Literature Review

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Risk connectedness is the central concept to risk management and measurement. With the development of the global market, new competitive situations and cooperative relationships have emerged between different fields. Meanwhile, due to the specialization of the market and division of labor between industries, the dependence among industries has gradually been strengthed. In the recent epidemic around the world - Covid2019, risk spread rapidly from the basic industries including traffic, medicine, and agriculture to the whole market, which demonstrates that a local market can become the source of risks as long as it is affected by risk factors and risks be linked to other industries through pipelines such as logistics, capital flow, and information flow. Finally, the overall risk connectedness effects have emerged, which significantly affected many aspects of each country.

The mechanism behind the risk transmission process is complicated, which covers numerous industries and countries. Thus, policymakers can make more optimal decisions to handle the risk as long as they can figure out the risk transmission mechanism. Also, companies in certain fields can effectively avoid risk once they know the mechanism. However, the whole market is a big network that involves many nodes and edges shown in Fig.1. Therefore, in this paper, I would like to write a basic literature review for the risk transmission mechanism, which can roughly summary previous work on this topic and pave the way for my future work.

Figure 1: General Network

Basically, the range of the literature included is not limited to a certain area such as finance. In the following sections, I will cite papers from finance, economy, statistics, social science, public policy. Also, I want to utilize those papers to show how they have dealt with similar problems with different models and how I can contribute to the literature.

The basic transmission process of the risk mentioned above is that firstly a big event emerges and brings about risks in certain fields or industries, then the risk will be transmitted to other areas and become the systemic risk. Thus, researchers are analyzing the systemic risk when they want to figure out how the risk is generated.

In the work of [Acharya et al., 2017], they present an economic model of systemic risk in which the undercapitalization of the financial sector as a whole is assumed to harm the real economy, leading to a systemic risk externality. They define system risk as to the risk of collapse of the entire market, as opposed to the risk associated with the individual component in a system. Also, they find that financial regulation should be focused on limiting systemic risk, that is, the risk of a crisis in the financial sector and its spillover to the economy at large.

Plus, [Allen L, 2012] answered the question which is: does systemic risk in the financial sector predict future economic downturns? In other words, can the systemic risk relate to economic downturns in the future? They derive a measure of aggregate systemic risk called CATFIN that complements systemic risk measures by forecasting macroeconomic downturns six months into the future using out-of-sample tests conducted with U.S., European, and Asian data. The result shows that the measure designed in [Allen L, 2012] can forecast macroeconomic declines in financial institutions but has not marginal prediction ability for both nonfinancial firms and simulated 'fake financial institutions'.

The concept of systemic risk discussed in [Allen L, 2012] and [Acharya et al., 2017] are similar. [Acharya et al., 2017] focus on the general definition of systemic risk and how the concept can be applied to finance, but [Allen L, 2012] focuses on the relationship between systemic risk with economic depression. Those two papers can clearly demonstrate the central concept of my paper - systemic risk, but they both do not cover all industries in the market. Thus, I want to extend the content of systemic risk analysis to a wider range, which involves most of the industries in the market. To study the relationship between different components of the market, I need to demonstrate how they are connected, that is, connectedness.

In the work of [Billio M, 2012], they measure the connectedness between sectors in the financial market. Basically, the measurement of connectedness is established by utilizing principal component analysis and Granger causality networks. The author finds that all sectors have become highly correlated, which means a high degree of connectedness. The connectednesses between different sectors are not symmetric, which means that risk is more likely to flow from one industry to another. Also, they find that the connectedness will likely increase the level of systemic risk through a complex and time-varying network of relationships. The measurement can also be used to identify and quantify certain periods with big events.

With connectedness, I can clearly demonstrate how risk is transmitted and quantify the risk transmission process. However, the measurement of connectedness proposed by [Billio M, 2012] is limited since it cannot handle the high-dimension data with hundreds of variables. Thus, appropriate methods to estimate connected are required. In 1996, Robert Tibshirani proposed a method for variable selection in the linear regression model named lasso. The 'lasso' minimizes the residual sum of squares subject to the sum of the absolute value of the coefficients being less than a constant. The idea behind lasso is quite general and can be applied in a variety of statistical models. Thus, the lasso algorithm can handle high-dimension data if we apply it to a specific model. In 2009, Hui Zou and Hao modified the lasso method by designing an adaptive elastic-net model, which can not only deal with the problem result from the high dimensionality but also ensure the oracle property [Fan and Li, 2001]. Those methods to handle high-dimension data provide me with an ideal way to avoid econometric problems brought about by hundreds of industries in the market.

Though we have variable selection methods including lasso and adaptive elastic-net, they can hardly be applied to PCA and Granger causality networks used in [Billio M, 2012]. In the work of [Hsu, N. J., 2008], the author propose a subset selection method for vector autoregression (VAR) using the Lasso. The simulation results in the paper demonstrate that the Lasso method performs better than several conventional subset selection methods for small samples in terms of prediction mean squared errors and estimation errors under various settings. Plus, the author applies the method to model U.S. macroeconomic data and conduct variance decomposition to illustrate the relationship between each variable in the model.

In the work of [Demirer, M., 2018], the author utilized the VAR-Lasso model proposed by [Hsu, N. J., 2008] and regard the result of variance decomposition as the pairwise connectedness between different backs abound the world. To be more specific, the author uses VAR-Lasso methods to shrink, select, and estimate the high-dimension network data of the world's top 150 banks from 2003 to 2014. With this model, the author tells us how risk is transmitted in the global bank network. In particular, the paper contains both static analysis and dynamic analysis. In the static analysis, the author compares the network with respect to risk transmission before and after the financial crisis in 2008, which is a globally big event. The result shows that the model can clearly demonstrate the risk transmission process in the bank network.

One similar paper is the work of [Wang, G. J., 2018], they use the risk connectedness framework of [Demirer, M., 2018] to investigate connectedness in the Chinese banking system based on daily range-based volatility series of 14 publicly-traded commercial banks from 2008 to 2016. Statically, they find a positive rank correlation between the size and risk connectedness of banks. Their findings suggest that a bank might be "too big to fail," but not necessarily "too interconnected to fail" and vice versa, and that these two cases may coexist conditional on the system being in distress.

Additionally, [Diebold et al., 2017] uses variance decomposition from high-dimensional vector autoregressions to characterize connectedness in 19 key commodity return volatilities, 2011-2016. They study both static (full-sample) and dynamic (rolling-sample) connectedness and they summarize and visualize the results using tools from network analysis. The results reveal clear clustering of commodities into groups that match traditional industry groupings but with some notable differences. The energy sector is most important in terms of sending shocks to others, and energy, industrial metals, and precious metals are themselves tightly connected.

Based on the literature above, I would like to clarify my research. The central idea of my research is the systemic risk and I am interested in how risk is transmitted in the system. The measurement for the transmission process is connectedness, which can be captured by variance decomposition of VAR. Plus, the penalty term of the Lasoo or elastic-net has to be added due to the high dimensionality of the data. Previous research focuses on financial areas but my research will be extended to a wider range, which includes most of the industries in the society. Plus, I will not only study how financial events influence the whole system but also figure out how natural disasters and epidemics affect society.

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