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Role of *relevant* lead users of mainstream product in the emergence of disruptive innovation

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ABSTRACT

We combine insights received from prior research on the role of lead user and prior investigations of disruptive innovation. Our research illustrates the role of a particular lead user, which we refer to as the relevant lead user, in paving the way for the potentially disruptive technology to be a definitely disruptive one. Through focused consideration, we reveal characteristics that may be significant in identifying users as relevant in relation to potentially disruptive innovation. Our research also reveals that contrary to Christensen's assumption, incumbents do not embrace the inevitable and jump from the old technology to the new. Rather, the transformation occurs over a period of time.

1. Introduction

Christensen's (1997) notion of disruptive innovation—a theory that underscores the ability of new technologies that are initially inferior to eventually overturn mainstream technologies—has profoundly affected the study of technological change. Subsequent research (see, e.g., Adner, 2002; Christensen and Overdorf, 2000) has broadened our understanding of the theoretical underpinnings of disruption—an industry-wide phenomenon that affects large incumbents and helps new entrants dislodge established firms. In their quest to understand the boundary conditions of Christensen's thesis, Danneels (2004), Henderson (2006), Gans (2016), Roy and Cohen (2017), and others have observed that firm-level capabilities, such as marketing competencies and complementary technologies, buffer firms during disruptive changes.

Adner and Snow (2010; p. 1656) highlighted one of the key assumptions of the theory of disruption and noted that when challenged by a technological change, firms facing the threat are likely to have a "correct" response—to "embrace [the] inevitability" and "jump from the old technology to the new." However, a disruptive challenge is "surrounded by uncertainty" (Gans, 2016; p.10), which should make it unlikely to comprehend *ex-ante* if and when a *potentially* disruptive technology is likely to become a *definitely* disruptive one, thereby making technological displacement (Adner, 1999) inevitable. Further, combining the insights of Adner (2002) who stressed the critical role of demand conditions in disruption with those of Rogers (1983) who posited the heterogeneity among adopters, it seems unlikely that incumbents affected by disruption would "jump" from the old technology and adopt the disruptive new innovation simultaneously (Adner and Snow, 2010).

Wisdom received from Adner (1999), Adner and Snow (2010), and Gans (2016), therefore, encourage us to seek an answer to our research question, "*when, and how, does a potentially disruptive technology become definitely disruptive?*" Additionally, prior investigations by Rogers (1983) and Adner (2002) encourage us to extend our research question and seek an answer to the follow-up question: "does the technological displacement occur over a period of time with some users adopting the potentially disruptive technology earlier than others or do all users of mainstream technology adopt the potentially disruptive technology simultaneously?" Seeking the answers to our research question as well as the follow-up question is critical if both researchers and practitioners are to delineate the boundary conditions of Christensen's (1997) theory and have a complete understanding of how a potentially disruptive technology transforms to a definitely disruptive one over a period of time.

We use technological disruption in the U.S. industrial robotics industry, where the manufacturers of electrically controlled (EC) robots disrupted the manufacturers of mechanically controlled (MC) robots, as the context of our study.[1] We borrow insights from von Hippel (1986), Christensen (1997), and Adner (2002) to uncover the yet unexplored role of a *relevant* lead user— General Motors (GM) in our context, an incumbent that is not only a lead user of the mainstream product but

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[1] Building on Govindarajan and Kopalle (2006), we explain later in the paper why the transition from MC to EC robots was a disruptive change for MC robot manufacturers.

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also a lead user of the potentially disruptive product—in helping firms overcome the uncertainties associated with a potentially disruptive technology and thereby, over a period of time, transforming the potentially disruptive technology to a definitely disruptive one.[2]

Our investigation has several implications for the innovation literature. First, our study expands von Hippel's (1986) thesis and reveals that in the case of the industrial robotics industry, the adoption of the potentially disruptive technology by the relevant lead user—GM in our context—sends a credible signal (Weigelt and Camerer, 1988) to other users to "embrace" the new technology (Adner and Snow, 2010), thereby leading to the emergence of the disruptive technology as the future dominant design (Tushman and Anderson, 1986).

Second, our investigation refines Christensen's (1997) observation that disruption occurs when the product performance *provided* by the disruptive new technology *exceeds* the performance *demanded* by mainstream customers.[3] Contrary to Christensen and Bower's (1996; p. 210) observation—that mainstream computer users adopt the potentially disruptive technology simultaneously "once their needs for capacity and speed [are] met"—we find that adoption of the potentially disruptive EC robot technology occurs *over a period of time* and involves "trial and error" experimentation (Murmann and Frenken, 2006; p. 932) by the relevant lead user. In the case of the industrial robotics industry, disruption occurred between 1983 when GM, the relevant lead user, started manufacturing and using EC robots, and 1987 when ABB Robotics (ABB) introduced the first spray-painting robot.

In our pursuit to understand the role of relevant lead user in the industrial robotics industry, we follow Holbrook et al. (2000) and Tripsas and Gavetti (2000) and use archival data, industry insiders' accounts, and information from various secondary sources. Further, we countercheck our data and findings with various industry experts, including those at the Robotic Industries Association (RIA). Feedback from experts helped us "present facts and ask questions" and counter-questions "about possible explanations of these facts" (Bettis et al., 2014; p. 950).

Next, we review the literature and build our theory.

2. Literature review and theory

We proceed by reviewing the broader technological change literature. Thereafter, we explore the role of the relevant lead user in overcoming the uncertainties associated with a technological change. Finally, we review the literature on disruptive innovation and combine the insights from prior research to explore the role of the relevant lead user during a disruptive change.

2.1. Technological change, product performance features, and the role of demand conditions

Innovation researchers generally perceive the emergence of a new technology and its eventual displacement by another technology as a cyclical process that occurs over a period of time and involves a revolutionary technological breakthrough followed, in turn, by the era of ferment. Thereafter, the dominant design emerges, followed by an era of incremental change (Anderson and Tushman, 1990). Eventually, this era experiences yet another revolutionary breakthrough. During this cycle, the performance offered by the new technology improves along an S-shaped trajectory (Tushman and Rosenkopf, 1992).

Prior research underscores the critical role that users play during the technological change. Tushman and Rosenkopf (1992) note that during the era of ferment the critical dimensions of product utility are unclear and users are uncertain about the product's critical performance characteristics. For example, Yoxen (1987) observes that doctors were not clear on the relative priorities of scan time and picture resolution during the early years of CT scanners. Eventually, a potential dominant design "emerge[*s*] from market demand" and meets users' needs better than other existing technologies, not only in the new functional parameter but also on the existing ones (Tushman and Rosenkopf, 1992; p. 321). Highlighting the importance of innovation in the product performance feature for the emergence of a dominant design, Murmann and Frenken (2006; pp.940–941) observed that such features "determine the usefulness of an artifact in the eyes of users."

Extant research notes that despite finding an artifact useful, users are unlikely to adopt a new technology simultaneously and the diffusion of innovation occurs over a period of time. In his seminal thesis, Rogers (1983) observes that users are heterogeneous and the diffusion of a new technology follows an S-shaped curve, with different categories of users—such as innovators, early adopters and others—adopting the new technology at different times (Schilling, 2017).

Consistent with Rogers' (1983) thesis, innovation literature hints that during technological displacements, adoption of a new technology by incumbent firms is likely to be spread out over a period of time. More specifically, prior research notes that such displacements are often not driven by the mainstream technology's inherent limits that prevent firms from performance improvements (Christensen, 1992; Cooper and Schendel, 1976) or the new technology's superior performance (Levinthal, 1998). While overcoming the technological uncertainties associated with performance improvements are often challenging for firms, anecdotal evidence of firms that did not suffer from these challenges, yet failed to manage the technological transition (Christensen and Rosenbloom, 1995; Cooper and Schendel, 1976; Smith and Alexander, 1988) suggest that exploring the impact of lead users (von Hippel, 1986) may offer a complementary set of explanations of how firms overcome the demand uncertainties (Adner, 2002) associated with an emerging new technology. In particular, exploring the role of relevant lead user may offer new explanations of how firms overcome the challenges associated with a disruptive change. To build our theory, we next explore the role of lead users in helping firms overcome the uncertainties associated with technological changes and, thereafter, we explore the role of relevant lead user during disruption.

2.2. Role of lead users in overcoming uncertainties during technological change

Highlighting the role of lead users, von Hippel (1986) reports that across industries, users rather than manufacturers invent, prototype, and field test new innovations. Subsequent research recognizes the importance of access to users as a source of prescient information and that users are evolving from "passive audiences" to "active players" in new product innovations (Prahalad and Ramaswamy, 2004). One implication of this body of work is that the innovation opportunities available to a firm are associated with the lead users, who are likely to impact the firm's ability to sense new, emerging avenues. To build our theory that explores the role of *relevant* lead users during the process of disruption, we rely on von Hippel's (1986; p. 791) insightful observation that lead users are the ones "whose present strong needs will become general in a marketplace months or years in the future."

Prior to combining von Hippel's (1986) and Adner's (2002) insights to predict the role of relevant lead users during the process of

[2] To build our theory we borrow Oliveira and von Hippel's (2011; p. 808) definition that "[*l*]ead users are a subset of user populations [who are]… (1) ahead of the bulk of the market with respect to an important trend and; (2) expect to gain major benefits from solutions to needs they encounter at that leading edge."

[3] Our assertion is based on Bower and Christensen (1995, p. 50) who highlighted the importance of the intersection of the supply curve of the potentially disruptive technology and the performance *demanded* by the mainstream customers; and observed that the mainframe-computer makers were disrupted not because the "performance of [disruptive] personal-computing technology *surpassed* the performance of [established] mainframe technology but because it *intersected* with the performance *demanded* by the established market." Further, Bower and Christensen (1995, p. 48) also noted that 3.5-in. disk drives disrupted the 5.25-in. drives when the former drives "packed the capacity *demanded* in the mainstream personal computer market." See the figure "How Disk Drive Performance Met Market Needs" in Bower and Christensen (1995, p. 46).

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