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Sectoral risk research about input–output structure of the United States

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HIGHLIGHTS

- Sectoral status coefficient defines the extent of symmetry of local intersectoral network.
- The asymmetry structure American economy in sectoral level under complex network perspective.
- Correlation relationship research between the extent of symmetry of economy and output.
- Based on status coefficient series, we can identify sectoral risk effectively.

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ABSTRACT

There exist rare researches about economic risk in sectoral level, which is significantly important for risk prewarning. This paper employed status coefficient to measure the symmetry of economic subnetwork, which is negatively correlated with sectoral risk. Then, we do empirical research in both cross section and time series dimensions. In cross section dimension, we study the correlation between sectoral status coefficient and sectoral volatility, earning rate and Sharpe ratio respectively in the year 2015. Next, in the perspective of time series, we first investigate the correlation change between sectoral status coefficient and annual total output from 1997 to 2015. Then, we divide the 71 sectors in America into agriculture, manufacturing, services and government, compare the trend terms of average sectoral status coefficients of the four industries and illustrate the causes behind it. We also find obvious abnormality in the sector of housing. At last, this paper puts forward some suggestions for the federal government.

1. Introduction

Every time when confronted with financial crisis, the global economies would contract by a huge impact. In order to analyze the causes of the crisis, there are many researches about the risk of economic structure. Although a variety of systematic analysis methods have been introduced [1], the mechanism of how the sectors in the economic system influence each other is not known clearly until now. Network analysis has been widely used to model the intersections of agents in complex systems such as social networks, the Internet, neuroscience and so on, but it has not appeared in the analysis of economic complex systems until the beginning of 21th century. Allen and Gale [2] study financial contagions by employing complex network model, which is the first to apply complex network method to investigate complex economic system. Bech and Atalay [3] analyze the network topology of the federal fund market, finding that reciprocity is correlated with the federal funds rate and centrality is a useful predictor of the interest rate of a loan. Song et al. [4] investigate the daily correlation present among market indices of stock exchanges located all over the world based on network analysis and discover a fast

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and a low dynamics. Wang and Xie [5] research the correlation structure and dynamics of international real estate securities markets from the perspective of network. Yan et al. [6] systematically study the evolution of fluctuation modes and inner structures of global stock markets using 42 globally main stock indices. In summary, since physicists have made significant progress towards understanding the structure and functioning of complex networks which have been proven to be effective in analyzing economic phenomena, the complex network method has been widely used in economic studies now.

In the last few years, we have witnessed the great use of complex networks which model the underlying typology of "real world" complex systems. The main studies have focused on the statistical properties of various networks, such as power-law distribution of node degree [7], small world property [8,9], self-similarity [10], community structure [11] and so on. Based on these properties, many kinds of network models have been built to do some predictive researches. Among the above properties, the significance of an important property of the network, symmetry, has been neglected in some ways.

There are many kinds of expressions of symmetry of the network. To name just a few, "If an ensemble of causes is invariant with respect to any transformation, the ensemble of their effects is invariant with respect to the same transformation [12] ", "The symmetry group of the cause is a subgroup of the symmetry group of the effect [13] " and so on. To sum up, symmetry in a system means invariance of its elements under a group of transformations [14,15]. In a mathematical sense, symmetry of a graph is the set of transformations that leave the properties of the graph unchanged. And when we focus on network structures, the concept of symmetry comes from the concept of automorphism of the graph, which characterizes adjacency invariance to transformation operation on the node set [16]. Graph consists nodes and edges. Two nodes are defined as adjacent nodes if they are connected by an edge. An automorphism acting on the nodes can be seen as a permutation of the nodes preserving their adjacency. Then a network is asymmetric if its underlying graph contains only an identity permutation, otherwise, the network is symmetric [17].

But this kind of definition is so abstract that we need more concrete measurements of asymmetry of the network. For example, there is a ubiquitous law that nodes which have similar linkage pattern such as degree tend to have similar linkage targets [17]. When talking about the structural properties of the intersectoral network, the extent of asymmetry between sectors can be measured by the extent of variation of the degree sequence of the intersectoral network [18]. And if the network is locally symmetric, we can use geometric decomposition which is most powerful. That is, a network is locally symmetric if its automorphism group can be factorized into a large number of geometric factors [19].

Intuitively, higher symmetry means higher order and more stability. Talking about the relationship between asymmetry and fluctuations specifically, Acemoglu has argued that there exist network origins of aggregate fluctuations. On account of the complex of financial market, sectoral idiosyncratic shocks may result in sizable aggregate volatility if there exists significant asymmetry in the network [18]. That is to say, the risk of the economic network is larger if the degree of asymmetry of the network is higher. Therefore, we can analyze the risk of sectors in the whole intersectoral input–output network based on the level of asymmetry [20].

However, subject to the restrictions of data in China, Zhang and Nie [20] cannot analyze the sectoral status coefficient in time series dimension which is a very important aspect for analyzing an indicator. What is more, there are rare references concerned with the risk level of individual sectors and it is very important for the government to make policies in sectoral level. We can imagine that the loss would not be so big if the United States government could make control in time during financial crisis, so we need to study economic risk in sectoral level. The main contribution of this paper is that we first apply sectoral status coefficient to measure the symmetry of the U.S. local intersectoral input–output network, which characterizes the "cascade effect" of economy network not only by first-order interconnections and second-order interconnections, but also by higher-order interconnections. What is more, we first investigate sectoral status coefficient in time dimension due to the complete database in America and have many interesting findings.

The rest of the paper is organized as follows. Section 2 introduces the origin and economic application of sectoral status coefficient; Section 3 briefly outlines data sources and its processing; Section 4 discusses empirical results with both a cross sectional and time series perspective; and Section 5 concludes this paper.

2. Methodology

2.1. Clustering coefficient

In graph theory, clustering coefficient measures the extent of nodes tend to cluster together. There are two versions of this measure: the global and the local. The global clustering coefficient is the number of closed triplets over the total number of triplets, but we focus on the local clustering coefficient. Supposing the degree of node i is k_i, that is, node i has k_i immediately connected neighbors. The local clustering coefficient C_i of node i is given by the ratio of the number of links between the nodes within its neighborhood to the number of links that could possibly exist between them, which can be seen in the following equation:

$$C_i = \frac{E_i}{k_i\left(k_i - 1\right)/2}, \tag{1}$$

where E_i is the links between node i's neighborhood in fact. If node i has only one neighbor or no neighbor, then $C_i = 0$. If there exist all links that could possibly exist between them, then $C_i = 1$. It is obvious that $0 \leq C_i \leq 1$.

Clustering coefficient cannot measure the symmetry of the subnetwork precisely, although it is positive related to the symmetry as shown in Figs. 1 and 2.