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Exploring the mechanism of technology standardization and innovation using the solidification theory of binary eutectic alloy

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ABSTRACT

Technology standardization and technology development play an important role in promoting the competitiveness of businesses and enterprises. Therefore, it is crucial to thoroughly analyze and understand their functions and working mechanisms. Based on the theoretical analysis of the mechanisms of technology standardization and innovation, this paper made modeling efforts on the technology standardization process, the internal working mechanisms of technology innovation and standards, and the advancement of technology development and technology systems propelled by technology standardization. We feel that although there could be some characteristics that distinguish the mechanism of technology standardization and innovation in emerging economies from their counterparts in developed economies, the modeling efforts made in this study may be applicable to both emerging and developed economies. Using the proposed model, this paper derives valuable insights and makes practical recommendations for improving the level of technology development and advancing technology standardization systems.

1. Introduction

Globalization and technological advancement have significantly impacted businesses by demanding them to compete on the international market (Bruton and Chen, 2016; Lei et al., 2016; Li, 2013a; Xu, 2011a). Therefore, it is imperative for companies to seek innovative solutions to remain competitive in the global market (Li, 2012, 2013b; Xu, 2011b, 2016; Xu et al., 2016; Yu and Madiraju, 2015). However, when the global market continuously evolves, companies and technological entrepreneurs may start to behave conservatively and defensively, inhibiting their innovative activities to keep up the market trends (Utterback, 1994). Therefore, it is imperative for companies and technological entrepreneurship to find sustainable ways to continuously engage in innovation so as to stay on the top of the market.

Technological entrepreneurship and its social-economic impact are closely related to the development of technology standards (Drucker, 2014). Technology evolves quickly, so does technology standards. Technology standard-setters are normally in charge of the initiatives of an industry. An industry's technology development level in general represents the latest technologies, reflecting the competitive edges of its technology system and the innovativeness of its technological entrepreneurship. To propel an industry's technology development, a

higher technology standard is required as well as its corresponding technological innovation. Therefore, a company's strategic goal and its future development directions critically depend on if it can become a technology standard-setter. Hence, it is crucial to understand the mutual working mechanisms between technology standardization and technology development level, which is particularly important for a company to foster its technological entrepreneurship and innovation so as to survive the competition and maintain a continuous development in its industry.

Current research mostly aims at the relationship between technology standards and innovation. The synergy between technology standardization and innovation and how it influences technology development level have received little attention. Hence, it is imperative to uncover the working mechanisms of technology standardization and technology development so as to better understand how they can contribute to the development of technological entrepreneurship.

The rest of the paper proceeds as follows. Next section reviews prior literature by focusing on technology standards. Section 3 analyzes the mutual interactions between technology standards and technology development levels. Section 4 demonstrates a model of technology standardization and technical development based on the solidification theory of binary eutectic alloy. Section 5 further explores the effect of

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technology standards and technology innovation on technology development level based on the binary eutectic solidification theory. The last section concludes the paper by highlighting our contributions.

2. Literature review

This section reviews prior literature with an emphasis on the formation and evolution of technology standards, the process of technological standardization, and the impact of technology standards on innovation and technological development.

Reddy and Cort (1989) studied the formation of technology standards, emphasizing the important role of technology compatibility in technology standard formation. Arthur (1992) did a more detailed study on market irreversible and path dependence to explain the forming mechanism of technology standards. Egyedi (1999) considered technology standards as the internal factor to promote the formation of technology development. Studying the cases of manufacturing, computer hardware, machine parts design and product data exchange, Allen and Sriram (2000) noted that a technology standard is often derived from the innovation. Researchers put forward standardization motivation hypothesis from departmental and enterprise level, and empirically tested the hypothesis based on the data of German and international industry and enterprise. Furthermore, researchers thought that standardization is part of the R & D process and there are many factors that affect technology standardization with the underlying factor being technology. Technology is the core of technology standard; without it a technology standard would be like a river without water or a tree without roots. Researchers also pointed out that most of the standard formation is originated from technology innovation.

Antonelli (1994) studied the evolution of standards as an economic system and a variety of roles and effects of technology standard. He argued that technology standardization issues in traditional industries are not complicated. However, with the rapid development of information technology and shortened innovation cycles, the demand of technology standardization continuously increases and technology standard issues have also become increasingly prominent, resulting in the institutionalization of technology standardization. Technology standards can be considered as a reference of technology industry formation as Özsomer and Cavusgil (2000) pointed out that “the way of the formation of structuring high technology industry is always around the establishment of technology standard.” Hariharan (1990) proposed that all the models, technology specifications, steps or conceived programs have a significant market-positioning impact on the level of technology industry products. Technology standards speed up the competition among enterprises; therefore, in order to compete in the global market, companies need to develop alternative technologies so as to understand the relationship between technology standard and competition and adapt the technologies to their changing relationship once a technology standard is established (Katz and Shapiro, 1985). Competition will increase when companies try to increase their users' network around the world to establish a global technology standard (AT and T Wireless, 1995). In the current research regarding the development process of global industries, technology standards have been widely viewed as a crucial strategy (Özsomer and Cavusgil, 2000). The impact from standard technology promotes technology development and progress, which results in the external forces to facilitate the formation of technology standardization. Technology standardization is driven by the needs of the market which also contribute to the advancement of technology. In addition to the driving force of a market, government and organizations also play a role in technology standardization. For instance, the driving factor of technology standard formation for the HDTV industry is not the market, but the international organizations that have been pushing to use their technology standards (The Economist, 1993). Technology standards are important for competitors to coordinate the directions of their technology development when compatibility is an issue. Adopting the current technology

standards can reduce costs, especially for compatible alternative parts, and promote the large-scale production and market-size development (Farrell and Saloner, 1986).

The process of technology standardization not only requires the support from producers, users, and relevant government agencies, but also affects the existing technology standards in terms of their directions of future development. For instance, Allen and Sriram (2000) consider a technology standard as a complex system composed of a variety of technical activities, and argues that technology standards have both negative and positive impact on technology development once they become widely accepted rules. Technology standards typically come from those companies with the most innovative technology, and the standards can promote technology development directly or indirectly. The standardization of technology impacts its development through facilitating the process of technology advancement and innovation. For instance, Chen and Liu (2008) discovered the existence of the internal compliance relationship between technology standardization and progress. Veall (1985) believed that standardization promotes the development of the market of all industries as well as the competition among enterprises. Pelkmans (1987) found that the coordinated development of technology requires organic combination and closely participation of technology standardization. Kim (1997) confirmed the influence of technology standards on the process of technology development, and showed that the trajectory of technology development in developing countries is different from those in developed countries that include introduction, absorption, and improvement. Standardization plays a very important role in the process of establishing international competitive advantages (ANSI, 2000). Veall (1985) claimed that in a fully competitive market technology standards have a huge impact on the motivation and impetus for innovation. Standardization has a very significant impact on technology innovation (Jakobs, 1999), by representing the internal factors of technology development formation (Egyedi, 1999) and affecting the speed and direction of technology innovation. Kano (2000) proposed the concept of system innovation by considering technology innovation as an important part of technology development and believed that technology standards are mainly reflected through systematic and independent gradual innovation of technology. He also conducted a groundbreaking empirical research in communication, based on a series of continuously generated technology standards, analyzed the evolutionary process of system innovation in mobile communications, and concluded that technology standardization process does not inhibit technology innovation. In addition, he studied the relationship between technology standards and development by comparing the technology standard formation processes and results of mobile communication systems in Europe, Japan, and United States. Li (2001) studied the management principle of standard systems and proposed that optimization, harmonization, and simplification are the basic principles of standardization. He also believed that technology innovation and standardization seem to be mutually contradictory and exclusive, which in fact are unity of opposites. Instead of inhibiting innovation, technology standardization prepares the necessary conditions and platforms for technology innovation.

3. Analyzing technology standardization and technology development level

3.1. The connotation of technology standardization and innovation

International Organization for Standardization (ISO) defines a technology standard as “the file which has one or a series of certain mandatory requirements or guiding function, containing the detail of the technology requirements and related technology solutions”, which aims “to enable the relevant product or service to reach certain safety requirement or the requirement to enter the market” (Hou, 1996). Technology standards are repetitive technical entities uniformly regulated in a certain range, and are generally referred as the technology

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