

A Study on the Structural Hole of Patent Applicant Network in R&D Management

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Abstract

The arrangement of R&D staff refers to the issue of the linkage between structural holes in a network. In order to examine the linkages between multiple R&D projects in a company, we use the patent information as the index of R&D capability and examine our propositions by social network analysis. In this paper we focus on top-shared companies in Japanese cosmetic industry, and suppose that these companies keep their market shares due to their smoothly changes of business fields to cope with the threat of new comers from other industries. The analysis in this paper include: 1) calculate the betweenness centrality, and create heat maps to visualize the change of the betweenness centrality, 2) examine the structural hole.

Keywords: patent analysis, social network analysis, heat maps, Japanese cosmetic industry, structural hole

1. Introduction

The development of new products is needed for a company to sustain its competitive advantage, while the results of development process are affected by the management of R&D organization. The arrangement of R&D staff refers to the issue of the linkage between structural holes in a network [1]. By using the patent data as the index of R&D capability, the R&D network structures can be visualized and analyzed by social network analysis. In Japan, one of the industries that face strong competitions due to numbers of new entries

is cosmetic industry. Although new entries never stop, top-shared companies keep their market shares in the industry. We suppose that if there is any feature in these companies' R&D management, and the features of R&D management contribute these companies to keep their growth.

In this paper, we focus on four top-shared companies in Japanese cosmetic industry to examine their R&D

In this paper, we focus on four top-shared companies in Japanese cosmetic industry to examine their R&D strategies, as well as the change of core researchers in their R&D projects by social network analysis, based on

the patent data. The analysis include: 1) calculate the betweenness centrality, and create heat-maps to visualize the change of the betweenness centrality, 2) examine the structure hole. The results of these analyses will be discussed to find out the reason why these companies can cope with the new entries.

2. Background

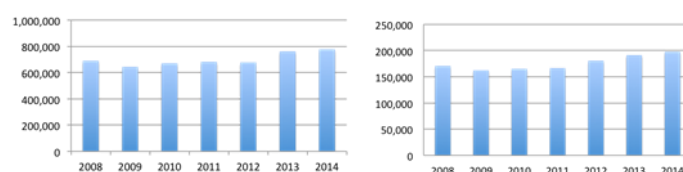
2.1 Structural hole and patent analysis

A structural hole is a relationship of non-redundancy between two contacts. The hole is a buffer, like an insulator in an electric circuit. As a result of the hole between them, the two contacts provide network benefits that are in some degree additive rather than overlapping [2]. Brokerage across the structural holes between groups provides a vision of options otherwise unseen, which is the mechanism by which brokerage becomes social capital.

Patent documents are an ample source of technical and commercial knowledge. The patent is one of the indicators of capacity for technological development. There are some researches aimed at visualizing and analyzing patents, or proposing efficient text-mining approaches for creating patent maps. However, there are few researches focusing on R&D management strategies based on text-mining analysis of patents. Therefore, this paper describes the features of Japanese cosmetic companies' R&D management based on the patent analysis.

2.2 The overview of cosmetic industry

Although the expansion of market scale benefits the Japanese cosmetic manufacturers to keep their growth, the mature of cosmetic market and customer slow down their speed of growth. The total sales of the industry have kept flat since the beginning of 2000, however, new comers from other industries have entered one after another after 2000. There are 12 large new comers into cosmetic industry and their entries concentrated on 2006-2009. The shares of sales of top 5 companies in 2014 were: Shiseido 37.9%, Kao 28.4%, Pola Holdings 9.5%, Kose 9.5%, Mandom 3.4%. The top 5 shared companies occupied the 80% of the total sales of the cosmetic market. Figure 1 shows the sales of Shiseido and Pola from 2008-2014. Their sales kept growing even after 2009, which the new entries most concentrated.



(a) Shiseido
(b) Pola
Figure 1 Total sales of each company

3. Methodology and data

In the following sections, the trends of R&D project management strategies of Japanese cosmetic companies are analyzed. In order to examine target companies' R&D strategies and the change of core researchers in their R&D projects, we visualize their patent information in 3 steps: the number calculation of patent publications, text mining, and social network analysis. Then diagrams are created by these analyses.

In Japan, patent documents are archived in J-PlatPat, and are browsed and retrieved ubiquitously. All patents are classified according to each three classification codes, IPC (International Patent Classification), FI (File Index) and F-term (File Forming Term). Both of FI and F-term are classification codes under IPC. Especially, F-term is given to every patent from F-term list based on the technical items indicated in patent documents. Thus, almost every patent has multi-F-term codes. Table 1 is most frequently used F-terms in cosmetic industry. Based on these F-term related to cosmetic, patents related to cosmetic published by each company are extracted and collected from the patent information.

Table1 F-term list of cosmetics patents

F-term	Contents
4C083AA	NATURAL INGREDIENTS AND INGREDIENTS WITH UNKNOWN STRUCTURES AND COMPOSITIONS
4C083AB	INORGANIC INGREDIENTS
4C083AC	ORGANIC INGREDIENTS CHARACTERIZED BY ELEMENTS
4C083AD	ORGANIC INGREDIENTS CHARACTERIZED BY STRUCTURES
4C083BB	FUNCTION SPECIFIC INGREDIENTS
4C083CC	KINDS OF PRODUCTS
4C083DD	FORMS OF PRODUCTS
4C083EE	EFFECTS
4C083FF	METHODS, DEVICES FOR MANUFACTURE

4. Analysis

4.1 An approach based on the number of patent publications

As our first approach, the numbers of patent publications associated with cosmetics in each of the companies are shown in Figure 2.

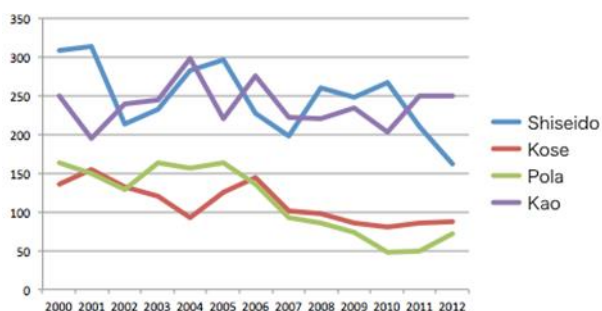


Figure 2 The number of patents of each companies

Every company obtains related patents to a certain extent and the number of patents of all of them kept on decreasing during the years. Shiseido and Kao obtain more than 200 patents every year although the rates of R&D spending and net sales fell. However, we can consider that R&D of Shiseido is efficiently because the rate of R&D spending and net sales of Shiseido is lower than Kao.

4.2 An approach by the text mining

We use the correspondence analysis based on text mining to disclose the technical trends and features based on typical words associated with cosmetic. Result of the analysis of Shiseido is Figure 3(a), and result of another cosmetic company Pola is Figure 3(b). The reference data in the analysis is the numbers of each their patent document in each year, including to cosmetic noun. These figures are based on dates of patent publication, and patents are applied to products in the companies. Figure 3(a) shows that there is low R&D continuity in Shiseido. Therefore it is considered that Shiseido changed its contents of technology depend on the year. On the other hand, Pola has developed similar technology continuously because the results almost outputted around the same place over all of the period in Figure 3(b).

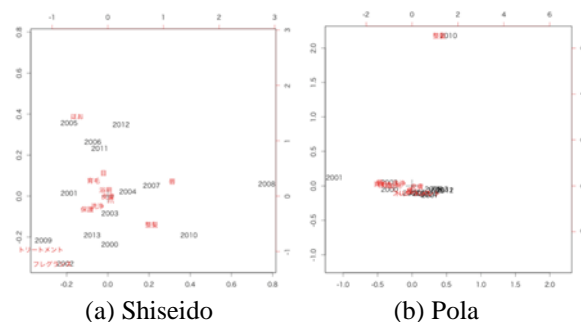


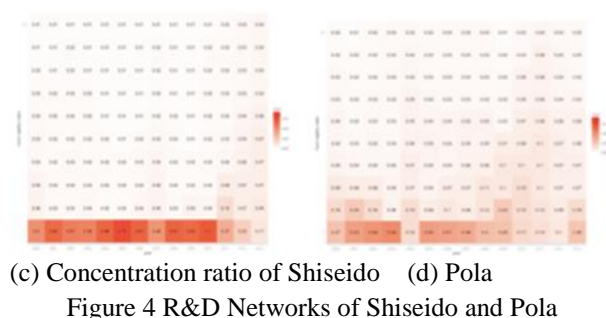
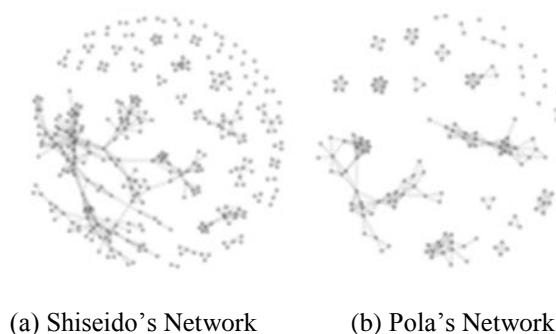
Figure 3 Results of correspondence analysis

4.3 An approach by the social network analysis

4.3.1. R&D network

We disclose the R&D project structures of the target companies by the social network analysis in this section.

The results are outputted as heat maps. Figure 4 (a) and (b) are the R&D networks that show Shiseido and Pola's personnel engaged in R&D (nodes) and linkages of joint patent applicants (edge). In addition, Figure 4 (c) and (d) are the heat maps that visualized the percentage of major R & D networks occupied in the entire networks. The vertical axis in the figure shows top 10 networks ranked by network size, and the scores mean the percentage of personnel belonging to the top 10 networks. When the color is dark, it means that the percentage of personnel belonging to the network is high. We can consider that Shiseido has adopted the overconcentration organization which emphasizes on cooperation because the percentage of the person who belongs to the biggest network in all of the years is high. On the other hand, other companies such as Pola and so on have adopted decentralized organization which differentiated by each function.



4.3.2. Structural hole resource of R&D

The structural hole means the gap between social groups. Since personnel who connect organizations play the role as the structural hole serves to relay the information, we use betweenness centrality to visualize the change of the core structural holes connection personnel in this paper. Betweenness Centrality is one of the well-known indices that Freeman proposed in the social network analysis [3].

In addition, we focus on the change of R&D area that structural holes connection core personnel involved in to express how the structural holes personnel develop new technologies. As one of the example, the core rigidity of human resource and the change of R&D area the structural holes personnel involved in Shiseido are shown in Figure 5 and 6. There is no significant change in Shiseido's core rigidity degree. However, it was found that the core rigidity degree somewhat reduced in recent years while new entrant company increased. In addition, structural hole personnel were found to involve in various areas at a constant level from area of the previous year.

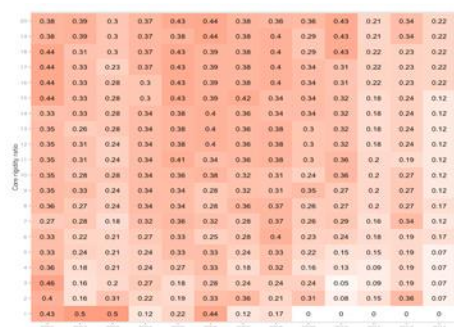


Figure 5 The Degree of core rigidity of Shiseido

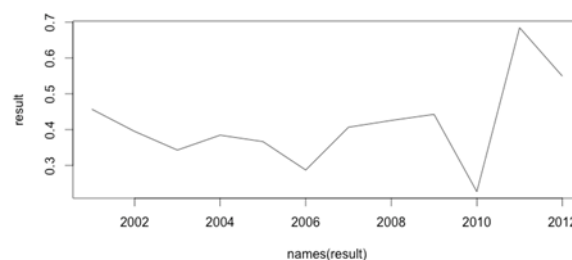


Figure 6 The change of R&D area that core structural hole personnel involved in

5. Conclusions

There is a thesis that innovation has exploitation and exploration type [4]. From these results, the innovation type of Shiseido's R&D strategy is an "exploration type", and the innovation type of other companies (Pola and so on) of R&D strategy is an "exploitation type". As further works, the patent data of the other country and the other companies should be carefully examined. We would like to modify our approach into more sophisticated one and to build up a more reliable theoretical background.

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