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Systemic Risk Definitions and Network Applications in Financial Systems

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Abstract

Introduction: Although the complex financial markets more often lead to more social welfare in modern economic systems, they can also cause more severe failures in the case of market downturns. Accordingly, Similar to other complex systems, financial markets are also exposed to systemic risks. Considering the importance of systemic risks in financial markets, we reviewed different concepts, definitions, and the related principles of the systemic risk.

Purpose: Accordingly, similar to other complex systems, financial markets are also exposed to systemic risks. Considering the importance of systemic risks in financial markets, we reviewed different concepts, definitions, and the related principles of the systemic risk. We also reviewed the main definitions of financial systemic risk in different aspects.

Methodology: To analyze the systemic risks in the financial markets, we introduce the main approaches of systemic risk analysis and elaborate financial network analysis as one of the main approaches.

Findings: The results show that the systemic risk events can be related to the buildup of small shock on different agents in the financial systems as well as great shocks in one or a few numbers of financial agents.

Paper Type: Research Article

Keywords: Network Theory; Systemic Risk; Complex Systems; Prudential Policies; Casecading Failure

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INTRODUCTION

Most of the great crises have related to a major human factor. For this reason, these crises cannot resolve by relying solely on technical approaches. We need to understand the socio-economic dynamics of these systems that cumulatively affect the whole system. These major crises relate to the nonlinear or network interactions among different agents and propagate as a cascading failure throughout the system. Accordingly, the occurrence of a shock in one or more of the factors of the system can lead to its transmission to other components of the system and eventually to major crises. In the risk management literature, the risk that exposes systems to such crises is called "systemic risk". The systemic risk is related to a type of risk in the system that can lead to unexpected major changes in a system or impose large uncontrollable threats on the system. These types of risks can be natural disasters such as earthquakes and tsunamis, or failure of engineering systems such as temporary blackouts or human-centered outbreaks such as epidemics, climate change, global wars, floods, and economic crises.

Financial and economic systems recognized as one of the most complex and influential human systems. The reason can attribute to the presence of many components and various interactions among them and the existence of informal social relationships. On the other hand, as crises in different countries are highly dependent on the structure of financial and economic systems, the researchers in recent years have a strong tendency to analyze these systems as a complex and interconnected system. However, the complexity of these systems makes it difficult to identify them properly and, in most cases, only a partial understanding of these systems considered in different studies.

So far, there is no consensus on the precise definition of the systemic risk concept. In the existing literature, the definition of systemic risk in financial and economic systems focuses on different aspects of this phenomenon. Accordingly, financial and economic imbalances, mistrust among the elements of the system, the correlation of financial institutions with the exposure of different risks, negative effects on the real sector of the economy, information asymmetry, feedback effects on the system, price bubbles, contagion, and externalities recognized as the most important aspects of systemic risk; Although many of these aspects overlap with each other, it is difficult to define a clear boundary among them (Bisias, Flood, Lo, & Valavanis, 2012).

In general, the problem of systemic risk can examine in the form of three general factors: "interconnectedness", "correlation" and "contagion". Interconnectedness considers the causal relationships between different components of the system, such as the balance sheet relationships, which leads to systemic risk when a shock in one or more components of the system occurs. The correlation factor considers the existence of comovement between various components of the system. It indicates that different components of the system, apart from the existence of causal relationships, may also influence each other. Contagion as the third factor indicates that specific shocks in the system can spread out in the whole financial system, through interconnectedness or correlation channels.

Considering the adverse effects of systemic risk on financial and economic systems which leads to the loss of investors and organizations and fosters mistrust in different markets, the need to provide a strategy to control and mitigate the systemic risks is obvious. Due to the lack of a unified understanding of the concept of systemic risk in the financial and economic markets, this study provides an overview of different concepts and modeling approaches for systemic risk analysis. Firstly, the concept of complex socio-economic systems and their relations to the systemic risks will examine. In the next section, the concept of financial system risk will describe. A brief overview of different ways of systemic risk modeling will represent in section 4. Section 5 will focus on the application of financial networks as one of the most effective ways to analyze these kinds of risks; and finally, we will review the micro and macroeconomic policies to avoid these crises in financial institutes.

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METHODOLOGY

To analyze the systemic risks in the financial markets, we introduce the main approaches of systemic risk analysis and elaborate financial network analysis as one of the main approaches.

RESULTS AND DISCUSSION

Systemic Risk Concept

Several scientists believe that in the current world, our knowledge of the cosmic complex and the fundamental particles of life is far more than what we know about the function of socio-economic (human-centered) systems. This is a great challenge that has to change. We desperately need a better understanding of socio-economic systems, the origins of instabilities, and the ways to avoid crises and also the side effects of policies in human-centered systems.

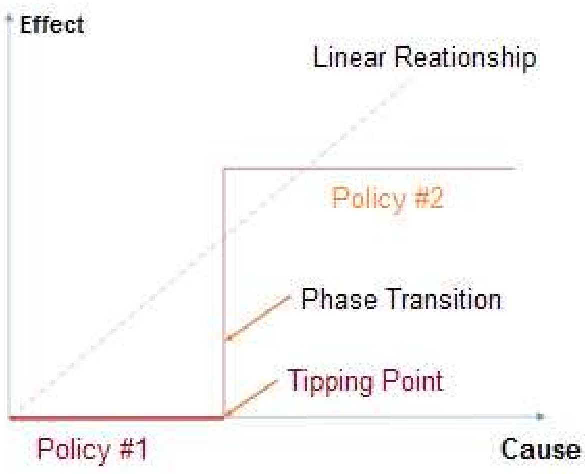
In dealing with large socioeconomic systems, it can see that linear, experiential, or intuitive approaches are usually not capable. Such approaches to the system analysis usually lead to the illusion of control, which eventually leads to inconsistent behaviors, unexpected side effects, and major structural shifts in the behavior of the system. In the literature, the word complexity used in three general forms (Helbing, 2010):

- Structured complexity due to a large number of system components with deterministic and predictable behavior (for example, a car).
- Dynamic complexity with a large number of interacting components with difficulty to predict the behavior of the system
- The algorithmic complexity that shows the capability of the computer to handle the system size (optimization or simulation).

Systemic risks are mainly due to the dynamic complexities. Therefore, it is very difficult to predict systems behavior concerning different policies. A system with dynamic complexity has some specific features that can lead to systemic risk. Some of the main features are summarized as follows:

a) It has nonlinear interactions- In such systems, their causes and effects are not relative to each other linearly. As Fig. 1 shows, the behavior of a system can be non-responsive to all control factors. There may be a structural shift in the system behavior at a tipping point.

Figure 1. Non-linear relationship in a complex system



b) Power-law and Heavy-tailed Distribution- In such systems, strong interactions among components lead to the creation of power-law distributions or generally heavy-tailed distributions versus normal distributions. Accordingly, in such systems, extreme events occur more frequently. For example, the Black Monday incident on Wall Street was an event equivalent to 35 standard deviations of New York Stock Exchange returns.

c) Network interactions and systemic risks due to cascading failure- One particular type of nonlinear interactions in these systems are the network interactions that cause to the contagion of failure in a cascading process (domino effect). A system failure originates through one of three ways:

   1. The stability parameters of the system move to a critical point (threshold level) which, after passing this point, the system becomes unstable.
   2. The system is metastable in a way that responds quickly to small deviations but becomes unstable in the case of large deviations in the system (e.g. natural disasters).

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3. The system is metastable, but the simultaneous occurrence of several deviations in different parts of the system leads to system failure. In general, human-centered crises usually formed by the interaction of small shocks in a network structure.

d) Self- organized Crisis- In many cases, the entry of a system into instability is not due to external factors, but rather some internal processes drive the system into crisis. In these cases, it is also possible for extreme events to emerge, which is called a self-organized crisis.

e) Limited predictability, randomness, turbulence and chaos- Many of the nonlinear components of the system can cause some complex dynamics which can cause turbulence and chaotic behavior in the systems. High sensitivity to a small deviation in a system is also called "Butterfly Effect". It means that after a sufficient time, even flying of a butterfly can significantly change the behavior of the system. Another problem in predicting the behavior of a complex system can be related to the randomness of system components.

f) Illusion of Control- It means that socio-economic systems also have other characteristics that make them very difficult to control. In these systems, large changes can have very little or even no effect on the system. Considering the network interactions among different components of the system, the large changes even can have a reverse effect on the system. It demonstrates that these complex systems confront external control efforts.

On the other hand, when the system approaches the tipping point, even a small change can result in structural shifts and phase transitions in the system. In such a case, the systems have the "slow adjustment" property, which means that it takes a long time to depreciate these deviations and return the systems to its equilibrium. For this reason, the need for early warning signals in such systems seems very necessary. Financial and economic markets are among these systems. Delays are another factor that leads to instability in the behavior of systems. Many control efforts are based on statistical analysis, which is a time-consuming process. Delay in these analyses, and consequently in their associated policies, leads to instability in the system. For example, business cycles can be due to the same delays in the system. Besides, there is another problem with some hidden factors that can be called "unknown unknowns". An example of such factors could be the introduction of new products and technologies into the economy.

Accordingly, the logic of failure in such a system is that a decision-maker adopts a policy to change the system, but the system does not change. The decision-maker intensifies its policy until the system suddenly enters a structural shift and organizes itself into another structure (which is not necessarily desirable). In this case, the decision-maker tries to counteract the causes of this change to get the system to its original status, but if these decisions have a delay, the system exhibits oscillatory and chaotic behavior.

The best way to avoid systemic risks in complex systems is to reinforce self-organization and self-control by mechanism design; this means that gaining coordination in complex systems occurs when interaction rules among system components are correctly determined. These mechanisms should not determine how the components of the system operate, but rather should determine some thresholds for the actions of components. It gives a degree of freedom to the system to determine the best decisions. Therefore, the correct determination of mechanisms is one of the main challenges of the researchers.

In recent years, various models have been introduced to address the challenges of complex systems including big data analysis, network analysis, system dynamics, scenario-based modeling, Statistical physics, chaos theory, system theory and cybernetics, disaster theory, extreme values theory and agent-based modeling (Helbing, 2010).

Systemic risk in financial systems

So far, there is no consensus on the exact definition of systemic risk in the financial markets. Systemic risk is more than a combination of the risks that affect individual institutions. While credit risk, liquidity risk, operational risk directly affects individual firms, systemic risk can only indirectly affect them. Before the crisis, the authorities examined these types of risks independently, but the interactions among them can lead to adverse results.

It is possible to measure the systemic risk as a measure of impairment in the financial systems. Systemic risks can originate from internal (for example, the collective behavior of many financial institutions, or a few of systemically important financial institution), or external causes and derived from factors outside the financial system (i.e. imbalances in the real sector of the economy). Dow (2000) suggests that systemic risk can attribute to the following factors:

- Highly risky activities of one or more traders
- Aggressive approach of the financial institution to Short Term Profitability
- Collective failure in the financial systems that leads to an inability to cope with economic changes and increases the exposure of other financial institutions to similar shocks throughout the system (Dow, 2000).

In another paper, Eijffinger presents the following points to define the concept of systemic risk (Eijffinger, 2012):

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- In most studies, systemic risk has been related to a large part of the financial system or the most important financial institutions. In these cases, the effect of systemic risk limits to the malfunction in the financial systems such as disrupting the financial intermediation sector. In a few studies, the concept of systemic risk has been considered equivalent to the concept of mistrust and moral hazard in the financial system, mainly due to problems in the analysis.
- Another factor of systemic risk is the contagion of shocks among different components of the system that ultimately leads to the transmission of shocks into the real sector of the economy.
- Before the recent financial crisis in 2007, the concept of systemic risk was limited to the analysis of loss contagion, but after that, there is a remarkable focus on the disruption in the financial systems.

On the other hand, we can say that systemic risk has micro and macro aspects. Nier argues in his paper that the macro aspect of systemic risk occurs when the financial system exposed to the integration of different kinds of risks arising from the increased correlations to other factors. Conversely, the micro aspect of systemic risk occurs based on the failure of one or a few numbers of institutions on the entire financial system. Although these two aspects of systemic risk are closely related, it is usually more likely to have a greater impact from the macro aspect to the micro aspect (Nier, 2009).

The micro aspect of systemic risk relates to the degree to which a firm affects economic stability by creating negative externalities. Nicolo et al. (2012) have categorized these negative externalities to the following three factors:

1. Externalities related to the similarity and complementarity of corporate business strategies: It is because of their tendency to simultaneously increase credit and liquidity risk during periods of the economic boom that results in lower credit standards. Factors such as information asymmetries, competitive pressures, and even government bailout policies during periods of recession encourage companies to increase risk-taking.
2. Externalities related to asset auction: It occurs when highly indebted companies have to liquidate their assets at a specific time, while the buyers are not also in a good position, causing a sharp drop in asset prices.
3. Externalities related to the degree of interconnectedness among companies. These connections are channels for shock propagation within the financial and economic system (Nicolò, Favara, & Ratnovski, 2012).

In the event of systemic risks arising from the micro aspect (one or few institutions), the resulting costs should handle by all components of the financial system and the real sector of the economy. Therefore, these risks created by one or a few institutions do not internalize and affect the entire economic and financial system. For this reason, many corporations are encouraged to ride free of charge to others and take advantage of the potential benefits of taking risks. Generally, the costs of systemic risk are non-uniformly distributed among all system components without any attention to the share of each component in systemic risk.

The extent to which institutions contribute to systemic risk (also known as systemic importance) is not always constant and depends on economic and market conditions. Institutions with low systemic risk contributions during the boom periods may have very high contributions during the downturn periods and vice versa. For this reason, size is not the only factor that affects the systemic risk, but also other factors such as interconnectedness among institutions are effective.

On the other hand, in many cases, the collective behavior of a set of corporation results in systemic risks. For example, banks and financial institutions collectively increase their credit risk during the boom periods, and, despite diversification at the micro-level, lead to increased systemic risk at the macro level. Therefore, exposure of several corporations to a similar shock can lead to systemic risks, like the impact of a systemically important organization.

Systemic risks are incremental which means that systemic risks are not only due to the actions of corporations but also can be due to factors outside the financial and economic system which are in the direction of business cycles. Systemic risks can also increase due to some companies that are critical for the proper function of the financial system. For this reason, the risk of specific shocks in centralized systems is far greater than in decentralized systems. Accordingly, the high level of concentration in a financial system increases the exposure of the financial-economic system to shock in a systemically important company.

DeBandt and Hartmann (2000) have examined systemic risk from both vertical and horizontal dimensions. In the horizontal view, we only deal with systemic risks based on the events in one specific economic sector. From the vertical perspective, we focus on systemic risk events and their effects on the whole system as a measure of the severity of an event. However, it is hard to precisely distinguish between the effect of systemic events on the real sector of the economy and the financial system. According to them, the systemic risk can apply to a two-dimensional matrix. One dimension represents the extent of the shock, which is the magnitude of the negative effect on the entire financial system. The other dimension shows the magnitude of the shock effect,

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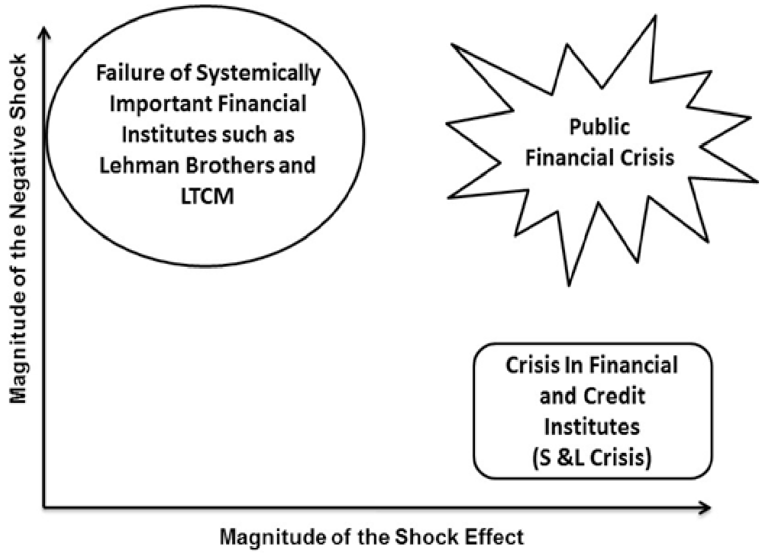
which is a combination of the systemic importance of the companies and the number of companies under shock. Figure 2 shows an overview of this matrix (DeBandt & Hartmann, 2000).

Another major point is the difference between systemic risk and systemic risk. Systematic risk is the unmanageable risk that relates to non-diversifiable risk factors in financial assets and is only affected by changes in the price of financial assets. On the other hand, systemic risk is the risk of spreading failures from one or a few companies to the entire financial-economic system.

Although various categories are presented in the literature for the concept of systemic risk, some of which are discussed above, one can classify systemic risks into two general categories as follows:

1. The cross-sectoral / structural dimension refers to the occurrence of systemic risk in a financial system at the same time. This dimension results in systemic risk due to the instability of companies, the similarity of the risk exposure among companies, the size, structure, and the degree of concentration in the financial system, and also other direct and indirect relationships between companies. The purpose of systemic risk analysis is to increase the stability and resilience of the financial system in the face of risk. In this dimension, the effect of macroeconomic factors is an externality factor in the analysis. Macro-prudential policies to prevent this dimension of systemic risk have been focused mainly on structural measures.
2. Time / cyclical dimension that deals with the build-up of systemic risk over time. This dimension takes risks that are not directly the result of the actions of one or a few companies but relates to the collective behavior of a set of factors. This leads to an increase in the volatility of the financial system and the real sector of the economy. This dimension of systemic risk also leads to the feedback effects, severe debt burden, underestimation of risks in booms time and overestimation during the downturns. These kinds of consequences finally result in the elimination of debt and the occurrence of business cycles. The purpose of systemic risk analysis in this dimension is to reduce the collective inequillibriums and reduce their impacts on the entire financial system. In this dimension, the effect of macroeconomic factors is an internal effect on the analysis. Macro-prudential policies have focused primarily on business cycles, corporate balance sheets, and their deals (Smaga, 2014).

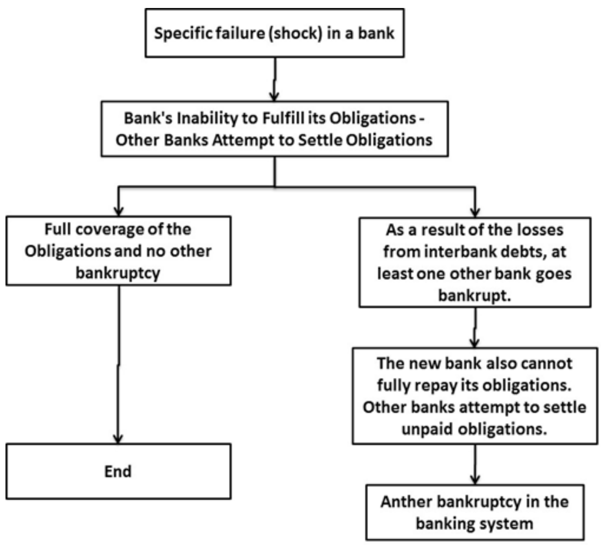
Figure 2. Systemic Risk Matrix (DeBandt & Hartmann, 2000)



Systemic Risk Triple

Generally, systemic risk can examine based on three factors, namely "contagion", "interconnection" and "correlation". Contagion is one of the most important forms of systemic risk. Contagion is a mechanism whereby instability in the financial-economic structure develops rapidly and results in a crisis. The contagion can introduce as the probability that the instability in a particular company will spread to other parts of the system and cause a crisis. The steps of contagion in a banking system illustrates below.

Figure 3. Contagion Process in the Banking System



Accordingly, contagion consists of two major components. The first component is a shock affecting one or more companies, and the

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second component is a transmission channel that increases the shock multiple times. Among companies, the banks are the most vulnerable to the Contagion. Contagion in the banking system will lead to a severe contagion in the financial system and the real sector of the economy. The banking system is in charge of maturity transformation - financing long-term assets (loans) with short-term debts (bank deposits). Vulnerability to the contagion in the banking system can be due to high debt ratios, bank interconnections, shadow banking activities, mistrust risk, and the use of aggressive liquidity management strategies (Pasquariello, 2007).

Besides contagion, two other key factors in systemic risk include interconnection and correlation. Interconnection involves the causal relationships between different components of the system, such as the balance sheet relationships that lead to systemic risk in the event of a shock in one or more components of the system. The correlation factor also considers the existence of co-movement among different components of the system. This factor indicates that different components of the system, apart from the existence of known causal relationships, may also influence each other.

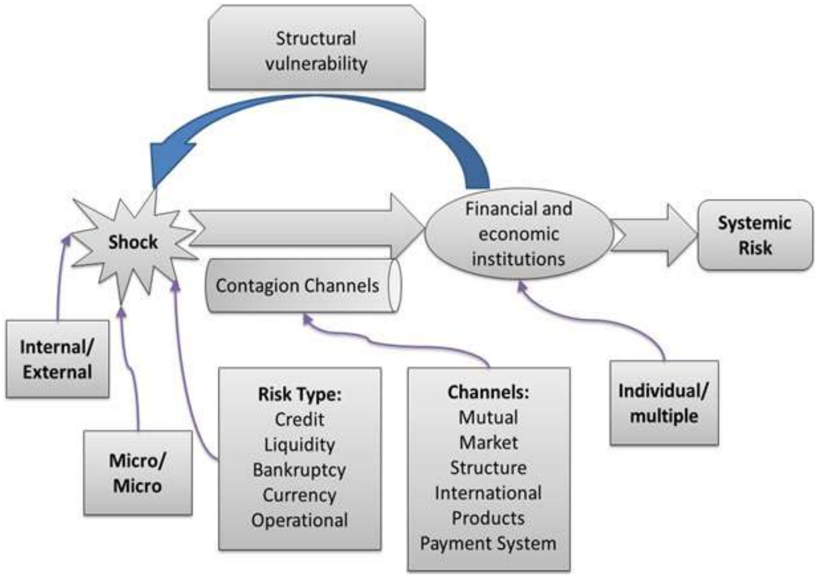
Financial systems are "Robust yet Fragile", meaning they are less likely to be infected but, if the problem arises, the effects will be widespread. Therefore, although diversification at the level of companies is advantageous, it can also increase the probability of systemic risk. Figure 4 shows a general model of how systemic risk creates and all possible modes of impact. Accordingly, the main elements of the model are:

- Shocks
- Contagion Channels
- Financial and economic institutions
- Structural Vulnerability (Increased Exposure to Systemic Risk)

Shocks also develop in this model through interconnected transmission channels, which have various forms such as:

- Mutual exposures, such as exposure to risk through financial statements or bilateral trade exchanges.
- Market-based such as behavioral factors and asset auctions.
- Structures such as the similarity of assets and liabilities structure and risk management and diversification methods.
- Internationals such as foreign banks and financing of global financial markets.
- The product, which involves the use of derivatives and specific financial instruments that can obscure the relationships and interconnections of companies.
- The payment system which includes relationships between banks and financial institutions in a settlement and payment system.

Figure 4. General Model of Systemic Risk Factors



Given the many definitions of systemic risk and the different categories of risk factors, it seems almost impossible to reach a consensus on how to measure the systemic risk; In particular, it is always possible to occur new mechanisms and channels that affect the whole financial and economic system. Therefore, to obtain a stable framework for monitoring and managing systemic risks and financial stability, it is necessary to deal with different aspects of systemic risk and to continually review them to adapt to new conditions in the system.

Systematic Risk Modeling and related Barriers

Given the complex nature of financial and economic systems, it is necessary to consider systemic financial feedbacks to analyze these systems. Therefore, the proposed models in the literature only deal with part of the systemic risk issue and its consequences. These models cannot consider the other components and their feedbacks in the financial and economic systems. As a consequence, it is not comprehensively possible to analyze and control systemic risks. In other words, although the existing models have a very good theoretical and analytical power to examine the dynamism in the financial systems, they are partial and do not consider the feedback structure of financial systems. Their main weakness of these models can summarize in two points:

- The equations of models and the considered processes are predetermined and do not have enough flexibility. Because of this, these models are too mechanical and have a low degree of freedom.
- Most studies have focused on a particular aspect of the financial system and have not considered the interactions of each aspect

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with other aspects. On the other hand, providing an open model to consider all aspects also seems practically impossible due to the limitations on the precise determination of the relationships and formal clarity of the model components.

Besides, agent-based simulation models can take a comprehensive view of the complex financial-economic system and its feedback structure. Therefore, applying simulation models can eliminate many of the shortcomings of previous models, which are partial and did not consider many of the subsystems in the financial systems. Conversely, a review of existing studies indicates that there is little acceptance of these models in the existing literature. Perhaps the most important reason is the lack of formal clarity and model replicability in such models. Specifically, simulation techniques are always challenging since there is often no accurate explanation of the forthcoming behavior of these models and related reasons (Upper, 2011). Therefore, we find a conflict between formal precision and the problems of limitations in modeling in one hand and the comprehensive modeling with unprecise relationships on the other hand. Therefore, both classes of models should combine in the analysis of financial and economic systems to take advantage of both models and avoid the disadvantages.

Network theory and its related models rely on theoretical relationships and appropriate accuracy in modeling, as well as the ability to propose a comprehensive model based on different aspects. Therefore, financial network models have the advantages of accurate and partial models, and at the same time, they lack their problems (Dastkhan & Shams Gharneh, Determination of Systemically Important Companies with Cross-Shareholding Network Analysis: A Case Study from an Emerging Market, 2016). Some studies combine network-based simulation models with econometric equations (see for example, (Dastkhan, 2019); (Billio, Getmansky, W.Lo, & & Pelizzon, 2012)).

Financial Networks and Systemic risk

Market participants characterize financial crises by rapid, unexpected, and severe instabilities in the financial systems. The recent global financial crisis has led to new efforts to understand the structure of financial systems and the roots of economic and financial instabilities. One of the important characteristics of financial systems is the existence of relationships among different agents that create a network of interconnected relationships. The network of relationships makes it possible that a limited number of failures in the system spread to the other components of the system and cause an epidemic crisis. Therefore, it is necessary to investigate the structure of financial and economic systems as one of the most important actions for managing systemic risks and global crises. It is necessary to focus on network theory and its related principles to analyze the financial networks.

The structure of the financial and economic networks can play a critical role in financial crises in at least three following ways:

- Financial networks may lose their robustness so that when some of the key elements of the system failed, the whole system will collapse.
- The pattern of the network edges may be such as to make the system susceptible to contagion. This contagion can occur both through formal relationships between companies and through the social relationships between individuals.
- The lack of diversity in financial networks may influence the resilience of financial and economic systems, which means that the systems are unable to adapt and recover to the new conditions.

A financial network is stable when it can overcome the failure of some nodes. One of the most important elements in analyzing the stability of financial networks is the existence of networks with heavy-tailed degree distributions, such as scale-free distribution and power-law distribution. In such networks, most nodes have a low degree of connections, but a few numbers of nodes have high relationships. Scale-free networks are robust to random shocks, as most of their nodes are low-degree and this is much more likely to disturb a low-degree node; but on the other hand, these networks are highly vulnerable to the shocks affecting high-degree and central nodes of networks (Dastkhan & Shams Gharneh, 2018). Some critical points should notice in analyzing financial networks:

1. A long period of stability is no guarantee to continue stability in financial networks. If the nodes of the financial network randomly exposed to failure, it will resolve in most cases. Sooner or later, however, these failures may penetrate high-degree nodes and lead to systemic risk in the financial and economic system.
2. The role of high-degree nodes in such networks is undeniable in systemic risk analysis. It introduced a paradigm change in financial literature from the so-called "too big to fail" to the "too interconnected to fail".
3. The available results show that preventing the failure in high-degree nodes can improve the stability in such networks. The insurance layers or government support in these nodes makes it possible (see for example, (Dastkhan & Shams Gharneh, 2017); (Peltonen, Rancan, & Sarlin, 2018), (Glatfelder, 2010)).
4. The insurance layers or government support in these nodes makes it possible. Besides, it is possible to design new mechanisms that can alter the structure of the financial network in such a way as to prevent the creation of high-degree nodes. These mechanisms may include but are not limited to antitrust legal procedures,

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imposing downsizing policies, restructuring or splitting into smaller units, and or even remove of high-degree nodes. For example, the Basel 3 agreement or some other restrictive laws alongside the incentives for companies that comply with these rules can eliminate the high-risk companies to some extent.

On the other hand, contagion is another important factor in financial networks. Numerous studies show that the concept of contagion in a financial network is strongly dependent on the network structure (see for example, (Dastkhan & Shams Gharneh, 2018); (Karimi & Raddant, 2014); (Lenzu & Tedeschi, 2012)). The important point is that not all nodes in a network have the same role in financial contagion. High-degree nodes play a much more active role in spreading failure in the financial system. Low-degree nodes can only be effective in contagion when they connect to distant nodes of the network. We know it as the "small-world characteristic" in network theory.

Besides the formal channels of contagion, the social relationships network is another type of contagion channel. The network of social relationships between bankers and the board of executives and the other agents in the financial system has a huge impact on the dynamics of the system. In many cases, individuals make their decisions based on the actions, decisions, and even beliefs of other socially connected individuals. This can lead to herd behavior and increase panic in the financial markets. On social media, some people in contact need to confirm an opinion to publish it. Therefore, in such networks the chances of propagation are higher when the connections of the network nodes are neither too high nor too low. The low number of relationships leads to low approval and stop contagion. In contrast, too many relationships cause many disapprovals from the contacts and prevent contagion.

As the third form of the financial network effects, financial network resilience knows as the degree of adaptation to changes and the ability to recover the functions of the financial system. This "self-healing" capability has been the subject of much interest in ecosystem literature. In sudden environmental changes, a more diverse system is more capable of evolving and adapting in contrast with a uniform ecosystem. Likewise, financial systems also need diversity to maintain resilience against different shocks (Haldane & May, 2011).

There is enough evidence that in recent decades, financial systems have lost their diversity as their complexity increases (Elliott, Golub, & & Jackson, 2014). Although diversification measures apply at every level of the financial and economic systems, the selected strategies are very uniform. As a result, the resilience of the system to environmental shifts has decreased. Therefore, a critical strategy to increase the resilience of financial and economic systems is to design new incentives to increase diversity in strategies and practices, not just investments (Cabrales, Gottardi, & Vega-Redondo, 2017).

Prudential Policies

Prudential policies are security standards that provide a guarantee of stability at the corporate level as well as at the entire market level. After the global financial crisis, financial policymakers and central banks have emphasized the need for more macro-prudential policies to preserve the financial system against such crises. Although the goal of prudential policies is always to maintain the financial system, existing prudential policies have been designed only to check the financial statements of corporations and financial institutions individually. The recent financial crisis has shown that these individual corporate policies, which called as micro-prudential policies in the literature, sometimes ignore the overall financial risks related to the whole system. As a result, policymakers focused on designing new policies to maintain the financial system as a whole, calling them as macro-prudential policies. The purpose of these policies is to improve the stability of the financial system, mitigate the challenges of credit cycles, and to reduce the risk of boom and bust cycles.

Macro-prudential policies do not reduce the importance of micro-prudential policies. They are essential to maintain the stability of the financial and economic system and are at the heart of prudential policies. The Basel Banking Oversight Committee has provided a defensible framework for micro-prudential policies with the introduction of the Basel 2 standard. They are also undertaking some efforts to develop and finalize the Basel 3 standard to maintain overall system stability.

Both executives of micro and macro-prudential policies use the related instruments, such as liquidity and capital reserves or balance sheet restrictions, at the individual level of corporations and institutions. However, they implement these policies for different purposes. For example, micro-prudential policies adjust individual capital levels based on corporate risk level, while macro-prudential policies adjust general capital levels in the market based on financial cycles to avoid systemic risks. Table 1 summarizes the most important micro and macro-prudential measures and their overlaps ((Hoogduin, Osisky, & Seal, July 2013); (Nicolò, Favara, & Ratnovski, 2012); (Borio, 2011); (Repullo, Saurina, & Carlos Trucharte, 2010)).

Table 1. Important Micro and Macro-prudential Policies and their Overlaps

Macro	Micro	Measures
		Minimum Capital Adequacy for a company
		Pillar 2 Capital Requirement
		Countercyclical Capital Buffer
		Capital Conservation Buffer
		Systemic Capital Surcharge

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	Dynamic Provisioning
	Capital Risk Weights
	Leverage/ Debt Ratio
	Large Exposure Limits
	Loan to value Limits
	Debt to Income Limit
	Risk Management Standards
	insurance layers / government support for failed companies
	Antitrust, Downsizing, Restructuring and Splitting Policies
	Providing legal and financial incentives for companies implementing non-imposed policies

It should note that financial policymakers and central banks must concern about market conditions and business cycles when they apply the above measures. In other words, the use of prudential policies of both types at the wrong time can exacerbate the crisis in the financial system.

CONCLUSION

Financial and economic systems are known as one of the most complex human systems. This can attribute to the existence of numerous factors and interactions among them as well as the informal social relationships in the financial systems. Accordingly, the financial and economic systems may be subject to systemic risks, as in other complex systems. In financial and economic systems, shocks in one or more companies propagate across the system in the form of a cascade effect and eventually causing systemic risks. In this paper, a brief overview of the most important characteristics of complex systems is presented. Different definitions and concepts of systemic risk in financial and economic systems also overview in the paper. Moreover, we evaluated different methods of systematic risk modeling and analysis in the financial systems. Then, we concentrated on financial networks as one of the most widely used approaches in the evaluation of systemic risks. A review of the most important prudential policies to mitigate the systemic risk in financial systems is provided. Review of complex systems shows that some features such as nonlinear interactions, network interactions, and power-law and heavy-tailed tailed distributions exacerbate the extreme events in such systems and can result in systemic risk and financial crises. The results also showed that various studies of systemic risk are not comprehensive and only focused on one or a limited number of aspects. However, a complete classification of systemic risk divides it into two aspects, the structural and the time aspects of systemic risk. In the structural aspect of systemic risk, the existence of systemically important companies can exacerbate systemic risk. Besides, examining the systemic risks shows that there are three factors of interconnection, correlation, and contagion as constituent elements of systemic risks. Interconnection can attribute to the causal relationships between the factors of the financial and economic systems, while correlation is related to the simultaneous movement between the factors, which is not necessarily caused by causal relationships. Contagion, as the root element of systemic risks, indicates the spread of failure from one or some companies to the entire system via the interconnection and correlation channels.

Investigating the models of systemic risk analysis showed that network-based models could provide a comprehensive simulation model of the financial system as well as a good accuracy in defining mathematical equations. Therefore, these models are known as the most popular model for systemic risk analysis in financial literature. The results also indicate that to control and manage systemic risks in financial and economic networks, we need approaches that take into account both the stability and the resilience of the financial system. By examining the concept of micro and macro-prudential policies, it should note that financial policymakers and central banks should use these measures according to market conditions and business cycles to maintain the stability and resilience of the financial system. In other words, the use of prudential policies of both types at the wrong time can exacerbate the crisis in the financial system.

REFERENCES

Billio, M., Getmansky, M., W.Lo, A., & & Pelizzon, L. (2012). Econometric measures of connectedness and systemic risk. Journal of Financial Economics, 535-559.

Bisias, D., Flood, M., Lo, A., & Valavanis, S. (2012). A survey of systemic risk analytics. Annual Review of Financial Economics 4, 255-296.

Borio, C. (2011). Implementing a Macroprudential Framework: Blending Boldness and Realism. Capitalism and Society. doi:DOI: https://doi.org/10.2202/1932-0213.1083.

Cabrales, A., Gottardi, P., & Vega-Redondo, F. (2017). Risk-sharing and contagion in networks. The Review of Financial Studies 30(9), 3086–3127.

Dastkhan, H. (2019). Network-based early warning system to predict financial crisis. Int J Fin Econ., 1–23. doi:https://doi.org/10.1002/ijfe.1806

Vol. 5, No. 1, June 2022,
pp. 37-56, ISSN p:2622-4755
e:2622-4798

Dastkhan, H., & Shams Gharneh, N. (2016). Determination of Systemically Important Companies with Cross-Shareholding Network Analysis: A Case Study from an Emerging Market. Int. J. Financial Stud. 4, 13., 1-17. doi:10.3390/ijfs4030013

Dastkhan, H., & Shams Gharneh, N. (2017). Simulation of Contagion in the Stock Markets Using Cross-Shareholding Networks: A Case from an Emerging Market. Computational Economics. doi:10.1007/s10614-017-9781-6

Dastkhan, H., & Shams Gharneh, N. (2018). How the ownership structures cause epidemics in financial markets A network-based simulation model. Physica A, 492, 324–342.

DeBandt, O., & Hartmann, P. (2000). Systemic risk: A survey. Frankfurt, Germany: Working Paper Series No 35, ECB, 13.

Dow, J. (2000). What Is Systemic Risk? Moral Hazard, Initial Shocks, and Propagation . Monetary and Economic Studies 18(2), 1-24.

Eijffinger, S. (2012). Defining and Measuring Systemic Risk. In S. Eijffinger, & D. Masciandaro, Handbook of Central Banking, Financial Regulation and Supervision (pp. 316-317). Cheltenham, Northampton: Edward Elgar.

Elliott, M., Golub, B., & & Jackson, M. (2014). Financial Networks and Contagion. American Economic Review 104,, 3115–3153.

Glatfelder, J. (2010). Ownership Networks and Corporate Control: Mapping Economic Power in a Globalized World. Zurich: A dissertation submitted to the ETH.

Haldane, A., & May, R. (2011). Systemic risk in banking ecosystems. Nature.

Helbing, D. (2010). Systemic Risks in Society and Economics. IRGC – Emerging Risks project, Working Paper.

Hoogduin, L., Osisky, J., & Seal, K. (July 2013). Macroprudential and Microprudential Policies: Toward Cohabitation. Duisenberg: DSF Policy Paper Series.

Karimi, F., & Raddant, M. (2014). Cascades in Real Interbank Markets. Computational Economics 47(1), 49-66.

Lenzu, S., & Tedeschi, G. (2012). Systemic risk on different interbank network topologies. Physica A 391, 4331–4341.

Nicolò, G. D., Favara, G., & Ratnovski, L. (2012). Externalities and Macroprudential Policy. IMF Discussion Note SDN/12/05, IMF.

Nier, E. W. (2009). Financial Stability Frameworks and the Role of Central Banks: Lessons from the Crisis. IMF Working Paper WP/09/70.

Pasquariello, P. (2007). Imperfect Competition, Information Heterogeneity and Financial Contagion. The Review of Financial Studies 20(2), 391–426.

Peltonen, T., Rancan, M., & Sarlin, P. (2018). Interconnectedness of the banking sector as a vulnerability to crises. International Journal of FInance& Economics. doi:10.1002/ijfe.1701

Repullo, R., Saurina, J., & Carlos Trucharte. (2010). Mitigating the pro-cyclicality of Basel II. Economic Policy 25, 659–702.

Smaga, P. (2014). The concept of systemic risk. Systemic Risk Centre Working Paper.

Upper, C. (2011). Simulation methods to assess the danger of contagion in interbank markets. Journal of Financial Stability.