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Innovation and de facto standardization: The influence of dominant design on innovative performance, radical innovation, and process innovation [☆]

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ABSTRACT

Setting technology standards is the route to market growth and to potentially influencing the performance of a whole industry. When a market accepts a particular technology as one that defines the specifications for products in the entire industry, a dominant design is set. In this article, we investigate how the existence of a dominant design affects subsequent innovation in an industry. In particular, we study the influence on innovative performance, radical innovation, and process innovation. Analyzing longitudinal, cross-sectional patent data for more than 2.6 million patents filed from 1978 to 2013, we find support for our hypotheses that an industry's innovative performance and degree of radical innovation are negatively influenced by dominant design in that industry, and that process innovation is fostered by the occurrence of a dominant design. We discuss the findings in the light of the increasing speed of technological development and standardization. Additionally, results from a sensitivity analysis for different threshold values of dominant design call for adjusting a binary definition of dominant design with different threshold values depending on the effects under study.

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1. Introduction and background

In the process of rapid technological change, superior technology plays an important role in the stimulation of product innovation and process innovation (Utterback and Abernathy, 1975; Tushman and Anderson, 1986). Surprisingly, many examples show that the development of a superior technology does not automatically lead to the establishment of a new standard (Viardot, 2005), e.g. as the evolution of standards can also be triggered by non-technological reasons (Arthur, 1990). The establishment of a new standard can be a major lever to reach dominant market share and survive on markets with rapid technological change (Suárez and Utterback, 1995). As an industry passes through the product life cycle, product variety tends to be reduced and the technology becomes standardized. Companies participate in a technology race, in which they want to dominate the choice of standards and consequently increase market share (Damsgaard and Lyytinen, 1998). A dominant design exists if the market

accepts a particular product's design as the standard for the whole industry or product category (Abernathy and Utterback, 1978; Utterback, 1994). A dominant design is the turning point for an industry, e.g. the 1908 Ford model T became the dominant design in the automotive industry in the early 20th century (Fujimoto, 2014). To better understand this phenomenon, this article investigates how the existence of a dominant design affects subsequent innovation in an industry.

With the institutionalized standardization of dominant design, i.e., by industrial norms, there is large potential for policy makers to control innovation activities (Blind, 2013). However, only recently policy initiatives have occurred, e.g. the Lead Market Initiative (LMI) including a communication titled "Towards an increased contribution from standardization to innovation in Europe" (European Commission, 2008), which focuses on standardization as a crucial innovation policy instrument (Choi et al., 2011; Blind, 2013). The final report of the LMI centers on strategic actions for developing more consistent standardization to encourage the diffusion of innovative practices (European Commission, 2011).

Utterback and Abernathy (1975) and Murmann and Frenken (2006) have conceptualized standardization on the product level. They state that a dominant design exists in an industry when a majority of innovations are based on the same technological design (Murmann and Frenken, 2006). In the race to strive for best-

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in-field innovations, companies need to consider not only their own innovations, but also the best and most recent innovations and dominant designs which are publically available in their technological field (Narula, 2004). Although the interrelation of standards, standardization, or dominant designs and innovation seems to be a major contributor to a firm's competitiveness, the influence of standardization on innovation has been investigated to a limited extent only (e.g. Farrell and Saloner, 1985; Galvin and Rice, 2008; Blind, 2013; Blind and Mangelsdorf, 2013). Blind (2013) recently studied this relationship in a comprehensive discussion on the influence of standards and standardization for the whole innovation process. From his perspective, the influence of standardization on innovation has been largely under researched because of two reasons: primarily, due to the traditional perspective that standards will always negatively influence innovation, and additionally, due to the fact that policy initiatives therefore did not consider standards as an instrument to foster innovation activities and as a consequence did not foment research on the topic. Publications on the investigation of this relationship are continually increasing, but only a few have strived to extend empirical research on the relationship between standardization and innovation (e.g. Swann, 2000; 2010). Nevertheless, research profiling 528 papers retrieved from the database ISI Web of Science shows that the research topic is generating growing interest with yearly publications on standards and innovation which nearly tripled between 1995 and 2000 and more than doubled between 2000 and 2008 (Choi et al., 2011).

2. Theory and hypotheses

This article studies the influence of standardization and dominant design on innovation on the industry level. To better understand the concepts of dominant design and standardization, we start by defining the basic terms in the context of this article. We then examine the existing theory about the impact of dominant design on subsequent innovation and formulate related hypotheses.

2.1. Definition and distinction of dominant design and standardization

The definition of dominant design has evolved over time from a broad concept to a more specific phenomenon. Srinivasan et al. (2006) and Narayanan and Chen (2012) provide very useful overviews of various definitions of dominant design including the definitions by authors such as Abernathy and Utterback (1978), Anderson and Tushman (1990), and Christensen, et al. (1998), which we complement with the definition of Murmann and Frenken (2006). They state that a "dominant design exists in a technological class when the majority of designs have the same technologies for the high-pleiotropy core components" (Murmann and Frenken, 2006, p. 23). In the context of the marketplace, James Utterback defined dominant design as a design that "wins the allegiance of the marketplace [...] that competitors and innovators must adhere to if they hope to command significant market following" (Utterback, 1994, p. 24). In other words, market forces may inevitably lead to acceptance of a product's design as the leading design in the industry or product category (Abernathy and Utterback, 1978; Utterback, 1994; Srinivasan et al., 2006). This phenomenon is also described as de facto standard or dominant design (Soh, 2010), which is the object of examination of this article.

In this context, we emphasize that dominant design and standards are strongly related, but not identical concepts, even if prior research has used these terms synonymously (Katz and Shapiro,

1986; Anderson and Tushman, 1990; Besen and Farrell, 1994; Schilling, 1998). Following the remarks of Srinivasan et al. (2006), we define standards as the inevitable requirement for technical specifications of products resulting from the interdependence among several components (Srinivasan et al., 2006) – standards are mainly implemented in industrial norms. From this perspective three aspects differentiate standards from dominant designs: Firstly, standards have the functional purpose to connect different components of a product or service, independently of its manufacturer/service provider or its market acceptance, whereas market acceptance is a central prerequisite of a dominant design (Srinivasan et al., 2006). Secondly, dominant designs emerge from competition in the product life cycle after a long process of problem solving (Gawer and Cusumano, 2014), e.g. in the home video market when Blu-Ray won the competition against HD-DVD, whereas standards emerge from the previous competition of dominant designs (Shapiro and Varian, 1999) or, in other words, from the progressive nature of the product life cycle in which an industry is forced to standardize core components (Gawer and Cusumano, 2014). Thirdly, standards can comprise many dominant designs, e.g. in the mobile phone market with the subscriber identity models SIM, Mini-SIM, and Micro-SIM. Hence, if a market accepts particular technology standards defining the specifications for products in the entire industry, a dominant design is set.

2.2. The influence of dominant design on innovative performance

The emergence of a dominant design in an industry is an important event, which directly affects the technology life cycle and indirectly affects the strategies and performance of firms in that industry (Srinivasan et al., 2006). The traditional perception of the interrelationship of standardization and innovation is that standardization hinders innovative performance (Blind, 2013). A common definition of innovative performance has been frequently discussed in innovation management research (Pakes and Griliches, 1980; Ahuja and Katila, 2001; Cockburn et al., 2010). In this article we define innovative performance in the context of an output factor as the cumulated results of innovative activities in an industry or product category. Nevertheless, standardization is also found to promote innovation if certain framework conditions are considered (Blind, 2013). Standards can explain technological specifics and therefore diffuse state of the art solutions (Swann, 2000). The firm that has brought up a dominant design shapes future generations of products, resulting in what Srinivasan et al. (2006) call an "architectural franchise" – a type of monopoly power which might lock out competition for a while and consequently increase innovative and firm performance (Schilling, 1998). Blind (2013) recently provided empirical evidence that standardization can promote innovation. By means of dominant design, innovation activities are positively influenced by avoiding a "lock-in into old technologies" (Blind, 2013, p. 9), by an increase of the efficiency of the supply chain through economies of scale and the reduction of product variety, which allows emerging technologies and industries to faster reach critical mass. On the other hand, dominant design can negatively influence innovation by the creation of monopoly power, the increase of competitors' costs, market concentration and a subsequent reduction in product choice, as well as a potentially premature selection of technologies (Swann, 2000). These negative effects are especially pronounced when a dominant design is protected by strong intellectual property rights (Woo et al., 2015).

Empirical evidence on the relationship between dominant design and a firm's individual innovative performance is given by Soh (2010). If a company aims to bring up or strengthen a dominant design, the tight collaboration with partners helps to accomplish this task. Soh (2010) finds that firms with high proximity

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