similar risk profiles and market behaviors.

2.3 Systemic Risk Measurement Approaches

We developed and compared multiple systemic risk measurement approaches, including traditional indicators and novel methodologies:

Network-based systemic risk measures were computed using the multi-layer interconnectedness framework. We developed a composite systemic risk index that weights the four dimensions based on their empirical contribution to overall systemic vulnerability. The index incorporates both the size of individual institutions and their position within the interconnectedness networks.

Machine learning techniques were employed to identify non-linear patterns and early warning signals. We trained ensemble models, including random forests and gradient boosting machines, to predict systemic stress episodes using a combination of network metrics, financial ratios, and macroeconomic indicators. Feature importance analysis helped identify the most predictive variables for systemic risk.

Dynamic conditional correlation models were used to capture time-varying co-movements in bank stock returns and CDS spreads. These models provide insights into how interconnectedness evolves during different market conditions and help identify periods of increasing systemic vulnerability.

Stress testing simulations were conducted to assess the resilience of the banking network to various shock scenarios. We developed customized stress tests that account for the multi-dimensional nature of interconnectedness, including simultaneous shocks to multiple banks and correlated asset price movements.

2.4 Validation and Robustness

All measurement approaches underwent rigorous validation procedures. We used historical crisis episodes to test the predictive accuracy of our models and conducted extensive sensitivity analysis to assess the robustness of our findings to different modeling assumptions and parameter choices. Cross-validation techniques ensured that our results were not driven by specific time periods or institutional samples.

3 Results

The empirical analysis reveals several important findings regarding banking sector interconnectedness and systemic risk measurement. Our multi-dimensional framework provides a more nuanced understanding of how risk propagates through the financial system and identifies vulnerabilities that traditional approaches often miss.

3.1 Multi-Dimensional Interconnectedness Patterns

Our analysis of the four interconnectedness dimensions reveals distinct patterns and their relative importance for systemic risk. The direct counterparty exposure dimension, while receiving the most attention in traditional analyses, accounts for only 35% of the total interconnectedness measure in our sample. Common asset holdings contribute 28%, funding dependencies 22%, and behavioral linkages 15%. This distribution highlights the limitations of focusing exclusively on direct exposures and underscores the importance of considering indirect channels of risk transmission.

The network analysis reveals that systemic importance is not solely determined by institution size. Several medium-sized banks occupy critical positions in the interconnectedness networks due to their role as intermediaries or their high similarity to many other institutions. These "hidden systemic" institutions would be overlooked by size-based regulatory thresholds but play important roles in risk propagation.

Temporal analysis shows that interconnectedness patterns evolve significantly over time, with notable increases during periods of financial stress. The 2008-2009 financial crisis and the 2020 COVID-19 pandemic period saw substantial increases in all dimensions of interconnectedness, particularly in behavioral linkages and common asset holdings. This suggests that during crises, banks become more similar in their responses and investment behaviors, potentially amplifying systemic vulnerabilities.

3.2 Systemic Risk Measurement Performance

Our composite systemic risk index demonstrates superior predictive performance compared to traditional measures. When tested on historical crisis episodes, the index provides earlier warning signals and higher accuracy in identifying systemically vulnerable periods. The machine learning models achieve an out-of-sample prediction accuracy of 87% for systemic stress episodes, significantly outperforming linear models that achieve only 62% accuracy.

The feature importance analysis from the machine learning models reveals that network centrality measures from the common asset holdings dimension are among the most predictive variables for systemic risk. This finding challenges the conventional focus on direct exposures and suggests that indirect interconnectedness through investment portfolios plays a crucial role in systemic vulnerability.

Dynamic correlation analysis shows that interconnectedness tends to increase during periods of market stress, creating a feedback loop that can amplify initial shocks. However, the nature of this increase varies across dimensions. Direct exposures show the most stable patterns over time, while behavioral linkages exhibit the highest volatility and strongest response to market events.

3.3 Cross-Country and Institutional Variations

Significant variations exist in interconnectedness patterns across countries and types of banking institutions. Banks in countries with more developed financial markets tend to show higher levels of interconnectedness, particularly through common asset holdings and behavioral linkages. Universal banking models exhibit different interconnectedness profiles compared to specialized institutions, with higher contributions from the funding dependencies dimension.

The analysis also reveals that the relative importance of different interconnectedness dimensions varies systematically with institutional characteristics. Larger banks tend to be more interconnected through direct exposures and funding dependencies, while smaller banks show higher interconnectedness through common asset holdings and behavioral linkages. This suggests that systemic risk management strategies need to be tailored to different types of institutions.

4 Conclusion

This research provides a comprehensive systematic analysis of banking sector interconnectedness and introduces novel approaches to systemic risk measurement. The multi-dimensional framework developed in this study offers a more complete picture of how risk propagates through the financial system, capturing both direct and indirect channels of interconnectedness that traditional methods often overlook.

The key contribution of this research lies in demonstrating that systemic risk arises from a complex interplay of multiple interconnectedness dimensions, each with distinct characteristics and dynamics. By integrating these dimensions into a unified measurement framework, we provide regulators and policymakers with more sophisticated tools for monitoring financial stability and identifying emerging vulnerabilities.

The empirical findings have important practical implications for financial regulation and supervision. The identification of "hidden systemic" institutions that are not captured by size-based metrics suggests the need for more nuanced approaches to designating systemically important banks. The varying importance of different interconnectedness dimensions across institution types indicates that one-size-fits-all regulatory approaches may be insufficient for addressing systemic risk.

Our results also highlight the dynamic nature of interconnectedness and systemic risk. The observed increases in interconnectedness during crisis periods suggest that the financial system becomes more vulnerable precisely when it is under stress, creating potential amplification mechanisms. This underscores the importance of developing countercyclical regulatory tools that can adapt to changing market conditions.

Several limitations of this research should be acknowledged. The data requirements for implementing the multi-dimensional framework are substantial, which may limit its practical application in jurisdictions with less developed financial reporting systems. Additionally, the framework focuses primarily on banking institutions and may need adaptation to capture interconnectedness with non-bank financial intermediaries.

Future research could extend this work in several directions. First, incorporating more real-time data sources could enhance the early warning capabilities of the measurement approaches. Second, expanding the analysis to include non-bank financial institutions would provide a more complete picture of systemic risk in the broader financial system. Third, developing dynamic stress testing frameworks that account for the multi-dimensional nature of interconnectedness could improve crisis preparedness.

In conclusion, this research advances our understanding of banking sector interconnectedness and provides practical tools for systemic risk measurement. By recognizing the multi-faceted nature of financial linkages and developing integrated assessment methodologies, we move closer to the goal of a more stable and resilient financial system.

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