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Topological properties and community detection of venture capital network: Evidence from China

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HIGHLIGHTS

- We construct a network of China's venture capital companies based on data from the Chinese GEM and SME board.
- We study the statistical properties, topological properties and community structure of the Chinese venture capital network.
- Our result shows that there are no dominant venture capital firms in China which act as hubs in the VC network, and multi-company syndication is not popular in China.
- We study the community structure of the Chinese venture capital network.

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ABSTRACT

Financial networks have been extensively studied as examples of real world complex networks. Based on the data from Chinese GEM and SME board, we establish a venture capital (VC) network to study the statistical properties, topological properties and community structure of the Chinese venture capital network. The result shows that there are no dominant venture capital firms in China which act as hubs in the VC network, and multi-company syndication is not popular in China, meaning that the relationships among venture capital companies are weak. The network is robust under either random or intentional attack, and possesses small world property. We also find from its community structure that, venture capital companies are more concentrated in developed districts but the links within the same district are scarce as compared to the links between different developed districts, indicating that venture capital companies are more willing to syndicate with companies in other developed districts. Furthermore, venture capital companies which invest in the same industry have closer relations within their communities than those which do not invest in the same industry.

1. Introduction

In recent years, complex network theory has been developed through the study of complex networks in natural and social fields [1–3]. Most of these social, biological and technological networks have substantial non-trivial topological features. Complex networks have been extensively studied, and the results have been applied to many real world networks, such as biological nets and the World-Wide-Web (WWW) [1,4–6].

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Fundamental topological properties such as the small-world and scale-free structures of real complex networks have been paid much attention to. The small world structure of a network implies that the number of nodes increases exponentially as a function of the diameter of the network [7–10]. On the other hand, a scale-free network is a network of which the degree distribution follows a power law, at least asymptotically. Recent interest in scale-free networks was pioneered by Barabasi and his coworkers who studied the topology of the World Wide Web [2].

Complex networks have been used to study economic topics, such as the scale-free properties in stock market [4], financial correlations [11], and new challenges of economics topics [12]. As an important sector of economic system, venture capital networks have been studied by many researchers. Bygrave [13] was the first one who opened a gate to the study of venture capital networks. It was found that venture capital firms were linked together and exchange resources with one another through connections within the network. Venture capital firms face great risks and uncertainties in the investment process, and have to take actions to deal with in a venture capital network. The formation of venture capital networks, in a narrow sense, means that firms which have common investees are connected. In such a network, the venture capital firms contact and share resources with each other in many ways which reduce their costs. The network would therefore be of great help to the venture capital firms and their investees in many aspects. Hochberg et al. [14] first studied the correlation between the feature of American venture capital network and the investment performance, and provided initial evidence on the evolution of VC networks. Zeng [15] analyzed the inter-firm innovation networks and found that they did not show cohesion features. Kogut et al. [16] used methods of complex graphs to demonstrate the rapid emergence of a national VC network of syndications, and emphasized the importance of dynamics and complex weighted graphs for the analysis of social and economic behavior.

Although China's VC market has a short history which has been traced back to the mid 1990s, it did make a dramatic progress in the last 20 years, and already has become one of the most important VC markets other than the US. Despite many similarities between the VC markets of China and the western countries, there is a distinct feature in China's VC market, that is, since China is a "guanxi society", where personal relationships play an extremely important role in the social interactions among the Chinese people, China's VC networks inevitably exhibit the characteristic of guanxi [17]. Since there are differences between the operations of venture capital firms in China and the Western countries, it would be of interest to study VC networks in China. To date, there are only a few studies on this topic. Ref. [17] was probably the first empirical study about VC networks and investment performance in China. Compared with the findings in Hochberg et al. [14], the authors of Ref. [17] concluded that networks are more important for investment performance in China than in the US. However, these earlier works paid more attention to the economic outcomes than to the physical features of China's VC networks. It is therefore meaningful to analyze the physical features of China's VC networks. In this paper, we will study the complex network of venture capital firms in China. We establish a venture capital (VC) network to study the statistical properties, topological properties and community structure of the Chinese venture capital market.

This paper is organized as follows. In Section 2, we introduce the data source and construct the VC network of the venture capital firms in China. Its statistical properties, namely, degree, mean lengths of the shortest paths, clustering coefficient and betweenness are presented in Section 3. Section 4 is the analysis of the topological properties of the VC network. In Section 5, we detect and analyze the community structure of the VC network. Section 6 is the conclusion.

2. Data and construction of venture capital network

2.1. Data source

We here focus on the companies listed in Chinese Small and Medium-sized Market (SME), which came into being in June 2004, and Chinese Growth Enterprise Market (GEM), which started in October 2009. The data comes from Resset database and the prospectus of all those listed companies. The time span is from 2004 through 2011. In total, we get a sample of 614 VC firms, which invest in the listed companies in SME and GEM, and which will be the nodes of the VC network in question. All venture capital firms in our data set survived the first year and did not go bankrupt during the sample period.

Fig. 1 depicts the number of venture capital companies which invest in listed companies from 2004 through 2011. The number of venture capital companies increased slowly in the first 2 years (2004 and 2005). The growth rate increased in the next 3 years (2006–2008) and reached its peak value in 2009 and mitigated in 2010, because 2009 was the birth year of GEM and there was a large flow of initial public offerings (IPO) in GEM.

2.2. Construction of venture capital network

At present, the construction of venture capital network is mostly based on syndication [13–15]. This means that if two venture capital companies have one or more common investees, a link will be created between them. We therefore construct the Chinese venture capital network based on syndication as follows. We take venture capital companies as nodes and syndications as links. This implies that if two venture capital companies have a link, they will have one or more common investees.

Fig. 2 is the VC network of China. Each node in the network denotes a venture capital firm while each line represents a link between two venture capital firms. Nodes with the same color are from the same province or district. It is easy to see