1C06 産学官連携を通じたイノベーション：
研究開発コミュニティーのネットワーク分析

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1. Introduction

This research has extended the field of innovation studies by capturing the nature and mechanism of the emerging new materials innovation. Titanium dioxide (TiO_2) photocatalyst embodies novel functions which had not been realized before. With the novel functions of decomposition of organic substances and hydrophilicity, TiO_2 photocatalyst has proved to be useful for various industrial applications. That has led to the creation of new markets which did not exist ten years ago, with the current size of commercial products embodying photocatalysts estimated to be 300 million US dollars in 2002 In this research, we aim to analyze how and why commercialization of a new material, namely titanium dioxide (TiO_2) photocatalyst, has been successfully achieved in Japan. We propose a hypothesis that the process of scientific research and product development conducted through collaboration between university and industry takes a characteristic organizational pattern translating applied science into successful market creation. We examine how basic research and product development are conducted and interacted with each other, leading to successful creation of new markets, in a way which is particularly appropriate to the commercialization of new materials.

2. Methodology

Regarding methodology, we will apply a series of network analysis [1][2][3]. The seminal work of the Powell's research group put stress on the networks of learning in an industry for explaining a role of inter-organizational collaboration branching out innovation [1]. "(W)hen the knowledge base of an industry is both complex and expanding and the sources of expertise are widely dispersed, the locus of innovation will be found in networks of learning, rather than individual firms". Powell insists that "firms must learn how to transfer knowledge across alliances and locate themselves in those network positions that enable them to keep pace with the most promising scientific or technological developments" [1].

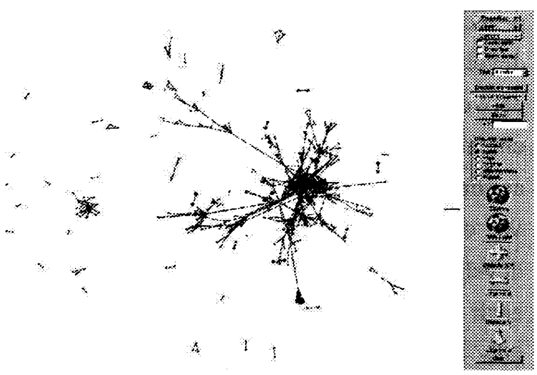
The purpose of this paper is to identify the forms of collaboration undertaken by university, industry and public agency that have arisen in response to the technological ferment generated by TiO_2 photocatalyst. We will scrutinize structure and function of the emergent "communities of practice" [4] in the TiO_2 photocatalyst industry and assess the contribution of cooperative ventures to organizational learning leading to joint patent applications and to successful commercialization. We investigate all the Japanese record of joint patent applications on photocatalyst, viewing jointly applied patents as links of a network whose nodes are university, industry and public agency participants. An exclusive analysis of jointly applied patents enables us to analyze the nature, structure and functions of the emergent co-inventor network in the new materials innovation.

3. Findings

We find that focal university researchers applied for a large number of patents jointly with industry and take a central position in the networks. As Powell points out, the information that passes through networks is influenced by each participant's position in the industry structure, and firms with access to more diverse set of activities and those with more experience at collaborating are better able to locate themselves in information-rich positions. With learning networks involving a large number of industry researchers and public agencies, the star scientists can create short channels between diverse partners in the research and development community, facilitating exchanges of user needs and clarifying industrial requirements for further scientific research.

By way of using 3D visualization tool, we will describe the structure of co-inventor networks, and illustrate the central position of the star scientists with a large number of patents applied jointly with over 30 companies. Observing the configuration of the co-inventor network sheds light on the central position of hub nodes, enabling us to assume the advantageous position of the star scientists in terms of their entrepreneurial capabilities. The star scientists can play a role of facilitating network learning among firms and public agencies by using their position as a hub of the network. Recognizing the importance of a hub in a community, we focus our analysis on the role of positions in the network. First, regarding the factors influencing the structure of the co-inventors networks, we find that firms with more patents jointly applied with diverse partners, with more pro-active scientists and those with more experience at collaborating are better able to locate themselves in information-rich positions. An increase in the number of pair patents, the research age, or the research openness of a node will make the node closer to the central position.

Second, differential locations in a network of partnerships result in firms having divergent capabilities for benefiting from collaboration. Being in the center of the network shapes a firm's reputation and generates its visibility, producing access to resources via benefit-rich networks. Network locations thus shape the nature of competition. Firms more centrally located should have better timely access to promising new ventures [1]. We find that the sales of firms are explained by the centrality measure of networks.



Topology of the "Community of Practice" at 2002

4. Conclusions

We firstly clarified the structure of the community of practice on photocatalyst by utilizing jointly applied Japanese photocatalyst patents. The growth of the communities of practice was shown graphically and explained scientifically. Based on the analytic approach to evolving networks possessing the scale-free character, we paid special attention to the position of Hashimoto and Fujishima being as a central hub in the network.

Considering the crucial position of the star scientists, we suggest the possible explanation which factors decides the center of the network topology. The success in the Japanese photocatalyst R&D and commercialization is attributed to the fact that the community of practice has been steadily growing between the university scientists who have been proactive in industrializing their scientific findings, and the firms which seek to work with star scientists. Our observations suggest that when firms are engaged in long term R&D experiences with pro-active scientists, market potentials developed by the firms tend to be fully established. In that case, the function of network learning identified by Powell seems to be working for new materials innovation. Also, the public sector has made a significant contribution to promoting the growth of the community of practice in the field of photocatalyst. Typified by JST and KAST, the public agencies' support for pro-active scientists in the early stage of R&D enabled them to grow into the hub in the network and then contributed to the evolution of the network by facilitating network learning among the participants in the community.

5. References

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