

# A Review of Research on Financial Risk Contagion\*

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**Abstract**—This paper summarizes the research on financial risk contagion and reviews related literature research from the empirical research methods of financial risk contagion and the research methods of complex network theory.

**Keywords**—risk of infection; model; financial system

## I. INTRODUCTION

The 19th CPC national congress called for deepening the reform of the financial system, strengthening the capacity of financial services to the real economy, increasing the proportion of direct financing and promoting the healthy development of multi-tiered capital markets. We will improve the two-pillar regulatory framework for monetary and macro-prudential policies and deepen market-oriented reform of interest rates and exchange rates. We will improve the financial regulatory system and ensure that systemic financial risks do not occur. This puts forward an urgent demand for us to understand the risk contagion mechanism in the financial system and the effective intervention when local risks appear.

## II. RESEARCH ON THE DEFINITION OF FINANCIAL RISK CONTAGION

The word "contagion" is based on epidemiology, and World Bank has three definitions of "financial risk contagion", which is a generalized risk infection, a strict and very strict risk infection. The broad risk contagion is the behavior of the market fluctuations in other markets; strict risk contagion to other market transfer refers to the financial market volatility, even across borders over the relevance of the state or other fundamental connection between the normal periods of relevance. In a very strict sense, risk contagion refers to the increase in volatility correlation between financial markets during the crisis, which is relative to the stable market. Boyer et al. (2006) defined contagion as the "excessive correlation" between stock markets during periods of high volatility, in which "excess" was defined as

the significant increase in the correlation between investing in stocks (relative to stocks of less concern). In addition, the application of the impact strength of the Forbes (2012) to define risk contagion, which is that the spread of a general negative impact in a country is not contagious, and only one country's extreme negative impact is transmitted to another (or a group) country. Xiaolin Gong (2012), a domestic scholar, defined contagion as the increase of risk linkage at the macroeconomic and financial levels after impact. Zhang lei (2013) defined infectivity as the transmission process from one country to other countries after suffering extreme negative shocks. Empirical analysis of financial risk contagion

## III. RESEARCH ON METHODS TO MEASURE FINANCIAL RISK CONTAGION

### A. VAR Model

This method is to make correlation analysis mainly by building VAR model for different countries or between different financial markets in the same country, mainly adopts granger causality test, impulse response analysis and variance decomposition method. Cha and Sekyung (1999) studied the risk contagion effect of the U.S. stock market on the stock market of emerging countries by using the multiple VAR model, and found that the 1987 U.S. stock market crash had a significant contagion effect on the stock market of emerging markets. Based on VAR model, Zhibo Zhang and Zhongying Qi (2005) analyzed the changes in causality between the volatility of financial markets of various countries before and after the Asian financial crisis in the 1990s, as well as the changes in the impact response of affected countries in the face of crisis contagion, so as to test the contagion effect of crisis. Yang. J. and Zhou. Y.G. (2013), who studied the global credit crisis of the global credit crisis during the global credit crisis, the problem of credit risk contagion to the global credit crisis, and in the study, the authors used a fusion cluster analysis, the main ingredient analysis, and the VAR model, and through the research, the leverage ratio, especially the short-term debt ratio, is the important determinant of the financial institution's credit risk transfer, and the corporate governance index, the size of the firm, the liquid assets are relatively secondary; Park and head, Jr. R. V. (2014) studied the emerging market economies, the problem of financial risk contagion and influencing factors, mainly uses the method is based on the VAR model using 25 new financial pressure exponent of the market, has the advantage of VAR model can better solve the problem of endogenous variable and hetero-scedasticity, etc., but the

\*Foundation item: Heilongjiang youth innovation talent training program project: Research on risk contagion and prevention and control strategy in financial network based on SIR and SIS combined model (UNPYSCT-2018051); Research project of philosophy and social science in Heilongjiang province: results of risk contagion and simulation research in financial network based on SIRS model (18JYE660); Higher education teaching reform research project: Research on the hyper-network model of financial talent cultivation in the context of big data (SJGY20180191); The research project of the basic scientific research project of the province of Harbin Finance University, which is based on the financial ethics perspective, the research stage of the financial development evaluation of the county area (2017-KYYWF-0088);

downside is not dynamic analysis was carried out on the correlation between the financial markets.

### B. Copulas Connect Function

The risk contagion between financial markets is closely related to the dependent structure of financial markets. Compared with the correlation coefficient method, this method can deal with the non-linear interdependence. Compared with GARCH model and VAR model, this method does not need to make strict assumptions about the movement law of the rate of return. In recent years, Copula function, time-varying Copula function and variable structure Copula function have been used to study the contagion of financial risk. Peng and Ng (2012) studied the cross-market interdependence between five commonly used stock indexes (S&P500, NASDAQ 100, DAX 30, FTSE 100 and Nikkei 225) and their corresponding volatility indexes by using dynamic hybrid Copula. The results show that in some cases, although contagion cannot be significantly detected by the coordinated movement of stock indexes, it can be captured by the dependence of volatility indexes. That means contagion is reflected not only in the first moment of exponential returns, but also in the second moment of volatility.

### C. Epidemic Model

Kermack & McKendrick (1927) was the first to establish SIR model in the field of epidemiology, and studied the epidemic law of Black Death in London from 1665 to 1666 based on the epidemic law of 1906 plague in Bombay, laying a foundation for the dynamics of infectious diseases. It is thought that there is a threshold in that infection model, and when a virus transmission rate is high than a threshold value, the virus can infect, and vice versa, the virus does not spread in the network; According to different population Settings, SIR compartment model can evolve into SIS, SIRS and SIR models. May et al. (2008) believed that the spread of infectious diseases was very similar to the spread of financial risks. Haldane (2009) compared the spread of SARS virus and the risk spread caused by the bankruptcy of Lehman brothers, and found that the infection conditions of both were consistent with the characteristics of virus transmission in their respective networks. As for the infection of financial risks, the intervention of the regulatory authorities is similar to the result of SARS epidemic control. It can be seen that the risk infection in the financial field is similar to the virus infection in the biological field.

Garas (2010) applied the SIR contagion model of contagion system dynamics to the research on the spread of financial crisis among various countries in the world, which indicated that the research on financial risk has entered a new stage. Allen (2000) believed that incomplete market structure contributed to the susceptible group, and concluded that the more complete the market structure, the easier the risk of infection was to be blocked. Gao (2012) used the complex network system engineering theory to construct the SIR model of bank network and obtained the risk contagion threshold. Demiris (2013) studied the SIR model of financial crisis diffusion with the Bayesian estimation method, took

into account the country's time financial and trade links, and found that the implementation of policies to reduce the vulnerability of the financial system is conducive to slowing down the spread of the crisis. Toivanen (2013) established the SIR model of risk contagion in the interbank market and set the probability of contagion as a discrete ratio. Li Shouwei (2011) established a random model of bank risk contagion with the help of the idea of infectious diseases, and found that increasing the governance rate and reducing the correlation degree could effectively spread risk. Ma Yuanyuan (2013) used SIR model to simulate the diffusion process of stock market crisis and gave the calculation method of stock market crisis diffusion model.

## IV. RESEARCH METHOD OF COMPLEX NETWORKS

### A. Definition of Network Theory

Network theory is a branch of mathematical theory with topological properties. If multiple principal nodes exist in a network and can evolve into many different network structures, such a network is called a complex network. Because the network can accurately describe the complex relationship between financial markets, for example, all the nodes in the network are connected to each other through various financial associations, which directly reflect the risk exposure problem between each node. It is possible to analyze that spread of risk of different risk based on the analysis of the financial risk of the complex network, and can analyze the trend of the risk spread in the financial market, and can directly and image form the internal relation of the financial system, and analyze the interaction and relationship between the financial markets. In recent years, more and more scholars have introduced their research into financial area to study the risk of transmission of risk because of the clear advantages of complex networks, which describe the correlation structure between market and the interaction between investors.

Allen and Gale (2000), based on the model setting of Diamond and Dybvig (1983), conducted a pioneering study on risk contagion in the interbank market. They argued that sparse networks were more likely to spread risk. The logic was that tight networks spread the impact of a single bank failure across the system. Allen (2009) studied risk contagion in the interbank market. Jia Yandong (2011) analyzed the risk diffusion mechanism based on the financial network model and provided the measurement method of the systematic importance of financial institutions. Mu Tong and Yi He (2012) took China's large-sum payment system as the object, established a risk evolution model in the complex financial network, and used this model to evaluate the rescue strategy for systemic risk. The results showed that the balanced rescue strategy was strictly superior to the unbalanced rescue strategy in most cases.

### B. Research Methods of Complex Networks

In recent years, complex network theory has made breakthrough progress. Watts and Strogatz (1998), Barabasi and Albert (1999) successively proposed the "small-world network" model and the "scale-free network" model,

indicating the gradual maturity of complex network theory. Complex network refers to the network with self-organization, self-similarity, attractor, small world, part or all of the properties of scale-free. Complex network refers to the network with self-organization, self-similarity, attractor, small world, part or all of the properties of scale-free. The theory is that by treating financial institutions as the nodes of a network, the relationship between financial institutions and financial institutions is regarded as a chain of networks, which can directly and figuratively portray the inherent correlation of the financial system, and the interaction and association between financial institutions is based on this analysis. Since complex networks have obvious advantages in describing the correlation structure between markets and the interaction between investors, scholars at home and abroad have begun to introduce the theory of complex networks into the research field of financial risk contagion. Allen and Gale (2000) were the first to use this method to study the relationship between financial structure and risk contagion, pointing out that risk contagion depends on the inter-relationship within the financial system, and the fully connected network is more stable than the non-fully connected network.

Gai and Kapadia (2010) believed that the high connectivity of financial network could not only reduce the probability of infection, but also increased the risk of infection when problems occurred. Dette (2011) constructed the structure of international financial network and established the potential cascading network model of financial interdependence and financial pressure through the default loss function. The simulation found that the default behaviors of small countries (such as Greece) could be absorbed by the network. Upper (2011) summarized the simulation methods for the spread of risk contagion in the interbank market network, discussed the assumptions and applications of various simulation methods, and pointed out that infectious defaults could not be completely eliminated. The robustness test showed that these methods could accurately predict whether the risk contagion would cause systemic risk and identify the Banks that triggered the risk contagion. However, due to the lack of behavioral basis, these methods are not suitable for the analysis of policy choices in crisis.

## V. CONCLUSION

From the above literatures, it can be seen that studies on the understanding of infectious diseases and immune strategies provide new ideas for the analysis of financial crisis and financial system stability. In general, foreign studies on the theory of risk cross-infection between financial markets are relatively mature, and the theory of medical infectious diseases has been used to study the transmission of financial crisis and the stability of financial system. Domestic scholars mainly using VAR model, copulas connect model and SIR model empirical analysis methods, such as the study of financial market risk of cross infection, but many model only from the financial risk of a certain perspective to describe the process of risk contagion, does not conform to the current financial market risk

transmission path of the complexity and variability characteristics. It can be seen that the research on the introduction of dynamic models of infectious diseases into financial risk contagion is still in the exploratory stage. Therefore, how to choose the appropriate model to describe the contagion process of financial market risk is still the focus of research.

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