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Concentric diversification based on technological capabilities: Link analysis of products and technologies

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ABSTRACT

This research responds to the needs for concentric diversification by focusing on how firms can find new business opportunities based on their technological capabilities. We propose a systematic approach to identifying potential areas for concentric diversification at a product level via link analysis of products and technologies. For this, first, text mining is utilised to construct an integrated patent-product database from the US patent and trademark database. Second, association rule mining is employed to construct a product ecology network using directed technological relationships between products. Third, a link prediction analysis is conducted to identify potential areas for concentric diversification at a product level. Finally, three quantitative indicators are developed to assess the characteristics of the areas identified. Our case study employs a total of 850,676 patents and 328,288 products in the integrated patent-product database from 2010 to 2014 and shows that the proposed approach enables a wide-ranging search for potential areas for concentric diversification and the quick assessment of their characteristics, with statistically significant results. We believe that the proposed approach will be useful as a complementary tool for decision making for small and medium-sized high-tech companies that are considering entering new business areas, but which have little domain knowledge.

1. Introduction

Diversification is one of the pivotal strategies for organisations to recreate and enlarge their competencies (Ahuja and Lampert, 2001; Hamel and Prahalad, 1994). The existing literature suggests that concentric diversification based on technological capabilities is a relatively low-risk but profitable strategy since it is derived from the reproduction of core competencies that are related to existing products or services (Chen and Chang, 2012; Collis and Montgomery, 1995; Dutton, 1997; Markides, 1997; Zook and Allen, 2001). From a resource-based view, many researchers have verified that technological capabilities have a significant positive effect on the success of diversification (Silverman, 1999). However, while the results of such empirical analyses or case studies have been widely accepted in academia and in practice, a major question still remains as to how decision makers can best identify areas for concentric diversification.

Modelling and analysing technological capabilities for concentric diversification is a task beset with hazards including uncertainty, data unavailability, and the complexity of real world feedback. As such, industrial practitioners depend largely on expert-centric approaches (e.g. brainstorming and Delphi). While internal experts have professional knowledge and experience about corporate technologies, they may have little knowledge about the technologies involved in potential new business areas (Shin et al., 2013). Using external experts (e.g. consultants) may resolve this issue, but they frequently misjudge corporate technological and organisational capabilities and identify promising but inappropriate areas for the particular companies with which they are temporarily working. Hence, such expert-centric approaches need to be supported by high quality and well-organised information (Lee et al., 2013, 2015).

Highlighting the possible avenues for methodological adaptation, there have recently been certain shifts in the direction of research on concentric diversification, from case studies or empirical analysis to evidence-based quantitative approaches. Perhaps the most scientific approaches are offered by patent analysis as this provides global and reliable information about a wide range of technologies (Granstrand et al., 1997). Patent publications are considered valuable data sources as they are published according to international standards and contain information on almost 80% of technologies (Lee et al., 2015). So far, a variety of models and methods have been presented, such as patent citation analysis (Narin, 1994), keyword-based network analysis (Yoon and Park, 2004), keyword-based morphology analysis (Yoon and Park,

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2005, 2007; Yoon et al., 2014), and patent-based roadmapping processes (Lee et al., 2009).

However, while previous studies have proved quite useful for various purposes, they are subject to certain limitations in terms of data, methodology, and practicality. First, in terms of data limitations, the outcomes of previous studies are not specific about the areas that are suitable for concentric diversification, but show general patterns of technological relationships at a macro level (Yoon et al., 2015). This is mainly because patents do not explicitly contain product or service information where the patented technologies can be applied (Chiu et al., 2008; Garcia-Vega, 2006; Nesta and Saviotti, 2005). Thus new data sources need to be secured to allow a product- or service-level analysis, covering a wide range of business areas. Second, with respect to methodology limitations, previous studies cannot assist timely decision making in concentric diversification since they have been limited to *ex post* evaluation which measures past performance, impacts or consequence (Breschi et al., 2003; Chen and Chang, 2012; Silverman, 1999; Wang et al., 2015). The areas for concentric diversification identified via previous methods are thus likely to be no more than the existing ones in which many competitors have already entered or shown interests. Another major drawback of previous methods is concerned with an inability to consider the direction of diversification. Note that even though a company owning item A has the possibility to diversify to item B, it does not guarantee the company which owns item B will be able to diversify to item A. Hence, any approach that is proposed needs to model the direction of diversification to enhance the feasibility of analysis results. Finally, from a practical standpoint, the verification of previous methods was usually omitted; and even if verification was carried out, it was done in a domain-specific qualitative way (Archibugi and Pianta, 1992; Breschi et al., 2003; Chen and Chang, 2012; Nasiriyar et al., 2013; Wang et al., 2015). Thus any approach that is proposed should establish external validity to be deployed in practice.

Considering these issues, we propose a systematic approach to identifying potential areas for concentric diversification at a product level via link analysis of products and technologies. The tenet of this research is that significant technological relationships between products extracted from large-scale quantitative databases can provide valuable information on the feasibility of concentric diversification from one area to another. At the heart of the proposed approach are (1) text mining techniques for constructing an integrated patent-product database from the US patent and trademark database; (2) association rule mining with conviction indicators for constructing a product ecology network using directed technological relationships between products; (3) link prediction analysis for identifying potential areas for concentric diversification at a product level; and finally (4) indicator analysis for assessing the characteristics of the areas identified. The approach we propose therefore incorporates the issues noted above into analysis for concentric diversification. We also develop a software system to automate our approach, allowing even those who are unfamiliar with the patent-product database and complex models to benefit from our research results.

We applied the proposed approach to support Korean high-tech companies in discovering their next-growth engines at the request of the Korea Institute of Science and Technology Information (KISTI). Our case study shows, with statistically significant results, that the proposed approach enables a wide-ranging search for potential areas for concentric diversification at the product-level and the quick assessment of their characteristics. We believe that the systematic process and quantitative outcomes our approach offers can facilitate decision making in concentric diversification, especially for small and medium-sized high-tech companies that are considering entering new business areas, but that have little domain knowledge.

This paper is organised as follows. Section 2 presents the background to our research, and Section 3 explains our research framework, which is then illustrated by a case study on semiconductors in Section 4. Finally, Section 5 presents our conclusions.

2. Background

2.1. Concentric diversification

Most diversification strategies fail to deliver value and most successful companies achieve their growth by expanding into logical adjacencies that have shared economies, and not from unrelated diversification or moves into “hot” markets (Chen and Chang, 2012; Collis and Montgomery, 1995; Dutton, 1997; Markides, 1997; Zook and Allen, 2001). Owing to such risks involved in diversification, concentric diversification – defined as entry to a new business area based on companies' core competencies related to their existing products or services (Ansoff, 1965) – has been considered a key strategy to sustain business growth. It is reported that the success rate of concentric diversification has reached around 70 to 90%, whereas approximately 90% of companies' attempts to diversify outside of their core competencies have failed (Zook and Allen, 2001). If it is properly implemented, concentric diversification may have advantages in terms of reducing R&D cost (Cantwell and Piscitello, 2000), reducing time to market (Cantwell and Piscitello, 2000; Granstrand, 1998), and creating synergies with other businesses (Patel and Pavitt, 1997; Valvano and Vannoni, 2003).

Concentric diversification has been the subject of many previous studies. The early studies on concentric diversification were based on case studies or empirical analysis. Many researchers have focused on the relationship between concentric diversification and firm performance. For instance, Rumelt (1974) carried out a pioneering study which found a relationship between concentric diversification and profitability. Palich et al. (2000) found an inverted-U shaped relationship between concentric diversification and firm performance with meta analysis drawn from 55 previous studies using a curvilinear model. Focusing more on technological and innovation competencies, Miller's (2004) longitudinal study with patent citation analysis of 227 firms which diversified from 1980 to 1992, also verified that concentric diversification has a positive effect on technological growth. This was reconfirmed in his follow-up study by citation-weighted patent analysis (Miller, 2006). Quintana-Garcia and Benavides-Velasco (2008) applied a generalized estimating equation (GEE) regression model to verify the relationship between concentric diversification and innovative competencies by using the USPTO patent database. Wang et al. (2015) verified that the relationship between technological capabilities and the success of diversification was altered depending on the market situations.

Highlighting the possible avenues for methodological adaptation, recent studies focus more on quantitative data and scientific methods to assist decision making in concentric diversification. The dominant approach is based on patent analysis which provides global and reliable information about a wide range of technologies (Jaffe, 1986; Patel and Pavitt, 1997; Silverman, 1999). There has been a variety of research done with regards to diversification using patent databases. For instance, Yoon and Park (2004) proposed a text mining-based patent network to visualize technological relatedness and explore technological opportunities. Yoon and Park (2007) presented an integrated use of morphology analysis and conjoint analysis to identify and evaluate technology opportunities from patent documents. Lee et al. (2009) presented a patent-based technology-driven roadmapping process that starts from capability analysis and ends with business opportunity analysis. Seol et al. (2011) proposed an approach to exploring appropriate new business areas at the industry level using text mining techniques and data envelopment analysis.

However, while all these previous studies have proved valuable in using quantitative data and scientific methods, and in providing insights into concentric diversification, they are subject to certain limitations as mentioned. These drawbacks, which provide our underlying motivation, are fully addressed in this study. Table 1 summarises the difference between previous methods and the proposed approach.

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