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Standardization revisited: A critical literature review on standards and innovation

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ABSTRACT

Effective ICT standards enable different services to work together while promoting differentiation that facilitates competition and innovation. In order to ensure that the quality of ICT standards is well developed, it is important that these standards and standardization procedures meet certain requirements. This study reviews standardization research in terms of the process of standardization, innovation, and the demand-supply perspective. It draws implications that standards will be one of the important tools for national economic growth and for unconventional strategies of businesses. The analyses, based on the demand-supply framework, finally suggest promising opportunities for potential researchers.

Contents

1. Introduction

Technical standards are established norms or requirements applied to technical systems. They are a crucial aspect of almost all industries, and the success of firms may depend on the consequences of standard-based competition [50]. As a smart society is rapidly developing, the role and impact of standards have been increasing, especially in growing ICT industries [45]. The emergence of ICT paradigms, such as cloud computing, the Internet-of-Things, mobile traffic explosion, and ubiquitous connectivity, is driving what is arguably the most significant transformation of the architecture of mobile and wireless network systems. Simply put, ICT architectures need to evolve to support an exponentially more complex and diverse set of applications. This challenge has attracted ever-increasing attention from researchers in both academia and the industry, including ICT standard experts. As enablers of global systems' interoperability, standards are at the heart of the success of the ICT industry. Technology standard development organizations such as the Institute of Electrical and Electronics Engineers (IEEE), Internet Engineering Task Force (IETF), and 3rd Generation Partnership Project (3GPP) have decade-long track records as drivers of real technological change across the industry.

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The process of standardizing both technology and ways of conducting business is complicated and time-consuming, but it is vitally important given the magnitude of its impact on the industry and society. In light of this importance, numerous studies have examined standardization literature from various perspectives such as economics, management, policy, and technology standpoints. David and Greenstein [18], one of the first-published literature review studies, analyze early standardization processes from an economic viewpoint. Following that, Stango [61] focuses on the economic studies concerning standards wars in reviewing competition and adoption processes of technology standards in the market. Grindley [33] conducts a case study on technology standards by exemplifying several ICT goods in order to provide business strategies and managerial insights. Tassey [63] provides basic information of standards such as the economic functions of standards, types of standards, and even negative impact of standardizations. Focusing specifically on one aspect of the technology-based market, the author proposes standardization policy recommendations, for example, a standard-associated research project, sequential investment of the government and private sector in infrastructure standardization, and government funding dealing with the negative effects of standardization. Standardization concerning ICT-related technologies and products such as data modems [65] and programming languages [20] is also reviewed in a case analysis.

While a number of studies have been done in the area of standardization and its importance is drastically increasing, previous reviews of standard-related issues have not examined the topic in an extensive way. Although the existing standardization studies are well-reviewed from an economic perspective, attempts to categorize them into demand-side and supply-side literature are not easily found. Specifically, even though innovation activities for standardization in the ICT industry are becoming more important than ever, literature reviews on standardization issues from an innovation viewpoint are still way behind. While standard-based competition among firms, and even among countries, is getting more severe in the ICT industry, existing review studies do not sufficiently address this research gap. These gaps provide the research topic for this study.

The current study attempts to bridge the aforementioned gap by reviewing standardization research using a demand and supply framework. In the demand-side perspective, the ways that standards are adopted and diffused by technology users are examined. In the supply-side perspective, on the contrary, the ways that standards are established and promoted by standard-setting organizations or technology-leading firms are explained. In addition, this study addresses the relationship between standards and innovation in order to highlight standardization policies for national economic growth and standard-based competition as an innovation tool. The findings draw insightful implications from the current literature by reorganizing and clarifying the economic implications of demand and supply roles. Furthermore, practical implications for new types of standard-based competition for innovation can be drawn from the discussion.

The rest of this paper is organized as follows. The origin of standardization research is first introduced in Section 2 for readers to understand this research field. Next, the demand-side and supply-side of standardization research are reviewed in Section 3 and Section 4, respectively. After the relationship between standards and innovation is examined in Section 5, several strategies for national standardization policy and new types of standard-based competition for innovation are discussed in Section 6 and Section 7, respectively. Finally, conclusions and a discussion of some remaining research opportunities follow in Section 8.

2. The origin of standardization research

In the conventional manufacturing industry, a standard generally refers to a common set of quality norms or criteria. Jakobs [38] defines a standard as "a publicly available definitive specification of procedures, rules and requirements, issued by a legitimate and recognized authority…" (p. 11). A standard defined in this way can be used as criteria for simple measurement, an objective for solving matching problems, a quality assurance policy for alleviating asymmetric information, or a reduction of information and transaction costs [19]. While such definitions have been similarly applied in general science and engineering fields [32], the concept of a standard differs slightly when it is applied to the ICT industry.

The fact that the concept of a standard can be unique to the ICT industry is attributed to the characteristics of information goods, which are proposed by Shapiro and Varian [54]. First, the ICT industry depends heavily on technology systems. As a system consists of diverse parts or components manufactured by multiple firms, compatibility or interoperability between parts or components is essential for the survival of firms.

Second, goods or services in the ICT industry involve high switching costs [57]. When a new system is introduced, a significant amount of money and time are required for learning until users become familiar with the system. Such expenses are referred to as switching costs, and firms seek to raise these costs in order to lock consumers into their products or services. Although governments attempt to decrease switching costs to relieve consumers of their financial burden, the efforts are not always effective and often end up failing. The issue of switching costs remains an unsolved question for both the academia and the industry.

Third, network externality is a key factor in standard policy. In any ICT industry, network externalities play a substantial role in industry competition and market structure. Network externality means that a greater number of users adopting a technology result in greater user benefits while maintaining a positive feedback effect. ICT firms pay particular attention to such effects in order to promote their products. Therefore, firms competitively attempt to create sufficient demand to reach 'critical mass,' when the utility of information goods starts to be realized. Network externalities help the existing installed base reach a tipping point where a sufficient utility is maintained.

In addition to the three aforementioned characteristics, the recent emergence of two-sided markets where information goods are mainly carried on transactions increases standard-based competition in the shape of the platform. Generally, a two-sided market is referred to as a market where values are created by interaction between two users or firms using a specific platform. Rochet and Tirole [51] define it as a market that can affect the amount of transactions by changing pricing structure. Evans and Schmalensee [22] categorize two-sided markets into exchange, advertiser-supported media, transaction devices, and software platforms. The reasons why two-sided markets have been issued recently in remarkable numbers are as follows: (1) indirect network externalities occur in two-sided markets such that as the size of a specific network increases, the benefits of another network increase, and (2) the platform mediating the relationship between the demand group and supply group can alter the transaction quantity by requiring a higher price of only one group. In other words, a firm preempting a platform standard can lead the two-sided markets. Android and iOS, which are de facto standards of smartphone operating systems leading a two-sided market in the mobile platform, are representative examples.

Due to the aforementioned characteristics of the ICT industry, the concept of a standard is applied differently in various contexts. A winner-takes-all phenomenon can be described by these characteristics; capturing the first mover advantage would result in the greatest benefit in the initial stage of the market. Firms develop strategies to make their own technologies a standard in the market, and governments around the world are also committed to establishing standardization policies in order to gain international competitive advantages.

There have been a number of studies looking at standardization strategies from managerial and economic viewpoints. The economic concept of a standard is suggested by David [17], addressing the QWERTY keyboard. The study investigates the reason why QWERTY has been a standard for keyboards for 100 years despite its