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The adaptive mechanism between technology standardization and technology development: An empirical study

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ABSTRACT

The relationship between economy and technology has become more and more important, especially for emerging economies. The flow of capital, talents, information, technology, and other resources has increased the competition among enterprises. Technology standardization has been used to enhance enterprises' technical strength and accelerate the industrial technology development. However, technology standardization and technology development can promote each other only when both adapt to each other. Major factors influencing technology standardization and technology development have been studied by the grey absolute correlation, the grey relative correlation, and the grey comprehensive correlation. Policy recommendations are also presented to practitioners.

1. Introduction

Highly developed information technology lifts the global economic development to a new high (Gorkhali and Xu, 2017; Li, 2012, 2013, 2017; Liu et al., 2017; Lu, 2017; Peruzzini and Stjepandic, 2017; Tao et al., 2016; Verma and Singh, 2017; Wang, 2017; Xu, 2011, 2016; Xu et al., 2016). Enterprises face both domestic rivals as well as foreign competitors. As the carrier of advanced technology, technology standard determines the industry's technology level and technology difficulties. In other words, owning the technology standard will be able to lead the competition (He and Xu, 2014; Li et al., 2015; Xu et al., 2014). Technology development affects the country's economy level and determines the country's competition position. Technology development begins from the technical principle and improves the local technology level continuously or dramatically by accumulating both quantitative and qualitative changes. This will improve the overall technology system by enhancing the technology level and increasing the technical strength. Technology standards and technology development will mutually promote each other when both fit their circumstances. However, the literature has ignored the mechanism between technology standards and technology development. Therefore, this study tries to bridge an important gap in the literature: What is the adaptive mechanism between technology standardization and technology development in enterprises?

2. Literature review

2.1. Technology standardization and technology innovation

Sadahiko Kano (2000) boosted technology innovation to the system level by independent and gradual innovation and analogical technology standardization with dynamic connotations. Considered as a standard evolved during the technology development, technology standardization will achieve a structural and comprehensive innovation when the technology accumulates to a certain threshold. Additionally, technology standardization can integrate disordered technology innovations into an ordered system innovation (Lei et al., 2016; Swann, 2000). Allen and Sriram (2000) stated that technology standardization has promoted technology innovation. Meanwhile, technology standardization also has the hinder effect. But the overall positive effect exceeds negative effect through the adaptability of judgement. From the technology innovation's perspective, technology standardization is mainly reflected in two aspects: one is the efficiency of technology innovation, the other is the direction of technology innovation (Liu and Li, 2010). Goluchowicz and Blind (2011) utilized a Delphi methodology to identify future fields of standardization based on various science and technology indicators.

Li (1994) argued that technology standardization and technology innovation can promote each other as well as hinder each other. Technology innovation is the sufficient condition of technology

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standards. Reciprocally, technology standard is the implementation basis to guarantee technology innovation (Li, 2004). Li et al. (2010) also stated that technology standard is the base of technology innovation and pointed out the direction for technology innovation. Additionally, technology standard can directly affect the size and reduce the risk of technology innovation due to standard stability and technology accumulation. Technology standards also face different challenges when technology innovates too fast. Standards' quality may be sacrificed if standards' demand is more than standards' supply. Ultimately, it will affect the quality of technology innovation. Thus, in order to guarantee both qualities of technology standards and technology innovation, choosing the development pace and finding the equilibrium are equally important (Han et al., 2010). Recently, Huenteler et al. (2016) discovered the innovation pattern in energy technologies by analyzing two common innovation models in terms of the product-process innovation and the system-component innovation. Based on interviews with Korean firms, Yun et al. (2016) developed a new innovation diagram to examine the knowledge-based economy and open innovation.

2.2. Technology standardization and technology development

Similar as the network system, Farrell emphasized that the industrial economy must ensure the system compatibility. Given that a standard is compatible with its complementary industry standards, industrial specialization and cooperation can increase operations and production efficiency and promote technology development. Farrell and Saloner (1985) further pointed out how technology standard can promote technology innovation. Specifically, technology standard will achieve the large-scale and high quality production. After an industry establishes and stabilizes a technology standard, it can reduce the production cost and initiate technology innovation. Companies using obsolescent technologies will lose market so that inefficient technologies will be eliminated. Consequently, it will promote the development of industrial technologies (Besen and Farrell, 1994).

Within the endogenous economic framework, Pan and Lin (2005) found that technology standardization and patent are necessary for developing technology and maximizing economic growth. They also proposed a model to relate technology development and patent protection to social welfare. Additionally, the technology development efficiency could be improved by a patent keyword network analysis (Choi and Hwang, 2014). Chen and Liu (2008) analyzed the inner link between technology standardization and technology development using data collected from the Chinese communications equipment manufacturing industry during 1995–2005. They found that the technology innovation efficiency is negatively related to the number of technology standards established by the government. Therefore, increasing the number of technology standards will reduce the motivation of technology innovation and technology development. At the same time, they also pointed out that there are two factors for improving the technology development efficiency: 1) designing the optimal technology; and 2) selecting the time of technology standards. Thus, technology standard and technology selection must be closely integrated with the current technology development to promote new technology development. Lichtenhaler (2012) adopted the contingency theory to examine how the technology licensing shapes standards. The convergence structures in technology development and standardization are confirmed as moderately positively correlated (Gauch and Blind, 2015).

3. Adaptability analysis of technology standardization and technology development

3.1. Technology standardization

The international standard organization (ISO) defines technology standard as an established norm or document for a technology. It

specifies detailed requirements on the technology to ensure the high quality of products or services before entering the market (ISO/IEC, 2008). If an enterprise can reach technology standard, its production technology conforms to the standard. Consequently, the enterprise can enter the market successfully and make profits. However, the enterprise does not meet the basic requirements of the industry if the production technology is not up to the relevant norms and regulations. Given this, the enterprise has to improve the production technology. Otherwise, it will be eliminated by the market. Therefore, the enterprise either initiates the technology innovation to improve the technology ability or purchases technology licenses to achieve the corresponding technology standard. The realized technology standard will gradually become an effective economic tool and social norm to promote a healthy competition and ensure a smooth product circulation.

Technology standardization and technology standard are different. If the technology standard is a line, then the technology standardization is the process of drawing the line. Technology standardization is a dynamic process which is necessary to establish a technology as the technology standard. Therefore, technology standardization affects a country or a region's economic development and technology development.

3.2. Technology development

The technology development is a development process of related social and technology fields under the influence of technological factors. There are two major types of technology development: the gradual and the radical. Without changing the basic technical principle, the gradual development refers to a continuous improvement of technical performance. Technology innovation is considered as the most commonly used technical performance. The radical development will change the technology products by implementing fundamental changes of the technical principle. It can also be considered as a technology revolution when the technical principle is changed fundamentally. A mature technology can be achieved by the gradual development only. Meanwhile, technology innovation is based on a mature technology. Thus, it is impossible to realize technology innovation without the gradual development.

Based on the industry life cycle, this paper also adopted three stages: formation, growth, and mature for the technology development. As the trend curve of technological development shown in Figs. 1 and 2, the technology development in different development stages has different characteristics.

3.3. The mutual adaptability within the system

Essentially, a system is a set of interacting and interdependent component parts which determine both development direction and system capability (Xu, 2000). An adaptive modular design framework was proposed to demonstrate the planning process and technology foresight research stages (Lin et al., 2012). According to the system

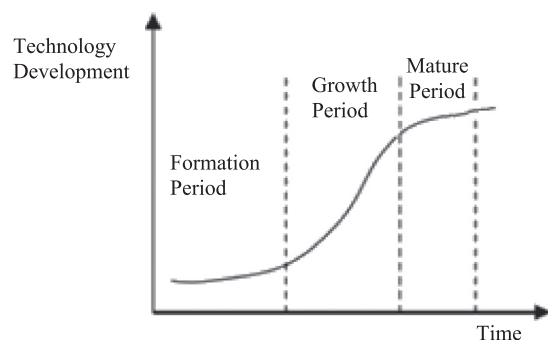


Fig. 1. Trend curve 1 of the gradual technology development.

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