Physica A 506 (2018) 36–49

Contents lists available at ScienceDirect

Physica A

journal homepage: www.elsevier.com/locate/physa

The transmission of fluctuation among price indices based on Granger causality network

Qingru Sun, Xiangyun Gao *, Shaobo Wen, Zhihua Chen, Xiaoqing Hao

School of Humanities and Economic Management, China University of Geosciences, Beijing 100083, China
Key Laboratory of Carrying Capacity Assessment for Resource and Environment, Ministry of Land and Resources, Beijing 100083, China
Key Laboratory of Strategic Studies, Ministry of Land and Resources, Beijing 100812, China

HIGHLIGHTS

- A Granger causality network among price indices is constructed.
- The fluctuation transmission features of price indices of China are analyzed.
- Different price indices play different roles in transmission.
- The fluctuation transmission path of price indices is identified.

ARTICLE INFO

Article history:
Received 14 August 2017
Received in revised form 1 March 2018
Available online 16 April 2018

Keywords:
Complex network theory
Time series
Granger causality
Price transmission
Price indices

ABSTRACT

In this paper, we provide a method of statistical physics to analyze the fluctuation of transmission by constructing Granger causality network among price indices (PIGCN) from a systematical perspective, using complex network theory combined with Granger causality method. In economic system, there are numerous price indices, of which the relationships are extreme complicated. Thus, time series data of 6 types of price indices of China, including 113 kinds of sub price indices, are selected as example of empirical study. Through the analysis of the structure of PIGCN, we identify important price indices with high transmission range, high intermediation capacity, high cohesion and the fluctuation transmission path of price indices, respectively. Furthermore, dynamic relationships among price indices are revealed. Based on these results, we provide several policy implications for monitoring the diffusion of risk of price fluctuation. Our method can also be used to study the price indices of other countries, which is generally applicable.

1. Introduction

The research on econophysics has drawn wide attention in recent years. It is an effective method to explore economic issue using statistical physics method. In economic field, price stability is the main goal for macroeconomic management. The price of each commodity is related to each other because of the substitution effect of commodities and supply–demand relationship, leading to that all of the commodities as a whole can be considered as a complex system. In a system of internal links, a very small initial change can lead to a series of chain reactions [1]. If the price of a commodity changes, it can cause the price of other commodities to fluctuate [2,3], which is similar to "domino effect". We define this phenomenon as the transmission of price fluctuation, which is a diffusion process when price fluctuating. In this paper, we identify vital price

* Corresponding author at: School of Humanities and Economic Management, China University of Geosciences, Beijing 100083, China.
E-mail address: gxy5669777@126.com (X. Gao).

https://doi.org/10.1016/j.physa.2018.04.055
0378-4371/

indices and the transmission path of price fluctuations, which are important and still an open and urgent issue, using complex network method in order to monitor the spread of risk of price fluctuation and decrease the difficulty of market regulation.

Many studies focused on the relationships among price indices. There are cointegration relationships [4], correlation relationships [5–8] and transmission relationships [9]. Specially, the causal relationships between the price indices, such as consumer price index (CPI) and producer price index (PPI), have been widely studied [10–12] largely utilizing econometric models, such as cointegration and Granger causality, proving that the relationships are different in different countries. They paid more focuses on macro fluctuations of price indices and price transmission between two price indices. However, previous studies ignore the transmission among a large number of price indices, which is significant for government to avoid systemic risks. Besides, the macroeconomic phenomenon occurs because of the economic performance of micro individuals. Specifically, macro price indices include a range of micro price indices, which in this paper we call sub price indices. For example, CPI consists of a basket of goods, such as food, clothing and so on. Furthermore, if the transmission relationships are evaluated from a macro perspective, some important information is missed because of sub price indices contain more transmission characteristics than macro price indices [13]. But if we put hundreds of variables into an econometric model, multicollinearity problems may arise. Therefore, it is inevitable to develop a new method.

For large-system research, complex network theory can analyze relations among many nodes (that will be defined later) and also explain the structure features [9] and correlation mechanism of a system [14,15]. The structure of a network determines the function of the system [16,17]; therefore, if we study the structure of a network, we can better understand the function of the system [18–21]. On the one hand, it is a useful method to identify risk based on complex network [22]. Through an analysis of the structure of economic networks [23,24], countries with many trade partners can be identified [25] which had a great influence on others and played a vital role to prevent risks. Financial networks were established to find financial institutions with high centrality [26]. They not only had large individual risk but also were important for systemic risk immunization [22]. On the other hand, analysis of the structure of networks can help us understand the transmission path of influence [27]. Scholars researched the transmission of macroeconomic fluctuation by analyzing the structure of economic networks. They found that microeconomic idiosyncratic shocks may lead to aggregate fluctuations and the shocks can be a powerful driver of macroeconomic fluctuations through input–output and geographic networks [1,28,29]. All the above research studied the character of systems by researching the structure of networks, which provided theories and methods for our research.

In this paper, we propose a novel method to analyze the transmission of fluctuation among numerous price indices, using Granger causality method combined with complex network theory. Taking China's price indices as empirical study, we construct a Granger causality network among price indices (PIGCN), with price indices act as nodes and causal relationships between price indices act as edges. Additionally, we study the topology structure of the PIGCN to analyze the transmission of fluctuation among price indices in the aspects of the fluctuation transmission range, intermediation capacity, cohesion and the fluctuation transmission path of price indices, indicating to identify important price indices and the transmission characteristics of price indices to monitor the diffusion of risk of price fluctuation. We also analyze dynamic evolution characteristics of the relationships between price indices. Finally, some policy implications for risk prevention and control are provided.

The paper is organized as follows. Section 2 introduces the method, including Granger causality and complex network model. Section 3 presents the data and empirical results. Conclusion is presented in Section 4.

2. Network construction and topology structure of the Granger causality network among price indices

2.1. Construction of Granger causality network model among price indices

The construction of the Granger causality network model includes the following three main steps.

Step 1: Unit root test

The unit root test is a method to test whether a time series is stationary. We use the Augmented Dickey–Fuller (ADF) test, and the equation is as follows.

$$\Delta x_t = c + \delta t + \gamma x_{t-1+} \sum_{i=1}^{k-1} \rho_i \Delta x_{t-i} + \varepsilon_t \tag{1}$$

where x_t is the value in time t, Δx_t represents the first order difference and ε_t is an error term. The primary hypothesis is defined as $H_0 : \gamma = 0$, indicating that the time series is not stationary. If the result refuses the primary hypothesis, it means that the time series is stationary.

Step 2: Granger causality test

Granger causality is based on precedence and predictability [30,31] and Granger causality test is a common method to research whether there is a causality between two variables [32]. It assumes that the predicted information of variables y