Holding-based network of nations based on listed energy companies: An empirical study on two-mode affiliation network of two sets of actors

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HIGHLIGHTS

- Using complex network theory to simulate heterogeneous economic networks.
- A novel empirical study of two-mode affiliation network of two sets of actors.
- Based on the shareholding relationships of global listed energy companies.
- Constructed one-mode derivative holding-based network of nations.
- Analyzing the global energy competition and cooperation relationships of nations.

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ABSTRACT

Economic networks in the real world are not homogeneous; therefore, it is important to study economic networks with heterogeneous nodes and edges to simulate a real network more precisely. In this paper, we present an empirical study of the one-mode derivative holding-based network constructed by the two-mode affiliation network of two sets of actors using the data of worldwide listed energy companies and their shareholders. First, we identify the primitive relationship in the two-mode affiliation network of the two sets of actors. Then, we present the method used to construct the derivative network based on the shareholding relationship between two sets of actors and the affiliation relationship between actors and events. After constructing the derivative network, we analyze different topological features on the node level, edge level and entire network level and explain the meanings of the different values of the topological features combining the empirical data. This study is helpful for expanding the usage of complex networks to heterogeneous economic networks. For empirical research on the worldwide listed energy stock market, this study is useful for discovering the inner relationships between the nations and regions from a new perspective.

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1. Introduction

As a young but active method, the complex network is well used in many empirical studies, particularly in the sphere of economics, such as the stock market [1–3], futures and options markets [4,5], and international trade [6–9]. It is an effective way to simulate relationships between different economic agents and to analyze the internal correlation relationships of the economic agents. By analyzing correlative literature, we found that previous empirical studies on economic networks have primarily focused on discussing the static or dynamic topological characteristics or the interdependency of homogeneous economic networks that have only one set of nodes (agents or events) and edges (relationships) with the same attributes. However, all real economic networks are heterogeneous in terms of both the agents and the relationships between the agents [10]. It is urgent to study the economic networks with heterogeneous nodes and edges.

There are abundant heterogeneous networks that can simulate the real word on different levels. As a new trend of complex networks and social networks, increasingly more scholars focus on studying multi-mode networks, particularly the two-mode network (or bipartite network) [11]. Usually, we identify the agent of the two-mode network by two different attributes, actors and events. An affiliation network is a typical two-mode network that represents the affiliation relationship between actors and events. It is also called the "membership-network" [12] or the "hyper-network" [13]. It is popular to analyze the bipartite heterogeneous network by transforming a primitive two-mode network into a derivative one-mode network [14] according to the co-attendance or co-membership relationships between actors and events. However, in the real world, actors and events themselves have more or less primitive interactions other than derivative co-attendance or co-membership relationships. Therefore, it is important to study the two-mode affiliation network of more than one set of actors and events.

Listed companies play an important role in both domestic and global economics, and as the owners, shareholders are the organizations and individuals who hold the stocks of the listed companies, and they are the real controllers and beneficiaries of the listed company [2]. Therefore, both listed companies and their shareholders are important economic agents in the stock market. With the development of the international financial market, the internationalization of shareholding has become increasingly more common. One shareholder can hold dozens or even thousands of listed companies' stocks from different nations, and one listed company's shareholders likely also come from several different nations. The relationships between the economic agents (both the shareholders and the listed companies) and the nations to which they belong are a typical affiliation relationship. Meanwhile, as the actors, the economic agents have primitive shareholding relationships with each other. Therefore, we can divide the economic agents into two different sets of actors, the actors of listed companies and the actors of shareholders, and we can construct the two-mode affiliation network of the two sets of actors based on the relationships between the economic agents and the nations and between the shareholders and the listed companies.

Listed energy companies are an important component of listed companies. Energy shows a strong character of international mobility [15–17]. Because of energy's dominant nature in the economy, and its uneven distribution, both energy companies and nations are seeking international cooperation to obtain more resources not only to increase profit but also to ensure national energy safety [18] and to meet the needs of economic development. Therefore, as the main part of the energy market, listed energy companies and their shareholders present stronger internationalization. In this paper, we empirically studied global listed energy companies to construct the primitive two-mode affiliation network of two sets of actors, and then, based on the shareholding relationships between the listed energy companies and their shareholders, we constructed the derivative holding-based network of the shareholders. Then, based on the affiliation relationship between the economic agents and the nations and the derivative holding-based relationship of the shareholders, we constructed the derivative holding-based network of the nations. Then, we calculated different topological features of the network to analyze the global cooperation relationships in the energy stock market between different nations. This study presents novel research about the two-mode affiliation network of two sets of actors by empirical data. For the listed energy stock market, it is useful to discover the inner relationships between the nations and the different roles of the nations around the world.

2. Data and methods

2.1. Data

Global listed energy companies serve as the empirical data, which include the global listed energy companies, their primary shareholders, and the nation to which the companies and their primary shareholders belong. The initial data were downloaded from a well-known database of global listed companies, ORISE PUBLICLY LISTED COMPANIES WORLDWIDE (https://osiris.bvdinfo.com), on December 31, 2013. The attributes of the data include the name of the listed energy company, the name of the listed energy company's shareholder, the ID of the listed energy company, the BVD ID of the listed energy company's shareholder, the nation to which the listed energy company belongs, and the nation to which the listed energy company's shareholder belongs. There are 2334 listed energy companies and 8302 shareholders in the database (after removing duplicate items). To increase the efficiency and visualization of the data process, we transformed the economic agent into an implementation-defined encoding that includes one capital letter and four digits. Each code represents a unique economic agent (one shareholder or one listed energy company). We also abbreviated the names of the nations into two characters; for instance, CA represents Canada, and GB represents the United Kingdom. It is important to note that the data of some special administrative regions, such as Hong Kong, China, and some territories, such as the Cayman Islands, are listed separately in the ORISE PUBLICLY LISTED COMPANIES WORLDWIDE database.