Technological Forecasting & Social Change 107 (2016) 112–120

Contents lists available at ScienceDirect

Technological Forecasting & Social Change

How industrial convergence happens: A taxonomical approach based on empirical evidences

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ARTICLE INFO

Article history:
Received 15 May 2015
Received in revised form 10 December 2015
Accepted 23 March 2016
Available online 12 April 2016

Keywords:
Technology convergence
Industry convergence
Taxonomy
Clustering

ABSTRACT

The current innovation paradigm clearly shows that the notion of "industry" is changing. Innovation no longer occurs within single industries. This paper employs practical data on 100 successful Korean cases of industrial convergence to analyze how industrial convergence takes place. Together, these practical cases represent the essential characteristics of industry convergence. We identify the pattern of industry convergence through a clustering analysis that identifies the characteristics of each cluster. As a result, we identify four industry convergence types: technology enhancer, policy-driven environmental enhancer, service-integrated social business generator, and technology-driven new value generator.

1. Introduction

Innovation no longer takes place within single boundaries or industries. Customers can no longer be attracted merely by existing domain knowledge. Automobile development, for example, involves more than the mechanical domain. Information and communication technologies (ICTs) are combined with the automobile domain to provide a huge number of attractive functions, such as smart-cruise systems, GPS tracking systems, and biometric services. Nanotechnology also features overlapping scientific disciplines, mainly driven by physics and chemistry (Battard, 2012). The fiber and textile industry has been combined with the biomedical and ICT disciplines to develop environmentally aware fibers and "smart" textiles. The convergence between education and robotics has produced edutainment robots for use in educational environments. These phenomena could be described as instances of "industry convergence," defined as the blurring of boundaries between industries (Bröring et al., 2006). Industries have always been distinguished by their distinct products, actors, knowledge, technologies, and demand structures (Bröring et al., 2006). However, the current innovation paradigm clearly shows how the notion of "industry" is changing and that innovation no longer takes place within single industries.

Keeping the pace with this changing paradigm, the literature has closely investigated the phenomenon and implications of industry convergence (Katz, 1996; Duysters and Hagedoorn, 1998), most often from the perspective of computing and communication and consumer electronics (Katz, 1996; Duysters and Hagedoorn, 1998; Gambardella and Torrisi, 1998; Wirtz, 2001; Stieglitz, 2002; Chon et al., 2003). Industry convergence has typically been discussed as a merely conceptual entity. Most studies have been confined to analyses of case studies or propositions of theoretical/conceptual perspectives on industry convergence. Most relevant case studies have conducted qualitative analyses or examination of specific industries, such as nutraceuticals and functional foods (Bröring et al., 2006), media (Wirtz, 2001; Chon et al., 2003), IT industry (Duysters and Hagedoorn, 1998), and electronics (Gambardella and Torrisi, 1998; Stieglitz, 2002).

However, it is necessary to analyze how industrial convergence happens and what its patterns are through an in-depth consideration of its motivation, drivers, and processes. This task requires the study of real-world cases. In-depth empirical research based on real-world applications is critical in understanding industry convergence because only such an approach can provide practice-focused insight and significant managerial implications regarding the direction of innovation.

However, surprisingly few studies consider real-world cases to analyze convergence patterns. Those studies that have employed quantitative data to explain industry convergence have employed either proxy data (Duysters and Hagedoorn, 1998) or industry-specific data (Bröring et al., 2006). For example, Duysters and Hagedoorn (1998) employed two types of data—patent data and data on strategic technology alliances—to analyze technological convergence. The patent data

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http://dx.doi.org/10.1016/j.techfore.2016.03.020
0040-1625/

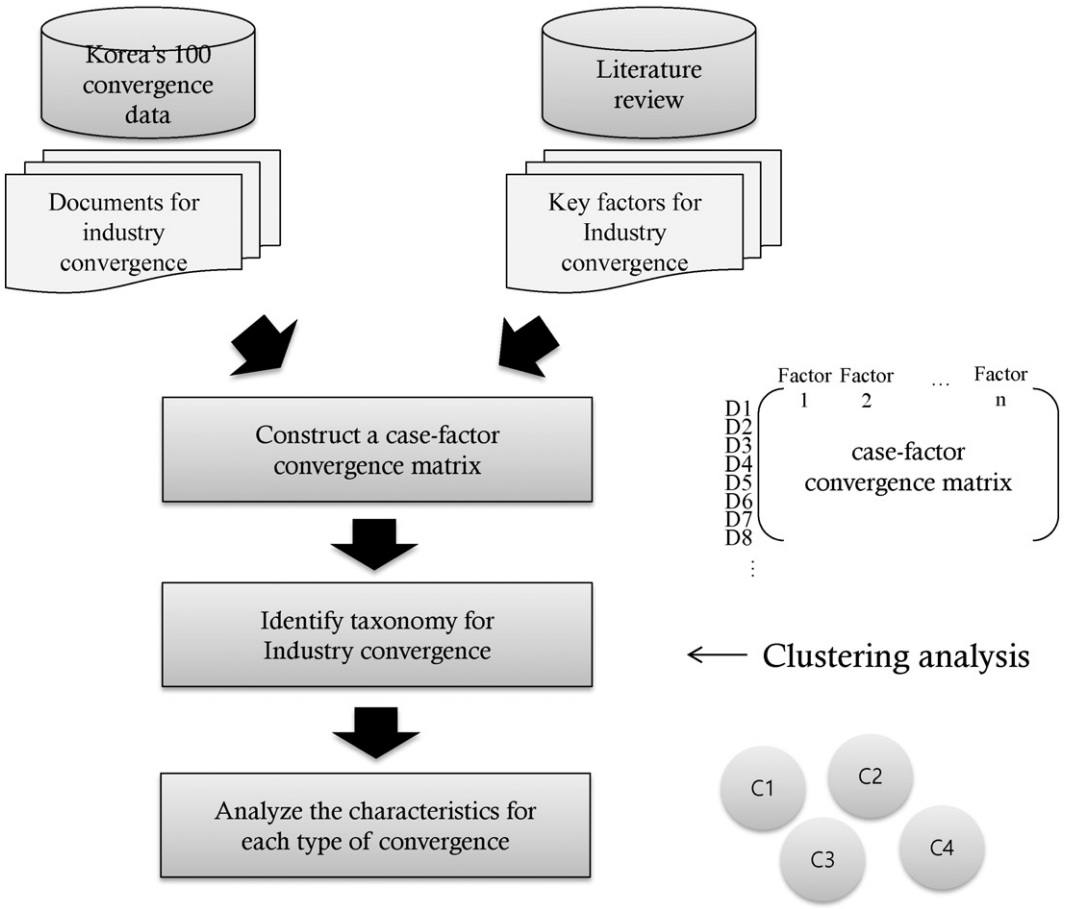

Fig. 1. Overall process.

were collected from the European Patent Office, and the data on strategic technology alliances were taken from the Maastricht Economic Research Institute on Innovation and Technology's Cooperative Agreements and Technology Indicators database, which relate to technology transfer. Gambardella and Torrisi (1998) investigated technological convergence by examining the technological diversification of the downstream activities of the largest 32 US and European electronics firms. Bröring et al. (2006) also employed a qualitative multi-respondent case study analysis, but it was limited to the chemical and food industries.

Therefore, it still remains a void in the literature in analyzing the industry convergence pattern using a comprehensive sample of real-world examples across industries. To bridge the gap, this paper employs practical data relevant to industry convergence—specifically, 100 Korean cases of successful industrial convergence—to analyze how industrial convergence happens. These practical cases represent the essential characteristics of industry convergence. We identify a pattern through a clustering analysis that determines the characteristics of each cluster.

Table 1
Distribution of case samples.

Industry/sector	# of cases	Industry/sector	# of cases
Automobile	10	Semiconductor	5
Shipbuilding	7	Display	5
Machinery	7	Mobile phone	3
Aerospace	2	Electronics	19
Fiber & textile	10	Information and communication	4
Daily supplies	11	Energy	3
Other	14		

The rest of this paper is organized as follows. The next section provides background information on industry convergence. Section 3 presents the procedures and data used in this research. Finally, a discussion of the limitations of this study concludes the paper.

2. Industry convergence

2.1. Definition of industrial convergence

The first use of the term "convergence" is attributed to Rosenberg (1978), who stated that changes in the machine tool industry in the second half of the 19th century inspired the expression "technological convergence," which was used to contrast with "sequences of parallel and unrelated activities." He employed the term to describe processes used by unrelated industry sectors and different stages of tool production (Curran and Leker, 2011).

Convergence refers to the blurring of boundaries between industries through the convergence of elements such as value propositions, technologies, and markets (Choi and Valikangas, 2001; Bröring and Leker, 2007). Blackman (1998) defined convergence as a trend in the evolution of technology services and industry structures. Others have defined it as innovations that emerge at the intersections of clearly defined industry boundaries, producing a much broader impact (Hacklin et al., 2009). The essence of convergence has been described as the connection of technologies in exciting new ways (Kodama, 2014).

According to Hacklin et al. (2009), convergence occurs in four stages: (1) knowledge convergence, (2) technological convergence, (3) applicational convergence, and (4) industrial convergence. Among these, industrial convergence—the point at which applicational convergence transitions into shifts in industry boundaries—has been