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Network dynamics of systemic losses and sustainable financial contagion in global financial systems with ESG integration

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Abstract

This paper develops an integrated framework to investigate the network dynamics of systemic losses and sustainable financial contagion in global financial systems with ESG integration. The framework begins by constructing a global financial network based on inter-institutional interconnectedness and correlation structures, enabling the identification of key transmission channels of systemic risk. We analyze the evolution of network topology and systemic loss propagation under various stress scenarios, including market disruptions and liquidation shocks, to assess the resilience of the financial system over time. Furthermore, advanced machine learning techniques are employed to evaluate and predict abnormal volatility among systemically important financial institutions, enhancing the detection of emerging contagion risks. The study also examines the role of ESG integration in mitigating financial contagion and influencing the transmission of systemic losses across global markets. Empirical findings indicate that stronger and more diversified network connections improve the resilience of financial systems against systemic shocks, while higher ESG adoption contributes to reducing the intensity of risk spillovers and promotes financial stability. Overall, the results highlight the importance of incorporating ESG considerations into financial network analysis to support a more sustainable, resilient, and interconnected global financial system. The proposed framework offers a comprehensive approach for understanding systemic risk dynamics and evaluating sustainable financial contagion in an increasingly complex financial environment.

Keywords: Network Dynamics; Systemic Losses; Sustainable Financial; ESG Integration; Global markets

1. Introduction

The global financial system has evolved into a highly interconnected and complex network of institutions, markets, and investment instruments(Parashar, Neha, et al.,2026). Advances in financial globalization, technological innovation, and cross-border capital mobility have strengthened the linkages among financial entities across the world. These interconnections facilitate efficient capital allocation, enhance market liquidity, and support economic growth(Helhel, Yeşim,2026). However, they also increase the vulnerability of financial systems to systemic shocks. A disturbance affecting a single institution or market can rapidly spread through interconnected channels, generating widespread losses and threatening the stability of the broader financial system. Understanding how such losses propagate through financial networks has therefore become a critical issue for academics, policymakers, regulators, and investors(Ameur, Hachmi Ben, et al.,2026).

Systemic losses represent one of the most significant challenges facing modern financial systems. Unlike isolated financial disruptions, systemic losses arise when financial distress extends beyond individual institutions and affects multiple sectors, markets, or economies simultaneously(Garefalakis, Alexandros, et al.,2026). The increasing interconnectedness of financial institutions has amplified the potential for contagion, making it more difficult to contain shocks once they emerge. Consequently, the identification of transmission channels and the assessment of network

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vulnerabilities have become essential components of financial risk management and financial stability analysis(Chen, Xiaojing, et al.,2026). Financial contagion refers to the process through which adverse shocks spread from one institution, market, or region to another. In interconnected financial networks, contagion can occur through various channels, including direct financial exposures, common asset holdings, investor behavior, liquidity shortages, and information spillovers. The effects of contagion are often amplified when financial institutions are highly connected, creating conditions under which localized disturbances can evolve into systemic crises(Gyamerah, Samuel Asante, et al.,2026). As global financial systems continue to expand in complexity, understanding the dynamics of financial contagion has become increasingly important for preventing systemic failures and strengthening financial resilience.

Network theory has emerged as a valuable framework for examining the structure and behavior of financial systems(Patriotta, & Voronov, 2026). By representing financial institutions as nodes and their relationships as connections, network analysis provides a powerful approach for identifying critical institutions, measuring interconnectedness, and evaluating systemic vulnerability. The network perspective allows researchers to examine how financial shocks propagate through complex systems and how changes in network structures influence the transmission of risk(Carvalho, Paisano,& Skouralis, 2026). Moreover, network-based approaches provide insights into the evolution of financial systems over time, enabling a better understanding of the mechanisms that contribute to systemic losses and contagion. In recent years, sustainable finance has gained considerable attention as investors increasingly seek to incorporate environmental, social, and governance (ESG) considerations into investment decisions. ESG integration reflects a growing recognition that sustainability-related factors can influence financial performance, risk management, and long-term value creation(Ali, 2026). As a result, ESG investing has become an important component of global capital markets and a key driver of sustainable economic development. Financial institutions, asset managers, and policymakers are increasingly adopting ESG principles to improve investment outcomes and promote responsible business practices.

Despite the rapid growth of ESG investing, questions remain regarding its relationship with systemic risk and financial contagion. Although ESG-oriented investments are often viewed as more resilient and sustainable, they remain embedded within broader financial networks and are therefore exposed to systemic shocks originating from other parts of the financial system. Market disruptions, liquidity crises, and changes in investor sentiment may affect both traditional and ESG-related assets, creating pathways through which financial contagion can spread. Understanding the interaction between systemic losses and ESG investments is therefore essential for evaluating the effectiveness of sustainable investment strategies in periods of financial stress(Lu, Wen-Min, et al.,2026).

The integration of ESG considerations into financial network analysis provides an important opportunity to enhance our understanding of sustainable financial stability. ESG factors may influence the behavior of institutions, investment decisions, and risk management practices, potentially affecting the resilience of financial networks. At the same time, the interconnected nature of financial markets suggests that ESG investments may both influence and be influenced by broader contagion dynamics(Sasso, Pasquale, et al.,2026). Consequently, examining systemic losses and financial contagion through the lens of ESG integration can provide valuable insights into the development of more sustainable and resilient financial systems. Recent advances in data analytics and computational methods have created new possibilities for studying complex financial networks. Sophisticated analytical techniques allow researchers to capture dynamic interactions among institutions, identify emerging vulnerabilities, and assess the evolution of systemic risk over time(Aguiar, 2026). These approaches enable a deeper understanding of how financial contagion develops, how systemic losses accumulate, and how network structures respond to periods of market stress. Such insights are increasingly important in a financial environment characterized by growing interconnectedness, rapid information flows, and evolving sustainability considerations(Khasmafkan-Nezam, 2026). Against this background, this study investigates the network dynamics of systemic losses and sustainable financial contagion in global financial systems with ESG integration. The study develops a comprehensive framework for analyzing interconnected financial networks, evaluating the propagation of systemic losses, and examining the role of ESG considerations in shaping contagion dynamics. By exploring the relationships among network structure, systemic vulnerability, and sustainable investment practices, the research contributes to a deeper understanding of financial stability in an increasingly interconnected global economy(Eitan, 2026).

2. Literature Review

The growing interconnectedness of global financial markets has stimulated extensive research on systemic risk, financial contagion, network dynamics, and sustainable finance(Sahiner, M., Sung, S., & Devlin, J., 2026). Financial crises have repeatedly demonstrated that shocks originating from a single institution, market, or region can rapidly spread throughout the financial system, generating systemic losses and threatening financial stability. As a result, researchers have increasingly focused on understanding the mechanisms through which financial contagion propagates, the role of network structures in amplifying or mitigating risks, and the implications of these processes for sustainable investment practices, particularly Environmental, Social, and Governance (ESG) investments. These relationships arise through lending activities, investment exposures, derivative contracts, and common asset holdings(Ghosh, B., Kazouz, H., & Mukharjee, S., 2026). The interconnected nature of these relationships creates channels through which financial shocks can spread across institutions and markets. Consequently, systemic risk is no longer viewed solely as the risk of individual institutional failure but as the risk arising from the collective interactions within the financial system. This perspective has encouraged the development of network-based approaches that examine financial systems as interconnected structures rather than isolated entities. Financial network theory has become one of the most influential frameworks for studying systemic risk and contagion(Rahman, Sami Ur, et al.,2026). Network models represent financial institutions as nodes and their relationships as links, allowing researchers to investigate how disturbances propagate throughout the system. These models have demonstrated that network topology plays a critical role in determining the resilience of financial systems. Highly interconnected networks may facilitate risk sharing under normal conditions, but they can also accelerate the transmission of shocks during periods of financial stress. The identification of systemically important institutions and critical transmission channels has therefore become a central objective of financial network analysis. A significant body of research has focused on the dynamics of systemic losses within financial networks. Systemic losses occur when shocks affect multiple institutions simultaneously and generate cascading effects across interconnected markets. Researchers have examined how financial distress spreads through direct exposures, indirect market interactions, and liquidity channels. Studies suggest that the severity of systemic losses depends not only on the magnitude of the initial shock but also on the structural characteristics of the network. Factors such as connectivity, centrality, concentration, and network density influence the speed and extent of contagion transmission. Consequently, understanding the dynamic evolution of financial networks is essential for assessing systemic vulnerability and designing effective risk management strategies. Another important strand of literature examines financial contagion and its underlying transmission mechanisms(Ansarinasab, 2026). Financial contagion refers to the spread of market disruptions from one institution or market segment to another through interconnected financial relationships. Traditional studies have investigated contagion through balance-sheet exposures and interbank relationships, while more recent research has expanded the analysis to include common asset holdings, investor behavior, liquidity spillovers, and information transmission. These studies indicate that contagion is often nonlinear and may intensify during periods of market uncertainty, creating challenges for regulators and policymakers seeking to maintain financial stability(Peng, Ke, et al.,2026).The emergence of sustainable finance has introduced a new dimension to the study of systemic risk and financial contagion. ESG investing has gained substantial attention as investors increasingly incorporate environmental, social, and governance considerations into portfolio management and investment decision-making. ESG integration is often associated with improved risk management, enhanced corporate governance, and greater long-term resilience. As a result, ESG investments have become an important component of global capital markets and a key instrument for promoting sustainable economic development.

Despite the rapid growth of ESG investing, the relationship between ESG assets and systemic financial risk remains an evolving area of research. Some studies suggest that ESG-oriented investments may demonstrate greater resilience during periods of market stress due to stronger governance practices and more sustainable business models. Other research argues that ESG investments remain exposed to broader market conditions and may be affected by systemic contagion through common financial linkages. Since ESG assets are embedded within global financial networks, shocks originating in traditional financial markets may spill over into sustainable investment portfolios, affecting their performance and risk characteristics(Wang, Gang-Jin, et al.,2026). Recent literature has increasingly explored the interaction between financial contagion and sustainable investment strategies. Researchers have examined whether ESG integration can reduce portfolio vulnerability, mitigate systemic risk exposure, and contribute to financial stability. Findings generally indicate that ESG considerations may influence risk transmission mechanisms, although the magnitude and direction of these effects vary across markets, sectors, and economic conditions(Caldecott, Ben, et al.,2026). The growing importance of sustainable finance has therefore created a need for more comprehensive frameworks capable of evaluating the relationship between systemic losses, financial contagion, and ESG integration. In parallel with developments in network science, advances in machine learning and artificial intelligence have transformed financial risk analysis. Machine learning techniques provide powerful tools for identifying complex patterns, forecasting market behavior, and detecting emerging risks that may not be captured by traditional econometric models. These methods are particularly valuable in financial systems characterized by large datasets, nonlinear relationships, and dynamic interactions. As a result, machine learning has become increasingly important for systemic risk assessment, financial forecasting, and the analysis of contagion dynamics.

Researchers have applied various machine learning algorithms to predict financial distress, assess market volatility, identify systemic vulnerabilities, and improve risk monitoring capabilities. The integration of machine learning with financial network analysis has emerged as a promising area of research, offering enhanced analytical capabilities for understanding the evolution of systemic risk. By combining structural information from financial networks with predictive modeling techniques, researchers can develop more accurate assessments of contagion pathways and systemic vulnerabilities. Although significant progress has been made in understanding financial networks, systemic risk, and ESG investing, several gaps remain in the existing literature. Most studies examine these topics independently, with limited attention given to the dynamic interaction between systemic losses, financial contagion, and ESG integration within a unified analytical framework(Chaudhry, Sajid M., et al.,2025). Furthermore, relatively few studies investigate how network structures influence the transmission of contagion to sustainable investment portfolios or how ESG considerations affect financial system resilience. To address these gaps, this study develops an integrated framework that combines financial network analysis, systemic loss dynamics, and ESG integration to examine sustainable financial contagion in global financial systems(Wu, Işık, & Yan, 2026). By analyzing network structures, contagion mechanisms, and sustainability-related factors simultaneously, the study contributes to a more comprehensive understanding of financial stability and sustainable investment resilience. This approach extends the existing literature by providing new insights into the evolving relationship between systemic risk and sustainable finance in increasingly interconnected global markets.

3. Methodology

This study proposes an integrated analytical framework to examine the network dynamics of systemic losses and sustainable financial contagion in global financial systems with ESG integration. The framework combines financial network modeling, systemic stress simulation, machine learning-based prediction, and ESG spillover analysis to capture both structural and dynamic aspects of financial instability. The objective is to understand how financial distress propagates through interconnected institutions and how such contagion affects ESG investment performance.

The methodology is organized into three main components. First, a financial network is constructed using real market data to capture interdependencies among financial institutions. This network is then used to simulate systemic loss propagation under different stress scenarios. Second, machine learning models are employed to detect abnormal volatility and identify institutions that play a central role in risk transmission. Third, the study evaluates the spillover effects of systemic risk on ESG investments to assess sustainability implications. The financial system is modeled as a network consisting of multiple interconnected financial institutions along with an external environment representing the broader economy. Each institution in the system is treated as a node, while the connections between them represent financial relationships such as lending exposure, derivative contracts, and correlated investment holdings. These interconnections form a complex structure through which financial shocks can spread. A disturbance affecting one institution can propagate to others depending on the strength and density of these linkages. This structure allows the identification of how vulnerabilities emerge and how systemic losses evolve over time. The system is analyzed under stress conditions by introducing financial shocks and observing how losses spread across institutions. This enables the study of cascading effects, where initial losses lead to subsequent distress in connected institutions. The evolution of the network is examined dynamically to understand how resilience changes under different levels of financial pressure. The dataset includes leading institutions from banking, insurance, investment, and government-sponsored sectors in the United States. These institutions are selected due to their systemic importance and their strong influence on global financial stability. Financial institutions are grouped into four categories: commercial banks, investment banks, insurance companies, and government-sponsored enterprises. These entities are highly interconnected through credit markets, capital markets, and investment activities, making them central to systemic risk transmission.

To construct the financial network, price movements of these institutions are used to measure their co-movement patterns in the market. Institutions that exhibit similar movement patterns are considered more closely connected in the network structure. Based on this network, several structural indicators are used to analyze systemic importance and connectivity. These include measures of centrality, clustering behavior, and overall network density. These indicators help identify institutions that play critical roles in amplifying or transmitting financial shocks. In addition, ESG-related investment data is incorporated into the analysis. This includes ESG portfolio holdings and ESG-managed fund allocations associated with the selected financial institutions. This allows the study to examine how systemic risk interacts with sustainable investment strategies.

To enhance the predictive capability of the framework, three machine learning models are used to detect abnormal volatility and identify potential risk propagation within the financial network. The first model is Random Forest, which operates by constructing multiple decision-based models and combining their outputs. This approach improves prediction stability by reducing overfitting and capturing diverse patterns in financial data. The second model is XGBoost, a powerful boosting technique that builds models sequentially. Each step focuses on correcting previous errors, allowing the model to capture complex nonlinear relationships in financial behavior. It is particularly effective in identifying subtle risk signals in large datasets. The third model is Deep Neural Networks, which are designed to capture highly complex and nonlinear interactions in financial systems. These models consist of multiple layers that process information progressively, allowing them to identify deep patterns in financial market behavior. Regularization techniques are applied to improve generalization and reduce overfitting. Together, these models provide a robust predictive framework for identifying abnormal financial behavior and detecting institutions that may contribute to systemic instability. A key focus of this study is the relationship between systemic financial risk and ESG investment performance. After identifying periods of high financial stress and abnormal volatility, the study evaluates how these conditions affect ESG portfolios.

Table 1 Sample institutions of financial networks

Institution Name	Type	No. of Sample
AIG	Insurance Companies	4689
ALL	Insurance Companies	4689
BRK	Insurance Companies	4689
MET	Insurance Companies	4689
PRU	Insurance Companies	4689
BAC	Investment Banks	4689
C	Investment Banks	4689
GS	Investment Banks	4689
JPM	Investment Banks	4689
LEH	Investment Banks	4689
MS	Investment Banks	4689
AXP	Commercial Banks	4689
BK	Commercial Banks	4689
COF	Commercial Banks	4689
PNC	Commercial Banks	4689
STT	Commercial Banks	4689
USB	Commercial Banks	4689
WFC	Commercial Banks	4689
FMCC	GSE	4689
FNMA	GSE	4689

The analysis examines whether financial contagion originating in traditional markets spills over into ESG investments. This includes assessing how ESG portfolios respond to systemic shocks and whether ESG integration provides resilience against financial instability. The study also compares ESG portfolio performance under different levels of financial stress. This allows for the evaluation of whether ESG investments behave differently from conventional investments during periods of systemic contagion. Overall, the methodology integrates financial network modeling, systemic loss simulation, machine learning prediction, and ESG spillover analysis into a unified framework. This approach enables a comprehensive understanding of how financial shocks propagate through global financial systems and how they influence sustainable investment outcomes. By combining structural network analysis with predictive modeling techniques, the framework provides a powerful tool for examining systemic risk and financial contagion in modern interconnected markets.

4. Results and discussion

This section presents the empirical findings on the network dynamics of systemic losses, the evolution of financial interconnectedness, the prediction of abnormal volatility using machine learning models, and the spillover effects of financial contagion on ESG investment performance. The results provide a comprehensive understanding of how systemic risk emerges, evolves, and propagates across global financial systems. We begin by constructing a simplified financial network consisting of interconnected financial institutions, each linked through bilateral obligations and external exposures to the broader financial system(Mallik, Shuvo Kumar, et al.,2025). The initial condition of the system reflects heterogeneous wealth distribution across institutions, forming the baseline for subsequent stress analysis.

When the system is subjected to shock propagation, losses are transmitted through interdependent balance sheets. The results show that financial distress does not remain isolated but spreads across institutions through contractual and exposure-based linkages. Some institutions experience immediate losses, while others are affected through secondary and delayed transmission channels, demonstrating clear evidence of cascading failure behavior. The simulation of clearing outcomes indicates that certain institutions become highly vulnerable due to their position within the network structure. Institutions with higher exposure to interconnected liabilities tend to experience deeper losses, while relatively less connected entities show greater stability. This confirms that systemic losses are strongly determined by the topology of financial interconnections. Two different cash flow environments are analyzed to evaluate system sensitivity. Under a stable cash flow condition, losses propagate in a relatively predictable manner. However, when stochastic fluctuations are introduced, the system exhibits higher volatility and more pronounced deviations in institutional wealth. The results demonstrate that uncertainty amplifies systemic instability and accelerates loss transmission across the network(Mallik, Shuvo Kumar, et al.,2025). Overall, the findings highlight that liquidity conditions, debt exposure, and cash flow stability jointly determine the resilience of financial institutions within interconnected systems. The dynamic evolution of the financial network is analyzed using real-world financial institution data over time. The results reveal that the structure of the network undergoes significant transformation, shifting from a sparse configuration in the early stage to a highly interconnected and dense system in later periods.

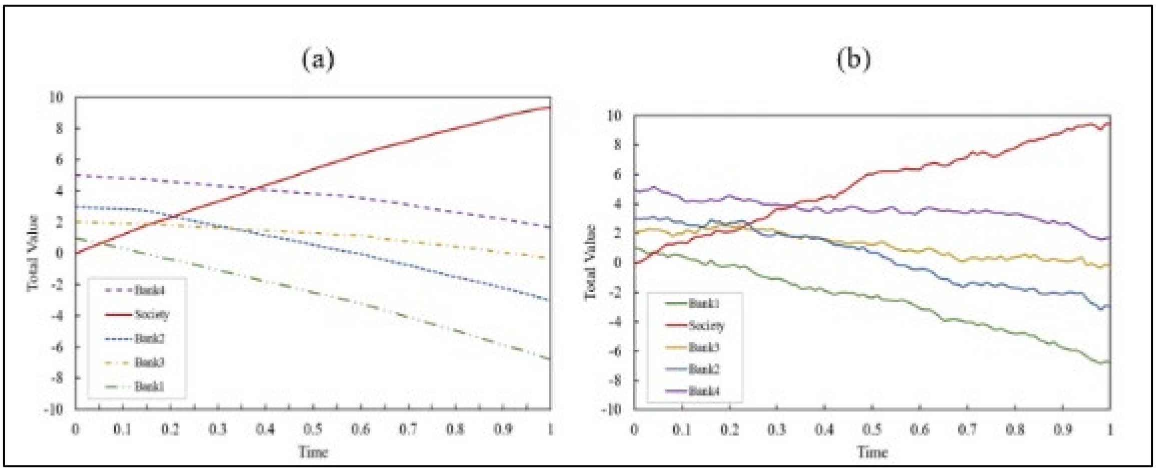


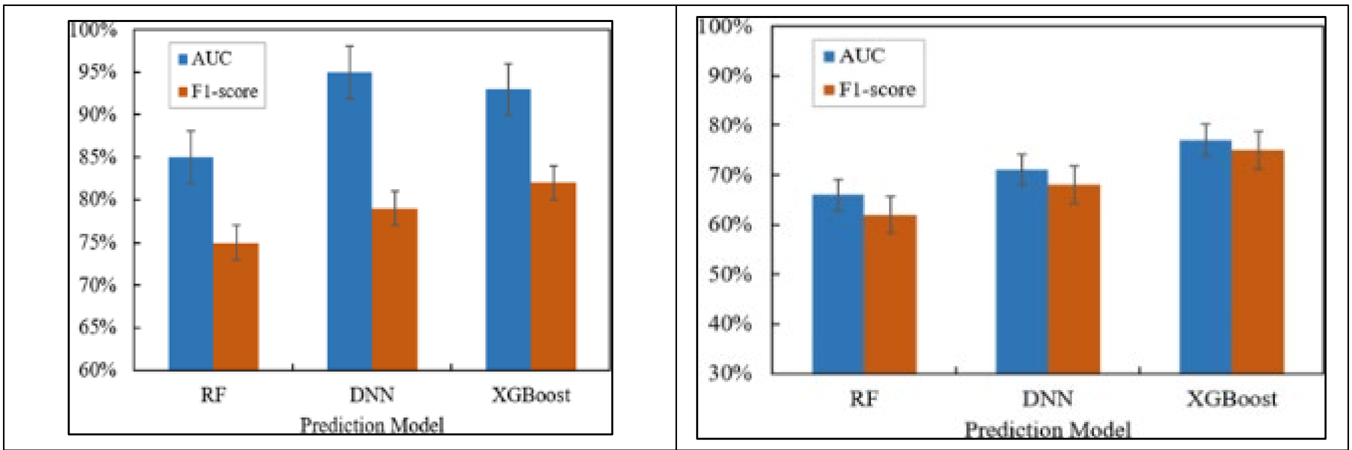
Figure 1 Comparison between static and random cash flow: (a) Total Network Value in static cash flow; (b) Total Network Value in dynamic cash flow

Initially, financial institutions exhibit limited connectivity, and systemic risk remains relatively contained. As time progresses, inter-institutional linkages increase substantially, reflecting growing financial integration and stronger co-movement among institutions. This leads to the emergence of a more complex and interdependent financial structure. Network centrality measures indicate that influence becomes increasingly concentrated in specific institutions over time. These highly central nodes play a critical role in transmitting financial shocks across the system. While this concentration enhances efficiency and interconnectedness, it also increases systemic vulnerability due to the potential failure of key nodes(Mallik, S. K., 2025).

Despite this, the overall robustness of the network improves in later stages due to diversification effects and stronger interconnections that distribute shocks more widely. Quantitative results indicate a significant increase in network resilience over time, although this resilience coexists with heightened sensitivity to failures of systemically important institutions. To identify risk-prone institutions, three machine learning models Random Forest, XGBoost, and Deep Neural Networks are applied to predict abnormal volatility events. Abnormal volatility is defined as extreme deviations in asset returns beyond historical statistical thresholds.

The results show that all models are capable of capturing volatility patterns; however, their predictive performance varies significantly. The Deep Neural Network performs strongly on training data but shows reduced generalization performance on test data, indicating overfitting due to model complexity and limited data size. The Random Forest model provides stable but comparatively weaker performance in capturing nonlinear dependencies. In contrast, the XGBoost model consistently outperforms the other methods in both accuracy and robustness, demonstrating superior capability in identifying abnormal volatility events across financial institutions. The results confirm that combining financial network features with machine learning significantly improves predictive accuracy for systemic risk detection. XGBoost emerges as the most reliable model for identifying early warning signals of financial instability(Chowdhury, Kaushik, et al.,2025).

This section evaluates how systemic financial risk propagates into ESG investment performance. The results indicate that financial contagion has a significant influence on ESG portfolios, confirming that ESG investments are not fully insulated from systemic shocks. Comparative portfolio analysis shows that ESG portfolios with higher sustainability ratings generally outperform lower-rated portfolios in terms of average returns. However, during periods of heightened systemic stress, ESG portfolios still experience performance deterioration due to exposure to broader financial market conditions.



(a) (b)

Figure 2 Performance of under training and testing data: (a) Training data; (b) Testing data

The findings also indicate that ESG portfolios demonstrate relatively higher stability compared to conventional financial portfolios. Nevertheless, volatility increases during systemic crisis periods, indicating that ESG investments are indirectly affected by financial network contagion channels. These results highlight that ESG investments, while more resilient in normal conditions, remain embedded within the global financial system and are subject to spillover effects originating from interconnected institutions. This emphasizes the importance of integrating systemic risk considerations into ESG portfolio construction and sustainable investment strategies.

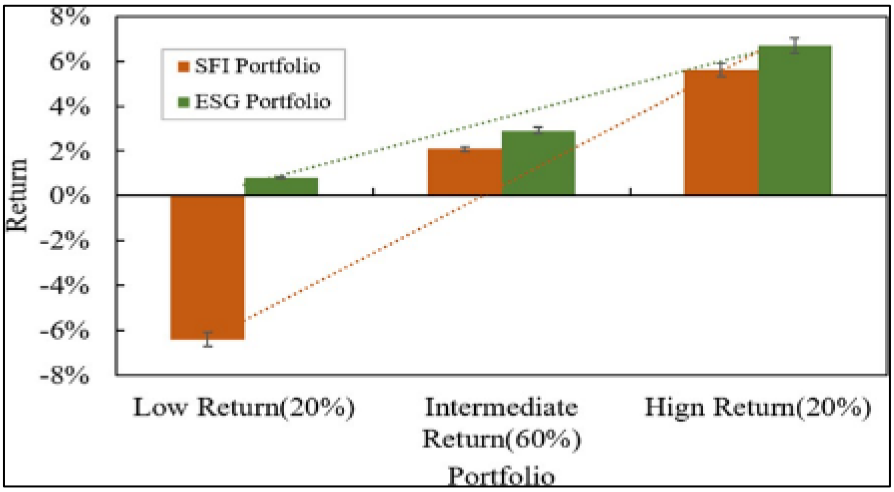


Figure 3 Performance difference between institutions portfolio and related ESG portfolio

The empirical findings underscore several important insights into the behavior of interconnected financial systems. First, systemic losses are strongly driven by network structure, with highly connected institutions acting as key transmission hubs for financial distress. Second, financial networks evolve toward greater complexity over time, enhancing both diversification benefits and systemic vulnerability. This dual effect reflects the inherent trade-off between efficiency and stability in modern financial systems. Third, machine learning methods particularly XGBoost provide effective tools for identifying abnormal volatility and early warning signals when combined with network-based structural features. Finally, the results demonstrate that systemic financial risk significantly influences ESG investment performance, reinforcing the need for integrating sustainability considerations with systemic risk analysis. ESG investments offer relative stability but are not immune to contagion effects arising from global financial interconnectedness. Overall, the results confirm that financial networks, systemic risk, and ESG investment performance are deeply interdependent, highlighting the need for holistic approaches to risk management in sustainable financial systems.

5. Conclusion

This study develops a comprehensive financial network-based framework to analyze the dynamics of systemic losses and the spillover effects of financial contagion on ESG investments within global financial systems. By integrating financial network modeling with machine learning techniques, the proposed framework provides a robust approach to understanding how risk propagates through interconnected institutions and how such transmission affects sustainable investment performance. The analysis begins with a theoretical financial network model that captures interdependencies among financial institutions and simulates the evolution of systemic risk under stress conditions. The model is further extended to a multi-node empirical framework using real financial market data, enabling the observation of dynamic changes in network structure over time. The results demonstrate that as financial interconnections become more complex, the overall robustness of the system increases, enhancing its ability to absorb and distribute shocks from systemic risk events. To assess predictive capability, machine learning models are employed to detect abnormal volatility within the financial network. Among the tested models, XGBoost consistently outperforms Random Forest and Deep Neural Networks in terms of predictive accuracy and generalization ability. This highlights the effectiveness of gradient-boosting approaches in capturing nonlinear dependencies and identifying early warning signals of financial instability when combined with network-based features. The study further investigates the impact of systemic risk spillovers on ESG investments. The empirical results confirm that ESG portfolios are not fully insulated from financial contagion effects. While ESG investments tend to demonstrate relatively stronger stability compared to non-ESG portfolios, they remain exposed to systemic shocks transmitted through global financial networks. This finding underscores the interconnected nature of sustainable and conventional financial markets. Despite the strengths of the proposed framework, several limitations remain. These include constraints related to data quality and availability, heterogeneity in financial reporting standards, limited interpretability of machine learning models, and the potential risk of overfitting in complex predictive systems. Addressing these challenges requires improved data governance, enhanced model transparency, and more standardized financial disclosures. Future research may also explore the role of ESG information disclosure in influencing firm-level idiosyncratic risk and systemic vulnerability. The findings of this study have important implications for multiple stakeholders. Investors should account for systemic risk and network contagion effects when constructing ESG portfolios, as sustainability metrics alone may not fully protect against financial shocks. Policymakers should strengthen regulatory frameworks aimed at reducing systemic risk and improving transparency in financial interconnections. Financial institutions and corporations should prioritize long-term resilience by managing their exposure within interconnected financial systems and integrating sustainability considerations into risk management practices. Overall, this study provides evidence that financial network structure and systemic risk dynamics play a critical role in shaping ESG investment performance. The results highlight the need for a more resilient and sustainable global financial system that integrates both risk contagion awareness and ESG principles into investment and policy decisions.

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