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Spatial characteristics of joint application networks in Japanese patents ☆

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Abstract

Technological innovation has extensively been studied to make firms sustainable and more competitive. Within this context, the most important recent issue has been the dynamics of collaborative innovation among firms. We therefore investigated a patent network, especially focusing on its spatial characteristics. The results can be summarized as follows. (1) The degree distribution in a patent network follows a power law. A firm can then be connected to many firms via hubs connected to the firm. (2) The neighbors' average degree has a null correlation, but the clustering coefficient has a negative correlation. The latter means that there is a hierarchical structure and bridging different modules may shorten the paths between the nodes in them. (3) The distance of links not only indicates the regional accumulations of firms, but the importance of time it takes to travel, which plays a key role in creating links. (4) The ratio of internal links in cities indicates that we have to consider the existing links firms have to facilitate the creation of new links.
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1. Introduction

Technological innovation has extensively been studied to make firms sustainable and more competitive. The most important recent issue has been the dynamics of collaborative innovation among firms [1]. Moreover, a lot of countries are promoting industrial cluster policies that facilitate collaborative innovation among firms in specific regions, and emphasizing that the key is creating networks among firms. However, studying industrial clusters based on networks of firms is not sufficient because of the difficulty of obtaining comprehensive linkage data.

There have been numerous extensive studies on innovation in the social science based on networks [2]. However, these studies have focused on the details of specific collaborative innovations, and have only treated

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1000 firms at most. All regional firms and their networks should be studied to enable industrial clusters to be discussed, and the firms should number more than 10,000.

This paper focuses on networks generated by joint applications of patents in Japan. These networks can cover all Japanese firms, and these enable us to study industrial clusters. Joint applications are common in Japan, even though they are not popular in Europe or the United States. This is why there have been no similar studies in those areas.

The entire dynamics of collaborative innovation cannot be observed by focusing on the joint applications of patents. This is because all innovation is not revealed in patents, and all patents cannot lead to innovation. However, this problem can be ignored. Since exact distinctions, whether various patents have contributed to innovation do not matter, we pay attention to the structure of innovation network among firms using the patent network.

This paper is organized as follows. Section 2 explains the patent data discussed in this paper and joint application networks derived from them. In Section 3, we discuss spatial characteristics that are important for industrial clusters, and conclude this paper.

2. Japanese patent data and joint application networks

The Japanese Patent Office publishes patent gazettes, which are called *Kokai Tokkyo Koho* (Published Unexamined Patent Applications) and *Tokkyo Koho* (Published Examined Patent Applications). These gazettes are digitized, but not organized because they do not trace changes in trade name or firms' addresses. To solve these problems, Tamada et al. have organized a database [3] and this paper is based on theirs. It includes 4,998,464 patents published from January 1994 to December 2003 in patent gazettes.

The industrial cluster program of Japan began in April 2003 but preparatory steps had not been done until March 2005. Hence, these patent data indicate a situation where the industrial cluster program had not yet affected firms. This means that we can study the innate characteristics of firms without the program having an effect, and discuss a preferable plan as to how to take advantage of the characteristics.

We extracted applicants' data from the front pages of patents and obtained a joint application network (called a patent network after this). A patent network has applicants as nodes, and joint applications as links (Fig. 1). The links do not have weight or directions. The applicants include firms and individuals. However, the objective of this paper is to discuss what an industrial cluster should be. We hence need a patent network that only consists of firms. We consequently removed the nodes of individuals and the links they had from the patent network.

How to develop a local network is a key issue in discussing an industrial cluster. However, analyses of the entire network can also contribute to this. Therefore, we will discuss analyses of the entire network in the rest of this section, particularly, the basic properties of the patent network, the degree distribution, the neighbors' average degree, and the clustering coefficient.

The largest connected component is a part of the network where all nodes can traverse each other, and which has the largest number of nodes. A network with all nodes has 67,659 nodes and 111,860 links, and the largest connected component has 34,830 nodes and 84,843 links, which represent approximately 51% and 76% of the network with all nodes, respectively.

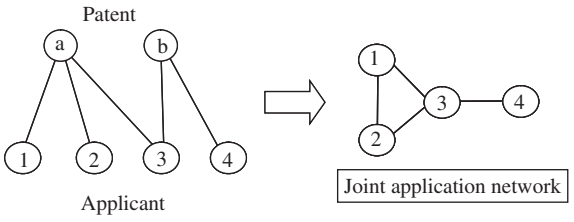

Fig. 1. Examples outlining how a joint application network is created. In the figure at left, there is patent 'a' that has applicants '1', '2', and '3' and 'b' that has '3' and '4'. Nodes are applicants in a joint application network. Applicants are connected to each other if they apply for a patent together. There is a joint application network in the figure at right.

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