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Connection law and networks

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Abstract Cooperation is one of the most important factors in organizations. The mechanisms of cooperation remain an important area of research. Barnard analyzed the principle of cooperation but not the mechanism of cooperation, because he considered the abilities of each individual to be equal. However, not all individuals are equal, therefore we examine how connections work within a cooperative network organization when individuals are unequal in ability. We apply a percolation model of a network organization to examine the connection law under the condition of unequal abilities of individuals. The conditions of connection will take on more significance in the age of information technology than ever before.

Key words Connection law · Network organization · Mechanism of cooperation · Percolation · Simulation

1 Introduction

Individuals and subgroups form many different groups. One special type of group is a business organization and/or firm. Cooperation is one of the most important factors in organizations and in how firms work together. The mechanisms of cooperation remain an area of continuing research.

In this article we review the relevant literature of network analysis and discuss the issue of cooperative mechanisms.

Our main contribution is that we discover the connection law under the condition of unequal abilities of individuals in a network organization. We apply a computer simulation with a percolation model to examine network dynamics.

The remainder of this article is organized as follows. In the next section, we review some background and previous literature on cooperation theories. In Sect. 3, we focus on a computer simulation with an invasion percolation model, and we explain the connection law in a network organization. The final section contains concluding remarks.

2 Background

An organization, especially a corporate organization like a profit-oriented enterprise, will not only vary with the structure of the organization, but also with the cooperative relationship with other firms and the fluctuations of the economic situation. Needless to say, cooperation with other firms is one of the most important factors determining the success or failure of a corporate organization. Cooperation is meaningful not only for the participants in the organization, but also for the management. Understanding the mechanism of cooperation can aid profit making.

The marketing of a firm is controlled by the relationships between business entities under the principle of competition. The relation between demand and supply is adjusted, and the effective allocation of managerial resources can be realized, through the mechanism of market price. On the other hand, the internal process of vertical integration is under the control of the authority within traditional organizations. Organizations generate a participant consciousness, trust, and a sense of belonging.

Network organizations realize the merit of both the market and the internal organization, and maintain a relationship among autonomous business entities under the utilization of common managerial resources. A network organization is a form which differs from the single hierarchical organization and the market.

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Network organizations are considered to be a form of cooperative system. Network organizations provide a higher degree of responsiveness to change that cannot be obtained within hierarchical organizational structures. Cooperation plays a very important role in network organizations. For instance, personal contacts play key roles in obtaining information about job opportunities. The relationships among the firms in a network organization have been analyzed. The association between corporate performance and the structure of a network, such as centrality and network size, were also measured.

Most recent research has focused on the relationships among firms and the structure of network organizations. However, rules concerning the mechanisms of cooperation have not significantly examined simulation models.

3 Connection law

The invasion percolation model is one kind of complex systems theory. The invasion percolation model will be executed here to uncover the mechanism of connection in business activities.

3.1 Connection by individuals

In order to uncover the mechanism of connection, a percolation model and hypothesis are executed as described below.

The percolation model is executed in a two-dimensional square lattice system. The following steps are executed.

Step 1. Each individual and/or business entity could be considered as a node in a percolation model. Each one has its own ability $p$. The starting node exists and its optional ability is $p$. The range of $p$ is from 0 to 1.

Step 2. The neighboring node of the starting node is in a von Neumann neighborhood containing a random number of $p$.

Step 3. Sort the abilities of each neighboring node of the starting node, and compare the ability of the starting node with the abilities of each neighboring node.

Step 4. Put the node whose value of $p$ is the smallest of the neighboring nodes into the cluster of the starting node if there is any node whose value of $p$ is smaller than that of the starting node, and then new neighboring nodes will be formed.

Step 5. Execute the sequence from step 3 to step 4 repeatedly until $n$. This execution will be continued if there exists a node whose $p$ is less than that of the starting node in the cluster of the new neighboring node; otherwise it will be stopped when the $p$ of all neighboring nodes is larger than that of the starting node.

From these steps, we can image that business entities, as the starting node, do their business activities repeatedly and expand their scale gradually depending upon the ability of the starting node. A business entity could be explained as an autonomous individual or an autonomous company.

The relationship between the ability (influence) of the starting node and the average of the cluster resulting from the repeated activities of the starting node in a computer simulation are illustrated in Figs. 1 and 2.

The cluster curve of the starting node in Fig. 2 can be divided into three parts. The first group of nodes contains those whose abilities are all smaller than 0.40. The increasing range of the average of each cluster is very small as the speed of incorporation increases. The second group contains those whose abilities are from 0.40 to 0.68, and there is obviously a large increase in range. The third group of nodes includes those whose abilities are over 0.68, and their trend is the same as the first group.

The conclusions to be drawn are as follows.

1. If the ability of each node is less than 0.4, the gap of clusters between each node is very small even if there is big difference between them.
2. If the ability of each node is larger than 0.40, the gap of clusters between each node is remarkable even if there are very small differences.
3. If the ability of each node is larger than 0.68, the gap of clusters between each node is very small again, even if there are some difference between them.