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Unveiling the core technology structure for companies through patent information

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ABSTRACT

Patent information provides an objective and public source to understand core technologies of companies. In this paper, a method is proposed for identifying core technology capabilities for a company in the semiconductor industry. The method is built on the patent similarity and K-means clustering algorithm. The indirect relations among the patents in the complex industry are considered in the method. In addition, the age of the patent is taken into account to avoid identifying aged core patents. The method is demonstrated by exploring the core technology capabilities that support the platform technology portfolio of the Taiwan Semiconductor Manufacturing Company (TSMC).

1. Introduction

Technological capabilities represent a critical source of the competitive advantage in a technologically competitive industry. According to resource-based theory, companies seek to accumulative or develop necessary resources to attain a competitive advantage in the future. A company's competitive advantage is rooted in its specific core competencies [1]. Core competencies are corporate-wide technologies and production skills that empower individual businesses to adapt quickly to changing opportunities [2]. Companies are required to accumulate and create core technology capabilities to maintain their competitive advantages [3].

Companies can create new technology internally through R&D activities and accumulated knowledge. They can also acquire new technology through alliances [4,5] as well as by mergers and acquisitions [6–9]. No matter how to create new technology, it is important to grasp themselves and other competitors' core technology capabilities as a foundation for technology development planning.

Panda and Ramanathan [10] have proposed a framework to evaluate TCs for a given company. Their framework contains three constructs: strategic, tactical, and compensative. Each construct consists of concrete indices with different weights. These indices and their weights are determined by the type of industry. Chiesa [11], through a study of strategic technology planning for the multimedia age in the Philips Co., has proposed a method to select core TCs. The first step of the method involves finding the relationship between the products and technologies. The second step is an estimation of the importance of each technology. The third step is to appraise the potential for each technology. The last step consists of selecting the technology areas that are worth the investment of R&D resources. Walsh and Linton [12] have proposed a method that identifies core TCs using standard operating procedures (SOPs) in the semiconductor foundry industry. They first list the SOPs in the industry, and then, competitors, customers, experts, and suppliers are asked to identify the core technologies in the SOPs through questionnaires. Walsh et al. [13] interviewed key people in 157 companies. These key persons included upper level managers, owners, technologists and individuals throughout the life of each company. Based on these interviews, they established the seven state-of-the-art

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competencies required for the production of world-class silicon in the sixth silicon epoch. The studies reviewed above face a common difficulty in identifying the core TCs of companies: acquiring the R&D information of the companies. R&D information is often a business secret of companies and is not easy for other companies to obtain.

One way to publicly acquire a company's R&D information is through patent information [14–17]. Patent information has some good qualities for analyzing a company's R&D information. First, patents are a direct outcome of the R&D process [18–21]. Then, patents provide a large amount of classified technological information. Patents, when filed, are classified according to standardized schemes (e.g. international patent classification). Thus, not only innovation strategies for an industry [22–25] but also rates and directions of inventive activity for a company [26,27] can be extracted by analyzing patent information. Last, patent information is public and is available in large numbers and for a long time series. However, using patent information is not appropriate for all industries. It does have some limitations. Firstly, other means may be resorted to protect a company's technological know-how, such as trade secrets or trademarks [28,29]. Secondly, an industry with a short life cycle is not appropriate since the long time lag (at least 18 months) between the first patent filing and the publication of the patent application [7]. Finally, simple patent counts cannot represent correctly patent values [30–32]. The appropriateness should be justified before patent information is employed for technology management.

Using patent information to extract technology capabilities of the companies in the semiconductor industry is appropriate. Firstly, the semiconductor industry belongs to a complex industry. A complex industry is an industry in which a number of patents contribute to a product [33]. In the complex industry, products are usually sophisticated and may contain several patented intermediate inputs whose patent rights are held by other companies. Patents in the complex industry form platforms for exchanging complementary technology [34]. Secondly, in addition to the industry characteristics, the companies in the semiconductor industry show a propensity for patenting their technology, according to Ref. [33]'s study. Although patenting is the least effective way to return their R&D investments, companies in the semiconductor industry aggressively patent their technology. One reason is that semiconductor companies aim to reduce risks about being held up by external patent owners. The other reason is to gain more bargaining chips when negotiating access to external technologies [35,36]. Hence, semiconductor companies rely on patenting not only to protect their technologies and business, but also to advance to new technologies in an industry characterized by rapid technological change and cumulative innovation. Therefore, the patent information can be used to explore technology capabilities of companies in the semiconductor industry.

To further extract core technology capabilities of the companies through patent information, patent self-citation behavior of the companies make it possible [37,38]. Patent self-citations represent accumulating tactic knowledge or know-how within a company. Since patents are codified knowledge [39], a self-citation demonstrates an internal transfer of the codified knowledge. When in the same narrow technology field, a self-citation would imply that a company is gaining a more competitive advantage [40]. When they continue to cite their own patents, the companies intentionally accumulate knowledge and build exclusivity for the technology areas it has staked out [41]. Self-citations are often found in patents positioned around particularly important patents (that are obviously cited) so that patent clusters or “thickets” are created. Hence, the patent clusters become a reflection of companies' core TCs, particularly within a narrow field or technology trajectory.

Mogee and Kolar employed patent information to identify the core TCs of Allergan Inc. [42] and Eli Lilly & CO. [43] in the pharmaceutical industry. In both of their two studies, they used patent co-citation frequency as the base for measuring the similarity between patents. Then, patents were classified by cluster analysis according to a co-citation frequency based similarity index and a patent group represented a core technology competence. However, two problems might be caused by applying a co-citation frequency based similarity index to measure the similarity of patents in the complex industry. First, co-citation frequency based similarity indexes are easily biased by the cited frequency of patents [44]. Consider the two pair patents as shown in Fig. 1. The areas of circles S_1, S_2, S_3 and S_4 represent the cited frequencies for patent P_1, P_2, P_3 and P_4, respectively. Also, the gray oval areas ω_{12} and ω_{34} represent the co-cited frequencies for the two patent pairs (P_1–P_2 and P_3–P_4), respectively. The two pairs of patents have the same similarity when ω_{12} equals ω_{34} when using a co-citation frequency based similarity index. However, the similarities in the patent pair P_3–P_4 should be greater than those in P_1–P_2 because the total of cited frequencies of P_3–P_4 is smaller than the total of P_1–P_2. Second, co-citation frequency based similarity indexes do not consider the indirect relations between patents. Indirect relations are critical in complex industries because products usually contain several patented intermediate inputs. The intermediate inputs create a network structure for patents [45–47].

In this study, we have proposed a method to identify existing core TCs through the analysis of patent information. Core Technology Analysis (CTA) is built on the patent similarity measured by the Pearson correlation coefficient as well as the K-means classification algorithm. The CTA method is comprised of four stages. The first stage involves construction of a citation matrix for the candidate patents. The candidate patents are patents that have been located in the databases. Next, core patents from the candidates are identified. Not only are the citation frequencies considered in selecting the core patents, but the ages of patents are

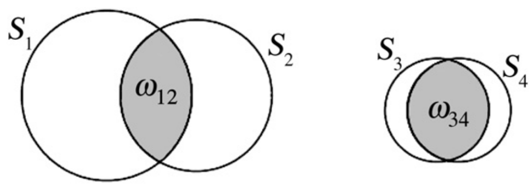

Fig. 1. The flaws in the use of the frequency of co-citation in the assessment of similarities in basic patent pairs [44].