Received: 4 February 2021 | Revised: 3 July 2023 | Accepted: 6 September 2023

DOI: 10.1111/jpim.12709

ORIGINAL ARTICLE

JOURNAL OF PRODUCT INNOVATION MANAGEMENT

When necessity is the mother of disruption: Users versus producers as sources of disruptive innovation

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Funding information
Deutsche Forschungsgemeinschaft, Grant/Award Number: SFB 768 33237764; Tempowerk Hamburg

Associate Editor: Aric Rindfleisch

Abstract

This study investigates the sources of disruptive innovation. The disruptive innovation literature suggests that these do not originate from existing customers, in contrast to what is predicted by the user innovation literature. We compile a unique content-analytical dataset based on 60 innovations identified as disruptive by the disruptive innovation literature. Using multinomial and binomial regression, we find that 43% of the sample disruptive innovations were originally developed by users. Disruptive innovations are more likely to originate from users (producers) if the environment has high turbulence in customer preferences (technology). Disruptive innovations that involve high functional (technological) novelty tend to be developed by users (producers). Users are also more likely to be the source of disruptive process innovations and to innovate in environments with weaker appropriability. Our article forges new links between the disruptive and the user innovation literatures, and offers guidance to managers on the likely source of disruptive threats.

KEYWORDS

appropriability regime, disruptive innovation, environmental turbulence, functional novelty, radical innovation, user innovation

1 | INTRODUCTION

Disruptive innovations are well known to be a major threat to incumbent firms, and sometimes cause their demise. At the same time, incumbents struggle to anticipate where disruption comes from (Fraser & Ansari, 2020; Govindarajan et al., 2011; Karimi & Walter, 2016; Klenner et al., 2013). The research has provided little guidance here; it has mostly paid little attention to the disruptor (Ansari et al., 2016) and the sources of disruption (Danneels, 2004), lacking an understanding of "the circumstances in which disruption is most and least likely to occur." (Christensen et al., 2018, p. 1067).

In contrast, some user innovation studies, while not focusing on disruptive innovation, have investigated the circumstances in which innovations are likely to come from different sources (Baldwin et al., 2006; Ogawa, 1998; von Hippel, 1988; von Hippel, 1998), specifically users versus producers, the two functional sources of innovation (OECD, 2018; von Hippel, 1988).[1] Without particular attention to the disruptive innovation school, this literature

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[1]*Producer innovators* are individuals or firms who create innovations primarily for the sake of profits from selling them, while *user innovators* are individuals or firms who create innovations for the sake of using them themselves (OECD, 2018; von Hippel, 1988).

mentions innovations that have been described as disruptive, such as the World Wide Web (Franke & Lüthje, 2020) or the personal computer (Meyer, 2007), and finds that they originated from user innovators (von Hippel, 2005a). In contrast, Christensen and others (Christensen & Bower, 1995) have taken a more negative view of user innovation (see Danneels, 2004), focusing on cases such as Netflix that spotlight corporate producer innovators.

We seek to shed light on the conditions in which disruptive innovations are likely to originate from users versus producers, considering the characteristics of both an innovation and its industry context. Thus, we ask: *In what conditions are disruptive innovations more or less likely to originate from users versus producers?*

Our theorizing develops the complementarity between the disruptive innovation and the user innovation schools by building from a competence-based perspective, which we see as a common denominator between these two schools. This perspective emphasizes the importance of actors' competences in understanding their actions in response to disruptive change. From this shared theoretical lens, we develop arguments about the likely sources of disruptive innovation in the user or producer sphere. We argue that users and producers, owing to their different competencies, vary in their interpretations of the environment and in the types of disruptive innovations they create.

We analyze the origins of disruptive innovation based on 60 vignettes of cases identified in a systematic review of the disruptive innovation literature. Thus, our sample does not include the population of all disruptive innovations, but only the ones who caught academic interest. For these cases, we built a unique dataset based on secondary data, which were presented as case vignettes and subsequently coded by five independent raters.

Of the sample disruptive innovations, we find that 43% originated from users and 43% from producers (including incumbents and new entrants); the remaining 13% stemmed from other sources. We show for instance that disruptive innovations are more likely to originate from users (producers) if the environment has high turbulence in customer preferences (technology). Disruptive innovations involving high functional novelty tend to be developed by users, while those involving radical technological changes are more likely to originate from producers.

Ours is a first-of-type study that illuminates the earliest phase of disruption, which has been neglected in the literature (Christensen et al., 2018; Kumaraswamy et al., 2018, p. 1029). We build theory on the conditions in which disruptive innovations are more likely to stem from users' necessity or from producers' profit motives. Thereby, we support theorizing on the ex ante

Practitioner points

- Early Identification of Disruption: Firms must prioritize the timely identification of potential disruptive innovations to stay ahead in evolving market dynamics.
- Understanding the Source of Innovation: Nearly half of disruptive innovations originate from users, especially in environments with fluctuating customer preferences and weaker appropriability rights.
- Guiding Principles for Search Strategies: Due to resource and attention constraints, firms should adopt guided search strategies, focusing on contextual factors influencing the source of disruptive innovation.
- Scouting User-Driven Innovations: In scenarios with rapidly changing customer demands and low appropriability, scouting for users' disruptive ideas can be particularly beneficial for producer firms.

identification of disruptive innovation. Further, we propose different sources of disruptive innovation as an explanation for differences in the disruptive innovation cases, as observed in the literature (Govindarajan & Kopalle, 2006; Markides, 2006).

We also contribute to the user innovation literature, specifically to our understanding of the contextual conditions that favor user versus producer innovation, an under-explored issue in the literature (Bogers et al., 2010). Moreover, our results reinforce evidence from cases and single-industry studies by showing that, across a broad range of industries, users were behind many well-known cases of disruption. This contributes to our understanding of the empirical significance of this source of innovation for game-changing innovations.

Our results are particularly useful for managers in incumbent firms who need to develop innovation scouting strategies, knowing that their resources and their capacity to understand early signals of potential disruptions are limited (Ocasio, 1997). Our findings indicate, for instance, that in environments that favor necessity-driven disruption, incumbents should adjust their search toward emphasizing loci of usage as well as noncommercial innovation diffusion pathways. Overall, a better understanding of the emergence of disruptive innovations can reduce errors of commission and omission (Kumaraswamy et al., 2018) when searching for and selecting potentially disruptive innovations for commercialization.

2 | LITERATURE

2.1 | Disruptive innovation

While disruptive innovation has become widely used for the general notion of high-novelty or breakthrough innovation, the original concept—which we adhere to here—is more specific. *Disruptive innovation* "describes a process by which a product or service initially takes root in simple applications at the bottom of a market—typically by being less expensive and more accessible—and then relentlessly moves upmarket, eventually displacing established competitors." (definition taken from www.christenseninstitute.org/disruptive-innovations/). Disruption occurs when "further development raises the disruptive technology's performance on the focal mainstream attributes to a level sufficient to satisfy mainstream customers." (Adner, 2002, p. 668).

Disruptive innovations threaten incumbents and can even cause their demise (Christensen, 2011; Christensen & Bower, 1995; King & Baatartogtokh, 2015). Incumbents tend to disregard such innovations, since they do not meet the requirements of existing customers. Incumbents' resource allocation processes (Christensen & Bower, 1996), organizational capabilities and routines (Bergek et al., 2013; Charitou & Markides, 2003; Henderson, 2006), value networks (Christensen & Rosenbloom, 1995), and power structures (Henderson, 2006) are geared to meeting the needs of current customers. For all these reasons, incumbents tend to allocate resources to sustaining innovations that target mainstream customers and to discount the potentials of disruptive innovations that develop in market niches (Govindarajan et al., 2011). To guard against disruptive innovation, this literature stream advises incumbents to look out for new entrants from unrelated industries because, for them, disruptive innovation does not cannibalize existing product offerings (Klenner et al., 2013).

The research has paid little attention to the origins of the disruptive innovation process (Christensen et al., 2018; Kumaraswamy et al., 2018). A key controversy has involved the role of the customer or user in disruption. Especially the earlier literature on disruption suggested that this is not worthwhile and could be dangerous for incumbents to look for disruptive ideas and innovations among current customers (Christensen, 2011; Christensen & Bower, 1996): "Our conclusion is that a primary reason why such firms lose their positions of industry leadership when faced with certain types of technological change has little to do with technology itself. [...] Rather, they fail because they listen too carefully to their customers—and customers place stringent limits on the strategies firms can and cannot pursue." (Christensen & Bower, 1996, p. 198).

Subsequent studies have softened this customer-skeptic view. Christensen (2006, p. 51) reformulated this position as follows: "A more accurate prescriptive statement is that managers always must listen to customers. They simply must be aware of the direction in which different customers will lead them. A customer will rarely lead its supplier to develop products that the customer cannot use. The right lead customers for sustaining innovations are different from those for disruptive innovations. And *the lead users for new-market innovations may not yet be users* [of the firm's current product offerings]." (italics added).

Supporting this perspective, Govindarajan et al. (2011) find that attending to current customers relates negatively to the creation of disruptive innovation, whereas focusing on emerging customers relates positively to it. Relatedly, Danneels (2004) differentiates between "lead customers" and "lead users." He stresses the importance of the original concept of "lead users" as per von Hippel's research, emphasizing that this methodology can be an effective strategy for identifying potentially disruptive technologies.

2.2 | User innovation

Innovators—individuals and firms—can be categorized according to their relationships to their innovations, that is, the benefit type that an innovator expects from innovating (OECD, 2018; von Hippel, 1988). Researchers and policymakers have long assumed that the sole incentive to innovate is the expectation of economic profit. In this view, the principal source of innovation is the *producer innovator*. Producer innovators are defined by the profit motive, which drives them to innovate (von Hippel, 1982). Examples of producer innovators are individuals or firms who patent an innovation in order to license it to others, firms that design a new process machine to sell to their customers, and firms that devise a new service offering for their clients (von Hippel, 2005b).

Users have been identified as another key source of innovation (Baldwin & von Hippel, 2011; von Hippel, 1976; von Hippel et al., 2011). *User innovators* are firms or individuals whose principal motivation to develop a new product or service is their own need for it. Examples of user innovators are firms who design process machines for their own use, a surgeon who develops a new medical device to facilitate surgical operations, and an individual consumer who writes a new software program to organize their own files (Dahlander & McKelvey, 2005; Lettl et al., 2006b; Urban & von Hippel, 1988). Representative national studies have shown that, in the United States, the United Kingdom, and other countries, some 5% of the consumer population are user innovators who develop or modify products for their own use (de Jong et al., 2015; von Hippel et al., 2011; von Hippel et al., 2012). Also, large-scale, cross-industry studies provide evidence of user innovation's ubiquity by firms concerning their internal processes, machinery, and equipment (Flowers et al., 2010).

Interestingly, producer innovation has been shown to dominate in particular product domains, such as tractor shovels, engineering thermoplastics, and plastics additives (von Hippel, 1988), while user innovation has prevailed in areas such as semi-conductors (von Hippel, 1977), medical devices (Shaw, 1985), and scientific instruments (von Hippel, 1976). Few studies have investigated the reasons for this heterogeneity (Bogers et al., 2010). The user innovation literature has provided extensive evidence that users are often the source of highly noel innovations (Lettl et al., 2006b; Lilien et al., 2002; Poetz & Schreier, 2012).

However, the user innovation literature has not explicitly studied disruptive innovation, even if some user innovations such as the www and personal photography are disruptive innovations. In a review, Bogers et al. (2010) stressed the need for a link between the user innovation literature and other research streams to lever their findings to extend our understanding of radical, architectural, and disruptive innovations.

3 | CONCEPTUAL MODEL

As explained in the previous section, users' roles in disruptive innovation have been viewed from contradictory perspectives. A number of scholars consider users to be an unlikely source of disruptive innovation (Christensen, 2011). After all, users typically address their existing local needs with limited local means (Lüthje et al., 2005) and often fail to diffuse their innovations (de Jong et al., 2015). Instead, this literature has proposed new entrants from unrelated industries as potential disruptors (Klenner et al., 2013), since they can draw on existing technological and inventive capabilities and complementary assets but do not cannibalize their existing product offerings. Other scholars—particularly von Hippel in his research on lead users (e.g., Hippel, 1986; Hippel, 1988)—have presented a more positive view, suggesting that breakthrough innovations often originate from users. Anecdotal examples of user-driven innovation—such as Tim Berners–Lee inventing the World Wide Web (Franke & Lüthje, 2020) and George Eastman inventing personal photography (Hoover, 2018)—support this view.

In light of these differing perspectives, our argument in this chapter is that there may be specific conditions in which users or producers are more likely to generate disruptive innovations. To formulate contingent hypotheses about the sources of disruptive innovation, we took a competence-based perspective, as actors' competences are crucial in explaining why and how they act in the face of disruptive change (Henderson, 2006).

Unique competencies are often put forth in both the user and disruptive innovation literatures to explain why users or producer firms entering from other markets, respectively, are a likely source of major innovations. Users are said to possess strong *customer competences* based on situated needs knowledge (Schreier & Prügl, 2008); they experience product-related problems at first hand and thus recognize new usage needs (Lüthje et al., 2005; von Hippel, 1994). In contrast, producers have strong inventive and *technological competence* based on solutions knowledge; they have experience in using technology to design and manufacture products that satisfy customer needs (Henderson, 2006). Both technological and customer competences are crucial for disruptive innovation (Danneels, 2002; Govindarajan et al., 2011; Roy & Sarkar, 2015). In short, we chose the competence-based view, since it is a shared theoretical base from which to build a unifying argument on the conditions that favor either innovator type.

Actors' competences are known to affect how (1) actors recognize disruptive shifts in an environment and (2) how they respond to them (Danneels, 2004; Henderson, 2006). We followed this view, arguing that, owing to their unequal competences, users and producers differ in how (1) they interpret an environment and (2) how they innovate. Incorporating these two aspects into our hypotheses, we consider (1) environment-related factors (Sections 3.1 and 3.2, Hypotheses 1–3) and (2) product-related and process-related factors (Sections 3.3 and 3.4, Hypotheses 4–6) that are more or less likely to be associated with user versus producer disruptive innovation.

Regarding (1) environment-related factors, we considered environmental turbulence and appropriability, since they both have both been associated conceptually (albeit not empirically) with the sources of innovation (Chesbrough et al., 2014; von Hippel, 1982). This choice is informed by the literature on competences in innovation, which points out that the extent of customer and technological competences, or lack thereof, shapes incumbents' actions in potentially disruptive environments (Henderson, 2006). These competences are especially crucial in dynamic and turbulent environments (Danneels, 2004). For (2) we consider that competences tend to shape the type of innovations that actors produce. Specifically, we focus on novelty and the product/process distinction—seminal aspects of any innovation (Adner & Levinthal, 2001; Garcia & Calantone, 2002)—and include them in our set of product-related and process-related factors.

Figure 1 summarizes our conceptual model.

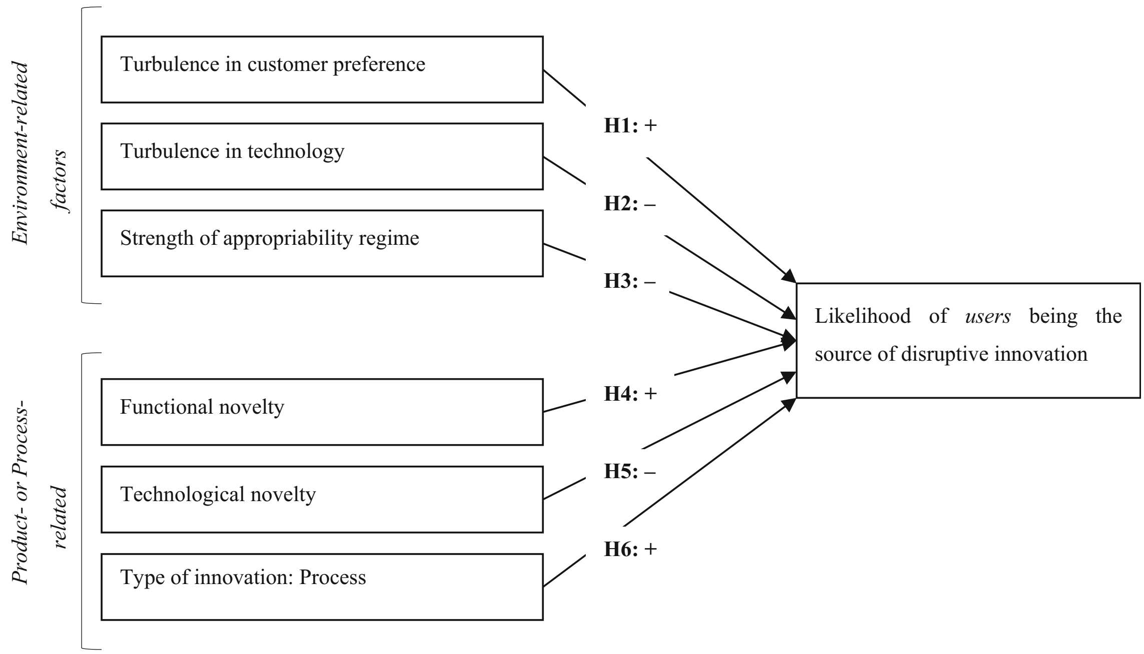

FIGURE 1 Conceptual model.

3.1 | Contextual characteristics: Turbulence

Environmental turbulence describes an environment's dynamism (Calantone et al., 2003; Volberda, 1996; Volberda et al., 2012). Its subdimensions distinguish the sources of change (Volberda et al., 2012), most importantly turbulence in customer preferences and technological turbulence (Dröge et al., 2008; Miller & Dröge, 1986).

Both the disruptive innovation and the user innovation research have acknowledged that environmental turbulence can affect the emergence of innovations, threatening incumbents' business models (Adner, 2002; Christensen, 1997; Tripsas, 2008), changing customer needs (Hippel, 1986; Ogawa, 1998), and eliciting user innovation activities (Baldwin et al., 2006; Baldwin & von Hippel, 2011). Thus, we included environmental turbulence as a factor that may be associated with the emergence of disruptive innovations by users or producers.

3.1.1 | Turbulence in customer preferences

Preference trajectories are generally characterized by periods of incremental evolution punctuated by discontinuous changes (Tripsas, 2008). Discontinuous changes or turbulences in customer preferences are characterized by different attributes valued by consumers, radical changes in performance requirements, or radical shifts in relative preferences across attributes (Tripsas, 2008). Discontinuous changes have been shown to foster technological transition by altering the relative attractiveness of technological alternatives. Thus, higher turbulence in customer preferences relates to a market's higher susceptibility to being disrupted (Klenner et al., 2013).[2] Actor-specific competences influence the likelihood of successfully dealing with such shifts (Bergek et al., 2013; Henderson, 2006).

We argue that users and producers differ in their competences under varying preference discontinuity levels. One might argue that producers have much to gain in times of discontinuous change, which may come with higher risks, but also with higher payoffs from innovation to first movers. To capitalize on this opportunity, producers can leverage their extensive innovation competences, from market research to product development.

Still, we expect users rather than producers to be the source of disruptive innovation in a context with high turbulence in preferences. They are more competent in recognizing discontinuous shifts in preferences early on because they have situated need knowledge from their own use experiences and social ties with other users

[2]By *market*, we mean a customer set "whose similar needs are being served by a set of competing technologies, firms, and brands." (Sood & Tellis, 2011, p. 340). Thus, even if an emerging customer segment should value secondary dimensions of competition differently to existing customers, both still form part of the same market. Disk drives are a case in point: even if emerging customers preferred different architectures to existing customers, they still shared the overarching need for storage capacity (Sood & Tellis, 2011).

(Franke & Shah, 2003; Hienerth & Lettl, 2011; Morrison et al., 2000), and are often able and motivated to self-provision innovative solutions before producers would be willing to enter:

First, users utilize products and processes in a natural context and rely on local competences when innovating (Lüthje et al., 2005). Empirical research has confirmed that users are often the first to identify unmet needs in a market (Lilien et al., 2002; von Hippel et al., 1999).

Second, users are embedded in user networks (von Hippel, 2007), exchanging ideas, sharing information about their needs, and discussing usage-related trends. This access to other users gives them an informational advantage in early sensing customer preference discontinuities. While in principle producers can also forge social ties to users, they are less likely than users to profit from it, since they lack the absorptive capacity to accurately interpret information embedded in user ties (Cohen & Levinthal, 1990; Schweisfurth & Raasch, 2018; von Hippel, 1994).

The literature has shown that users not only have new need knowledge; some also innovate to self-provision better solutions (Gambardella et al., 2017). Lead users in particular experience needs long before the general market and stand to benefit significantly from finding a solution to these needs, making them a likely source of innovation (Hippel, 1986).

In contexts with high turbulence in customer preferences, users are better able to discern these shifts, which enables them to innovate before producers do; in such contexts, users are also more likely to be motivated to innovate at any given point in time, since they may not expect a timely producer solution. At first, producers may not be aware of the shift, and subsequently they will likely wait for new customer requirements to be better understood, a sufficient market potential to be demonstrated, and uncertainty to be reduced (von Hippel et al., 2011). None of these aspects need to concern user innovators, who innovate for their own use.

These arguments lead us to hypothesize:

> **Hypothesis 1.** In environments with high turbulence in customer preferences, disruptive innovations tend to originate from users rather than producers.

3.1.2 | Turbulence in technology

Technological turbulence refers to discontinuity caused by technological innovations (Calantone et al., 2003). Industry evolution is characterized by periods of incremental technological change punctuated by discontinuous shifts that can change the industry structure significantly (Anderson & Tushman, 1990; Tushman & Anderson, 1986). We expect producers rather than users to be the source of disruptive innovation if the environment has high technological turbulence, primarily because producers have the competence to understand and interpret changes in technology more easily and accurately than users owing to their higher absorptive capacity in the technological domain.

Turbulence in technology introduces changes in technology for all potential innovators. The actors (both users and producers) need to process these changes, that is, they must recognize and make sense of technological variation (Tripsas, 2008). Owing to their specific competences, we expect producers to be better able to profit from technological turbulence. Compared to users, producers possess more extensive solution knowledge, complementary assets (Chatterji & Fabrizio, 2012), and second-order technological competence to understand additional solution knowledge (Danneels, 2002). This increases their absorptive capacity for new technologies (Cohen & Levinthal, 1990) and better positions them to learn about new technology-related opportunities that emerge in their industry environment.

At the same time, one could also make the counterargument that times of technological turbulence are particularly challenging for producers who need to make larger bets, that is investments in new machinery, skills, and structures, whereas users tend to rely on bricolage and quick-fix solutions (Lüthje et al., 2005). Thus, while producers may find it easier to grasp new technological affordances, users may find it easier to innovate in spite of them.

Nevertheless, technological change is harder to notice and accommodate for users. Compared to producers, their technological competences are likely less pronounced. Missing cognitive structures in the technological domain render them less likely to absorb, recognize, and correctly make sense of opportunities rooted in environmental technological change (Cohen & Levinthal, 1990). Conversely, their superior need knowledge does not provide cognitive structures and mental schemata that could help them absorb new solution knowledge: Schweisfurth and Raasch (2018) found an attenuating effect whereby prior need knowledge is negatively related to being able to absorb new solution knowledge.

For these reasons, we hypothesize:

> **Hypothesis 2.** In environments with high technological turbulence, disruptive innovations tend to originate from producers rather than users.

3.2 | Contextual characteristics: Appropriability regime

The term *appropriability regime* refers to an industry's characteristics that influence innovators' ability to capture returns from innovation. Its strength is determined by the efficacy of the intellectual property (IP) regime and the nature of the technology, specifically its complexity and imitability (Teece, 1986). In a weak appropriability regime, IP protection is limited or ineffective, technological advancements are quickly imitated or reverse-engineered, and competitive advantages gained through innovations are short-lived due to rapid industry changes or legal and ethical constraints. For example, the appropriability regime in innovation in medical procedures is generally weak, largely due to ethical, legal, and professional norms that encourage open sharing of medical knowledge and prohibit patenting of such procedures. In contrast, the consumer electronics industry has a stronger appropriability regime where intellectual property rights through patents and technological complexity offer some protection.

Strong appropriability provides the incentives that producer innovators require by reducing imitation competition and facilitating value capture in the form of economic profit from selling an innovation (Arrow, 1962). In such environments, producers (as opposed to users) can draw on existing competences for value appropriation (Reitzig & Puranam, 2009) and their experience in crafting strategies to capture value.

Conversely, since producer innovators innovate in order to sell their innovation for profit (von Hippel, 1988), weak appropriability regimes that facilitate value slippage to other economic actors are less likely to stimulate producer innovation. In such environments, users are still able to appropriate value from innovations, since they expect immediate rewards from their innovation through their own usage (Baldwin & von Hippel, 2011). In fact, most user innovators do not seek IP protection for their innovations at all (de Jong et al., 2015; von Hippel et al., 2012). Weak appropriability can even *support* user innovation by encouraging the free diffusion of innovation-related information (Baldwin & Clark, 2006; Harhoff et al., 2003), for instance in user innovation communities (Meyer, 2003). By freely revealing their innovative designs and ideas, users obtain “selective benefits” in the form of feedback and development assistance, reputational gains, and potentially preferential access to a commercial producer's offering based on their ideas (de Jong & von Hippel, 2009; Henkel, 2006; von Hippel & von Krogh, 2003). Thus, own use and other selective benefits provisioned from within the user community make up for weak appropriability in terms of profit. In net, we argue that user innovators' competences in producing low-investment solutions to local problems, either by themselves or jointly with other users experiencing similar problems, are well suited to weak appropriability regimes.

Furthermore, users who require a disruptive new product may be less inclined to wait for producer innovation to address their need, given that producers are less likely to launch an offering in conditions of weak appropriability. Based on these arguments, we propose:

> **Hypothesis 3.** In environments with weak appropriability, disruptive innovations tend to originate from users.

3.3 | Innovation characteristics: Novelty

Technological novelty and functional novelty are distinct dimensions of innovation (Andriani et al., 2017; Faulkner & Runde, 2009).

Technological novelty focuses on the physical and structural attributes of an object or artifact, and corresponds with its intrinsic design and capability. Technological novelty typically involves significant advancements in the object's physical form and technical characteristics. The invention of the MP3 introduced technological novelty, specifically a new method of audio compression that greatly reduced file sizes while maintaining quality. However, its functional novelty was minimal as it essentially served the same purpose as previous formats—storing and playing back music—but in a more efficient manner.

Functional novelty describes the extent to which the functions or applications provided by a product or process are new to the market, thereby addressing hitherto unmet user needs (Garcia & Calantone, 2002). A given technology can enable artifacts with high functional novelty when its latent applications—those not originally intended or recognized—are discovered and harnessed. This concept recognizes that a single technological artifact can possess multiple functions, and these functions can vary depending on the context or the user. Functional novelty does not lie in the artifact itself, but in how users perceive and utilize the artifact. The invention of medical ultrasound by Karl Dussik was an innovation with functional novelty as it applied existing ultrasonic technology in a novel way, specifically for the diagnosis of brain diseases. The technological novelty was not as pronounced, as it utilized existing ultrasound technology but revolutionized its function by transforming it into a diagnostic tool for intracranial structures.

Both types of novelty have the potential to disrupt industries, and may be associated with disruptive innovations by users or producers, as we will argue below.

3.3.1 | The extent of functional novelty

Even if *some* new functional features are integral to the definition of disruptive innovation (Govindarajan & Kopalle, 2006, see also Section 2.1), the *extent* of functional novelty provided by these features may vary significantly (Christensen & Raynor, 2010). Examples of disruptive innovations with high functional novelty are the photocopier and the transistor pocket radio, which created entirely new markets (Christensen & Raynor, 2010). An example of a disruptive innovation with low functional novelty is grid computing, which essentially offered the same functionality as the incumbent technology of massively parallel processing while relying on a simpler, decentralized computing technology for better scalability (Jakob et al., 2005). These examples highlight that "not all disruptive innovations are the same" (Markides, 2006, p. 24), that is, some may be much higher in functional novelty than others.

Prima facie, both users and producers should be motivated and able to develop innovations with high functional novelty, that is to discover and implement new functionalities enabled by a given technology. Still, it has been argued that users tend to be more competent in recognizing the shortcomings of existing market offerings as well as of new needs, based on their own use experience (Lüthje et al., 2005; von Hippel, 1994). Even in the absence of first-hand experience of a usage-related problem, their own user experience enhances their absorptive capacity (Cohen & Levinthal, 1990) in relation to information shared by other users. Building on these customer competences, users can come up with functional performance features that resolve existing use-related problems and are valued by other customers (Roy & Cohen, 2015).

For producers, disruptive innovations with higher functional novelty are harder to develop. In contrast to users, producers often lack competences in identifying and selecting the most promising ideas with high functional novelty, because they lack first-hand need knowledge (Chatterji & Fabrizio, 2013).

While the user innovation literature has paid little direct attention to disruptive innovation, it has indicated that, in specific industries, functionally novel innovations are more likely to originate from users than from producers (Hienerth, 2006; Lettl et al., 2006a; von Hippel, 2005b). For instance, in their study of the furniture industry, Nishikawa et al. (2013) found that users develop products with higher functional novelty. Therefore:

> **Hypothesis 4.** Disruptive innovations involving high functional novelty are more likely to be developed by users than by producers.

3.3.2 | The extent of technological novelty

Technological novelty captures the extent to which a product's components or architecture are substantially new (Afuah, 1998). Innovations with high technological novelty often render existing knowledge obsolete (Lettl et al., 2006b).

Disruptive innovations may but need not involve significant technological novelty. Some do, for instance, the video cassette recorder, which was based on helical scan technology, which at the time was revolutionary. In contrast, other well-known disruptive innovations such as e-mail were based entirely on preexisting technologies. This variance and its drivers have received very little attention in the literature (Yu & Hang, 2010).

Mirroring our reasoning in the previous section, we expect the extent of technological novelty to be associated with the likely source of disruptive innovation, favoring producer innovators. Compared to users, producers are more likely to have strong technological competences; they have deep knowledge of technologies and are specialized in developing novel technological solutions to usage-related problems in their market. Specialized expertise in a field is associated with more efficient problem-solving in this area owing to the repeated execution of similar problem-solving tasks (e.g., Gobet & Simon, 1998). Producers can build on existing knowledge to come up with new technological solutions. Even if the new technology incorporated into a disruptive innovation is not based on a firm's current technology base, producers are better able than users to lever their competence in generic technology development, that is, they have higher-order technological competences in how to develop new technologies that lead to higher technological novelty in disruptive innovations (Danneels, 2002).

In contrast, users typically lack technological competences and sophisticated technological know-how (Lüthje et al., 2005). Thus, user innovations often rely on bricolage, trial-and-error experimentation, and other quick-fix solutions, which the user innovator deems "good enough" for their purpose (Lüthje et al., 2005; Raasch et al., 2008). Empirically, users have been found to be more easily overstrained by technologically advanced and radically new innovations (O'Connor & Veryzer, 2001; Veryzer, 1998). However, Lettl et al. (2006b) found that some innovative heavy users of surgical equipment possess sophisticated technological knowledge and are able to spot and evaluate technological trends in advance. Nonetheless, in line with most of the literature, we argue:

> **Hypothesis 5.** Disruptive innovations involving high technological novelty are more likely to be developed by producers than by users.

3.4 | Innovation characteristics: Innovation type

Finally, it is interesting to consider the differences in the likely sources of product and process innovations. Product innovations involve implementing or commercializing a product with improved performance characteristics (OECD/Eurostat, 2005). Process innovations are new or significantly improved methods for production or delivery. They involve significant changes to techniques, procedures, equipment, or software employed to deliver a product or service (OECD/Eurostat, 2005). Processes are skillful and carried out to accomplish a nontrivial task (Hinsch et al., 2014). We argue that users and producers differ in their abilities to generate product and process innovations owing to their different knowledge sets and competences. While the impact of these differences in competences is not clear-cut, we propose that users are more likely to be the source of disruptive *process* innovations whereas producers are more likely to be the source of disruptive *product* innovations.

Producers, as opposed to users, have competences in bringing new *products* to life, such as design-related experience, existing CAD files, or sophisticated product development routines. Such competences are hard to build and difficult to transfer to other parties, such that product development and innovation likely happens at the producers' site (von Hippel, 1994). As a counter-argument, users could be said to be more likely to develop new products early on, as their innovation activities are often characterized by bricolage and quick-fix solutions, rather than the elaboration of a corporate product development process (Lüthje et al., 2005).

The development of *process* innovations is closely connected to the practical utilization of equipment. In this context, "equipment" refers to any tool, machinery, or device employed by users in a specific operational setting. It is essential to recognize that equipment alone does not guarantee utility; it becomes valuable only when integrated into users' routines and systems of use. As users engage with a piece of equipment, they continuously develop implicit knowledge on optimal usage, adaptation to varying conditions, and integration with other equipment (Hinsch et al., 2014). This system of use-related competence stems from actual experience and deep engagement, and is generally tacit in nature, making it difficult to transfer (Faulkner & Runde, 2009; von Hippel, 1994). Importantly, actual systems of use and techniques may differ from what the equipment producer intended. This can provide users with a unique advantage in the development of process innovations (Lüthje et al., 2005).

Again, it would be possible to make the counter-argument though: In some domains, there is very little room for users for finding new ways of using equipment. Instead, the producer is the one to analyze potential ways of using the equipment in great detail, to optimize the equipment for a specific usage, and to design this into the piece of equipment, educating the user about the intended use process.

Although there has been little empirical research into user versus producer innovations in products versus processes, the few existing studies support the former line of argumentation. The research has shown that users are the primary source of techniques and procedures in the fields of medical and sporting equipment, for instance (Hienerth, 2016; Hienerth et al., 2011; Hinsch et al., 2014). Users are also known to develop new techniques that trigger the development of new equipment (Faulkner & Runde, 2009; Hienerth et al., 2014; Lüthje et al., 2005; Raasch et al., 2008). Based on these considerations, we argue:

> **Hypothesis 6.** Users are more likely to be the source of disruptive process innovations than of disruptive product innovations. Conversely, manufacturers are more likely to be the source of disruptive product innovations.

4 | METHODOLOGY

To test these hypotheses, we used a content analysis approach based on extensive secondary data. Many disciplines—including marketing (Golder et al., 2009; Srinivasan et al., 2006), general management (Rhee & Fiss, 2014), strategic management (Kotabe & Swan, 1995), and innovation research (Bianchi et al., 2011; Perks & Roberts, 2013)—have fruitfully employed a similar approach. We employed archival accounts of events as information sources, analyzing these accounts by relying on content analysis to extract information from this qualitative material (Maggitti et al., 2013).

We proceeded in three steps, which we will now describe in some detail: the sampling of disruptive innovations through a systematic literature search (Section 4.1); extensive collection of secondary data on each innovation by two to three independent researchers and summarized in case vignettes of two to three pages each (Section 4.2); and data coding by five independent raters (Section 4.3). We describe our measures in Section 4.4.

4.1 | Sampling

In brief overview, our approach was to identify disruptive innovations from the academic literature in a rigorous and systematic way. We prioritized peer-reviewed management journals with a high impact factor to safeguard quality. Our inclusion criteria ensured that only relevant cases of disruptive innovation were considered. Further, our objective classification based on narrow keywords minimized the potential for errors.

Our unit of analysis was a disruptive innovation. To identify such innovations, we conducted a systematic literature search (Tranfield et al., 2003) of the management research literature, searching for articles published between 1990 and 2013 in peer-reviewed management journals with a five-year impact factor >2.5 (Journal Citation Report, Social Science Edition 2012, journals relating to the subject categories business and management). This included 40 journals.[3] For each, we used the same search string ("disruptive technology" OR "disruptive technologies" OR "disruptive innovation" OR "disruptive innovations") to identify a match in the title, abstract, or keywords of their papers. This yielded 49 articles. After carefully reading these articles, we extracted a list of 60 case examples of disruptive innovation. We also reviewed Christensen and co-authors' seminal work published in other outlets, particularly books (Christensen, 1993; Christensen, 2011; Christensen et al., 2000; Christensen et al., 2009; Christensen & Raynor, 2010). This yielded 74 cases.

Combining the two case sets and eliminating duplicates resulted in a long-list of 131 cases. We compiled these cases in a database, detailing the sources, the disruptive innovation, the reference technology being disrupted, and the authors' definitions of *disruptive innovation*.

To obtain our final case set, we applied three selection criteria: First, we focused on cases according to the original definition of disruptive innovation, which is confined to innovation in products and processes. This excluded 41 business model innovations, for instance the cases of Amazon and Dell.[4] Second, we included only precisely identified cases in the literature, which ensured that, for each instance, we were investigating a specific case from the literature rather than related material in the same area. This criterion excluded 14 cases that were described in more general terms, for instance, *modular construction*, *the Internet*, and *wafering*. Third, we checked whether all the cases satisfied the definition of disruptive innovation (cf. Section 2.1).

After applying these criteria, we obtained a shortlist of $n = 60$ cases, each of which we investigated in detail (see Online Appendix S1). The cases stemmed from several industries, including consumer electronics, ICT, healthcare, high-tech, materials, and transport. Of these 60 cases, after our coding (see Section 4.3), 26 (43.3%) turned out to originate from user innovators and 26 from producer innovators; the remaining eight cases originated from what Raasch and von Hippel (2013) call participators.

Notably, we could also have searched for case examples in the user innovation literature and could have investigated whether or not they were disruptive. We chose to not follow this route so as to avoid sample bias in the direction of user innovations.

We scrutinized our current sample to ascertain any biases leaning toward user innovation literature, by examining the thematic foundations of our selected publications. We intentionally disregarded books coauthored by Christensen as they are unlikely to have a bias toward the user innovation literature. From the rest of the material, we extracted the references cited by each publication (essentially its thematic roots) and classified them. Our classification approach was objective—we labeled a publication as a user innovation source if the title contained the word "user." Conversely, if a publication had the string "disrupt*" in its title, we labeled it as a disruptive innovation source.

We found that, on average, references from user innovation literature were cited 0.2 times per paper in our sample, while those from disruptive innovation literature were cited 7.8 times. In other words, the thematic foundation for disruptive innovation was roughly 40 times more influential than our reliance on user innovation literature. Only one paper featured more user innovation references than disruptive innovation references. Therefore, we are confident that our findings are not skewed

[3]Academy of Management Annals, Academy of Management Journal, Academy of Management Perspectives, Academy of Management Review, Administrative Science Quarterly, California Management Review, Decision Sciences, Entrepreneurship Theory and Practice, International Journal of Management Reviews, Journal of the Academy of Marketing Science, Journal of Business Venturing, Journal of Consumer Research, Journal of International Business Studies, Journal of International Management, Journal of International Marketing, Journal of Interactive Marketing, Journal of Management, Journal of Management Studies, Journal of Marketing, Journal of Marketing Research, Journal of Organizational Behavior, Journal of Product Innovation Management, Journal of Retailing, Journal of Service Research, Journal of World Business, Leadership Quarterly, Long Range Planning, Management Science, Marketing Science, Omega-International Journal of Management Science, Organizational Behavior and Human Decision Processes, Organization Science, Organization Studies, Organization, Research Policy, Strategic Entrepreneurship Journal, Strategic Organization, Strategic Management Journal, Technological Forecasting and Social Change, Technovation.

[4]In his later work, Christensen et al. extended the concept to include business model innovations (cf. Christensen & Raynor, 2010). To be conservative, we used the original definition, since this broader definition has been criticized for subsuming fairly different phenomena (e.g., Markides, 2006; Sood & Tellis, 2011; Yu & Hang, 2010).

by selection bias resulting from an overrepresentation of user innovations.

4.2 | Data sources and data collection

For every case in our sample, two to three researchers collected extensive secondary data on the disruptive innovation, the innovator, and the innovation's environment. Our more than 900 sources included scholarly writings, industry sources (associations, journals, databases), company sources (websites, annual reports), media coverage (press databases), and web-based sources (blogs, websites, forums).

Based on the information gleaned from these sources, the authors produced case vignettes. One would write up the vignette; the other would check whether the content matched their understanding of the case from our sources. A standard step in case study research, writing up cases in the form of vignettes served multiple purposes in our study. First, it was instrumental in organizing and managing the volume of data (Eisenhardt, 1989; Miles & Huberman, 1994). Our >900 sources necessitated a form of data reduction that preserved the essence of the information without overwhelming the coding process. The vignettes distilled this vast amount of data into more manageable narratives, focusing on the most relevant and salient details of each case. The systematic procedure of crafting vignettes from the rich data ensured a comprehensive and consistent approach to data processing, again enhancing our findings' reliability and validity (admittedly, at the expense of richness).

Second, the use of vignettes enhanced our coding's reliability. Without this data reduction step, coders might have based their assessments on different parts of the data, owing to the sheer volume of information. This could have resulted in selective attention to different parts and could have increased the likelihood of inconsistency across coders. Vignettes provided a common basis for coding, ensuring that all coders worked with the same condensed yet comprehensive representation of each case.

Third, the vignettes offered a mechanism for systematically comparing the cases. By presenting each case in a similar format, they facilitated the understanding of our concepts and construct. This comparability was essential for reliable coding and, in turn, drawing robust conclusions from our study.

To achieve these goals, the case vignettes included a standard format that covered the following aspects:

1. *A description of the innovation*: Functionality and underlying technology, compared to those of existing market offerings (this is required for measuring the product- or process-related independent variables, cf. Table 1: functional novelty, technological novelty, and innovation type);
2. *The innovation's history*: A description of the original innovator and the first commercializer (this is required for measuring our dependent variable, i.e., the functional innovator, cf. Table 1);
3. *The environment prior to the innovation*: The appropriability regime, technological changes, changes in demand and relevant customer groups (this is required for measuring the environment-related independent variables, cf. Table 1: strength of appropriability, technological turbulence, and turbulence in preferences).

To enhance reliability, the data were collected by two researchers in areas (1) and (3), and by three researchers in area (2). Information regarding (2) the innovation's history was crucial, because it identifies the original innovator and describes their motives to innovate. Across all cases and researchers, we applied a uniform definition to identify the original innovator: "the person, group, or organization who built the first functional prototype." This definition excluded earlier actors who may have had an idea about what may be needed or what could be done, but did not try to or manage to build a first prototype that delivered the needed functionalities. In case of disagreement among the three researchers about the original innovator's identity, we had group discussions and additional data collection until we reached a consensus.

4.3 | The coding process

Five independent raters,[5] all with sufficient prior innovation management knowledge, coded the data summarized in our case vignettes. Each vignette was coded by all five coders. All raters received additional training in the concept of disruptive innovation. To ensure reliability and unbiased assessment, the authors did not participate in the coding. All raters were provided with standardized coding materials and instructions (Krippendorff, 2004): the case booklet, which contained all the case vignettes, a coding manual with explanations of the measures and the coding instructions, and a coding sheet to document the ratings. They also received personal face-to-face training on the measures.

The coding of the dependent and independent variables was done in three steps based on the vignettes we

[5]The choice to employ five independent raters in our coding process was based on recommendations from the literature on content analysis and interrater reliability: "the more coders participate in the process […], the more likely can the reliability of data be ensured." (Krippendorff, 2004).

TABLE 1 Overview over the measures.

Variable name	Explanations given to the coders	Coding instructions	Scale and values	Interrater α	Source
Functional innovator	Innovators can be classified according to the functions they intend to fulfill by developing the innovation/the benefits they intend to derive from their innovative activities. Innovators can be motivated either by usage, selling, or others. Definition producers: Producer innovators are defined by the profit motive, which drives them to innovate. Definition users: User innovators are defined as firms or individuals for whom the principal motivation to develop a new product or service is their own need to use it.	Based on the innovator description, please assign one of the following categories (producer, user) to the innovator named in the case vignette. If neither user, nor producer is applicable, please assign 99 = other and describe the innovator's motivation to innovate in your own words.	Nominal: 1 = user, 0 = producer, 99 = other	n.a.	Shah (2000)
Turbulence in preferences	• Changes in relevant attributes: Users have a given product attributes set they care about. This variable deals with evaluating how incremental versus discontinuous relevant product attributes for customers changed in a given market. Incremental change with regard to this variable occurs when customers evaluate products based on a stable attributes set. Discontinuity occurs when new attributes are considered or old attributes are eliminated when evaluating a product. • Minimum performance required: For each attribute, there is a minimum performance level threshold. A product must meet that threshold level before a consumer will include it in the set of possible purchases. Incremental	Please evaluate the degree of discontinuity separately for all four types of changes: Changes in relevant attributes. Minimum performance required. Maximum performance valued. Relative preference.	Ordinal, 7-point Likert; 1 = not discontinuous at all to 7 = very discontinuous	0.731	Tripsas (2008)

(Continues)

TABLE 1 (Continued)

Variable name	Explanations given to the coders	Coding instructions	Scale and values	Interrater α	Source
	changes in minimum performance requirements occur when minimum performance requirements remain fairly constant. Discontinuous changes occur when there is a radical decrease or increase in the required minimum performance. • Maximum performance valued: Attributes are assumed to have decreasing marginal utility, such that there is a maximum performance threshold beyond which the marginal utility to the consumer approaches zero. So, beyond a certain level of functionality, consumers are unwilling to pay for performance improvements. • Relative preference: Users place different relative values on the product attributes included in the utility function. The relative importance of attributes may shift.				
Technological turbulence	This variable deals with how dynamically or fast technology changes in a given market. Try to think of major technological changes in terms of production and service deployment (Roy et al., 2018).	Please assess how easy versus difficult it is to forecast technology developments.	Ordinal, 7-point Likert; 1 = technology is well established, not subject to change to 7 = technology changes often and in major ways	0.536	Calantone et al. (2003)
Strength of appropriability	This variable deals with the appropriability regime in the given market before the invention. Appropriability refers to the possibilities that innovators have to capture value from their innovations. The term appropriability regime	Please assess how effective legal protection the mechanism is.	Ordinal, 7-point Likert; 1 = not effective at all to 7 = very effective	0.915	Derived from Teece (1986)

TABLE 1 (Continued)

Variable name	Explanations given to the coders	Coding instructions	Scale and values	Interrater α	Source
	describes environmental factors that determine whether and to what extent actors can profit from innovation. Its key dimensions are the nature of the technology and the efficacy of legal mechanisms of protection. We focus on the efficacy of legal protection mechanisms, which deals with the efficacy of legal IP protection mechanisms (such as patents).				
Functional novelty	Functional novelty captures whether a new product incorporates a substantially different functionality for the customer.	Please assess whether the innovation incorporates a substantially different functionality for the customer. The degree of novelty should be assessed in relation to all other cases in the sample.	Ordinal, 7-point Likert; 1 = not different at all to 7 = substantially different	0.641	Lettl et al. (2006)
Technological novelty	Technological novelty captures whether a new product incorporates a substantially different core technology.	Please assess whether the innovation incorporates a substantially different core technology. The degree of novelty should be assessed in relation to all other cases in the sample.	Ordinal, 7-point Likert; 1 = not different at all to 7 = substantially different	0.832	Chandy and Tellis (2000)
Innovation type	In this category, we differentiate between product and process innovations. Definition of product innovation: The introduction of a good or service that is new or significantly improved concerning its characteristics or intended uses, including significant improvements in technical specifications, components and materials, incorporated software, user-friendliness, or other functional characteristics. "Product" covers both goods and services.	Please decide whether the disruptive innovation in question is a product innovation or a process innovation.	Nominal: 0 = product, 1 = process	n.a.	OECD/Eurostat (2005)

(Continues)

TABLE 1 (Continued)

Variable name	Explanations given to the coders	Coding instructions	Scale and values	Interrater α	Source
	Definition of process innovation: The implementation of a new or significantly improved production or delivery method, including significant changes in techniques, equipment, and/or software. Process innovations include new or significantly improved methods for the creation and provision of services. They can involve significant changes in the equipment and software used in services-oriented firms or in the procedures or techniques that are employed to deliver services.				

created. First, all the raters coded the focal variables concerning (2) innovation history, which included our dependent variable, the innovator (user vs. producer). After 3 weeks, they rated the independent variables that described (1) the innovation's characteristics and, at a later date, the variables describing (3) the innovation's environment. This procedure was designed to minimize carryover effects from the coding of one variable to another, and therefore to reduce common method bias.

4.4 | The measurement

We will now describe our measures, starting with the dependent variable. Table 1 provides a complete overview, with explanations, instructions, scale, values, interrater reliabilities (where applicable), and the source of the scale. The original coding instructions included an example for each category or scale anchor to be coded, which we did not include for reasons of brevity. Unless stated otherwise, all the variables were rated by five coders. We used Cronbach's alpha to assess interrater reliability.

4.4.1 | Dependent variable: Functional source of innovation

The user innovation literature (Hippel, 1988; Ogawa, 1998) as well as recent guidelines on collecting, reporting, and using innovation data (OECD, 2018) stipulate that innovating entities can have two primary objectives to innovate: either they innovate primarily for the sake of profits from *selling* the innovation, or they seek benefits from *using* the innovation themselves. This is consistent with the view in the disruptive innovation literature, which identifies producers and users as dominant actors in value networks (Christensen & Rosenbloom, 1995). Following this distinction, we coded the original source of a disruptive innovation as either a producer innovator (if the main goal was economic profit), a user innovator (if the main goal was own use), or other (if the goal was to obtain benefits from the innovation process). We applied this rule to both collectives and individuals, since innovators can be firms or individuals. Throughout, we focused on the primary purpose pursued by the innovator. While the motivation to innovate can be hybrid (Raasch & von Hippel, 2013), its exact composition is hard to establish, particularly in retrospect and based on secondary data.

An example of a producer innovator's disruptive innovation is the invention of the Bluetooth standard by Ericsson. In the early 1990s, Ericsson Mobil's chief technology officer set up a team of engineers to come up with a radio technology standard. The goal was to enter new markets with headsets that could be used without wires and that could be paired with mobile phones. The Dutch engineer Jaap Haartsen was tasked with this problem; he solved it using a technology that later became part of the Bluetooth standard.

An example of a user innovator's disruptive innovation stems from George Eastman, the founder of Kodak. In

1877, Eastman wanted to invest in property and bought photography equipment to take photographs of land in his early twenties. He became fascinated with photography but was annoyed at having to carry the heavy, bulky camera equipment and the complicated photograph development process. Realizing that he required a better solution ("At first I wanted to make photography simpler merely for my own convenience" (Hoover, 2018)), he began to tinker in his mother's kitchen and, after some years of experimentation, developed a compact camera that would use film rolls, thereby revolutionizing photography.

After the coding of innovator types, we checked inter-rater reliability: At least four of the five raters agreed about the innovator type in round 1, for 74.2% of the cases. The remaining cases were discussed and additional information was sought where necessary so as to achieve agreement in round 2.

4.4.2 | Independent variables: The innovation environment's characteristics

Customer preference turbulence: This variable describes demand-side turbulence prior to the disruptive innovation, that is, shifts in customer preference trajectories. Tripsas (2008) distinguished four preference discontinuity types: radical changes in the attributes set considered by customers as they assess a product (through the addition or elimination of attributes), radical changes in the relative importance attached to different product attributes, and radical changes in the minimum performance level, or the maximum performance level required by customers. Our coders assessed all four preference discontinuity types separately.

Technological turbulence: This variable captures the technological turbulence present in the industry prior to the disruptive innovation, that is, the frequency and extent of technological changes (Calantone et al., 2003).

Appropriability: An *appropriability regime* refers to an environment's characteristics that influence innovators' ability to capture returns from innovation, with the efficacy of the intellectual property (IP) regime being one of its core determinants (Teece, 1986). Based on the description provided in the case vignettes, three raters assessed the efficacy of formal IP protection in the industry in the analyzed time period.

4.4.3 | Independent variables: The innovation's characteristics

Functional novelty: Functional novelty is the extent of new or unmet user needs targeted by the innovation (Lettl et al., 2006b). The coders assessed the extent to which the innovation *incorporates a substantially different functionality for customers* (*from 1 = not at all different to 7 = substantially different*).

Technological novelty: Technological novelty is the extent of new technology incorporated in the innovation (Chandy & Tellis, 2000). Based on information about the principal technological components of the innovation as well as those of established products, the coders assessed whether the innovation included a substantially different core technology compared to previous products (from 1 = not at all different to 7 = substantially different).

Innovation type: We distinguished product and process innovations according to the Oslo Manual (OECD/Eurostat, 2005) definition. Thus, products include goods and services as well as systems comprising both component types. Processes include methods for production or delivery, and techniques and procedures involving the use of products.

We controlled for whether the disruptive innovation was B2B or B2C, creating a continuous variable that ranged from fully B2C = 0 over both B2C and B2B = 1 to fully B2B = 2.[6,7]

5 | RESULTS

5.1 | Descriptive overview

Of the 60 cases of disruptive innovation, 26 (43.3%) originated from user innovators and 26 from producer innovators (the remaining eight cases were what Raasch & von Hippel, 2013 call *participators*). Descriptive statistics and correlations for the focal independent variables are summarized in Table 2.

5.2 | Findings

The results of our six estimated models are displayed in Table 3. We tested our hypotheses by using multinomial and binomial probit regressions. For multinomial probit (models 1 to 3), our dependent variable took three potential values (user vs. producer vs. other). The reference category is producer innovator, and the results for *other* are

[6]We thank an anonymous reviewer for suggesting this test; it is an interesting point to make.

[7]Unfortunately, we were unable to add more firm-specific controls. As most of the actors were not public firms (and in some cases, not firms at all but individuals innovators) when they came up with the disruptive innovation, we do not have information about firm size, R&D expenditure, or firm profits.

TABLE 2 Independent variables: Correlations and descriptive statistics.

		n	Min.	Max.	Mean	SD	1	2	3	4	5
1	Customer preference discontinuity	60	2.65	4.70	3.62	0.45	1				
2	Technological discontinuity	60	3.20	6.00	4.57	0.85	0.192	1			
3	Strength of the appropriability regime	60	1.00	6.00	3.41	1.73	−0.078	0.317*	1		
4	Functional novelty	60	2.00	7.00	4.07	1.00	0.515**	0.280*	0.008	1	
5	Technological novelty	60	2.20	6.80	4.44	1.17	0.165	0.317*	0.305*	0.380**	1
				n			Product				Process
6	Innovation type			60			40				20

Note: t = significant at the 0.1 level.
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; $^{+}p < 0.1$.

TABLE 3 Findings from multinomial and probit regression.

	Multinomial probit[a]			Probit		
Model	**1**	**2**	**3**	**4**	**5**	**6**
B2B	0.137	0.132	−0.622	0.069	0.111	−0.543
	(0.483)	(0.443)	(0.454)	(0.355)	(0.286)	(0.357)
1 Preference discontinuity	3.536***		4.495***	2.973***		3.080***
	(0.322)		(0.653)	(0.577)		(0.626)
2 Technology discontinuity	−1.004+		−1.431	−0.859+		−0.956
	(0.570)		(0.885)	(0.510)		(0.595)
3 Strength of appropriability	−0.577**		−0.943**	−0.513***		−0.469*
	(0.216)		(0.336)	(0.111)		(0.196)
4 Functional novelty		1.762***	2.713***		1.303***	2.031***
		(0.339)	(0.675)		(0.345)	(0.464)
5 Technological novelty		−1.119***	−2.133***		−0.785**	−1.571***
		(0.338)	(0.387)		(0.244)	(0.323)
6 Innovation type = product		−2.104**	−1.347		−1.489**	−0.910
		(0.724)	(0.827)		(0.521)	(0.639)
Intercept	−6.565*	−1.105	−8.094***	−5.356**	−1.054	−6.235**
	(2.969)	(1.866)	(2.077)	(1.974)	(1.655)	(2.119)
Observations	60	60	60	52	52	52
Log-likelihood	−39.20	−35.16	−18.67	−18.11	−19.92	−11.08
Errors in parentheses	Industry-clustered			Industry-clustered		

[a]Reference category = producers; the results for other (participators) are not shown.
***$p < 0.001$; **$p < 0.01$; *$p < 0.05$; $^{+}p < 0.1$.

not shown. For binomial probit (models 4 to 6), we excluded the eight cases that could not be classified as either user or producer innovations, which resulted in a reduced sample of 52 cases.

Models 1 and 4 included only the independent variables relating to the innovation environment; models 2 and 5 incorporated only the product-related or process-related variables; and models 3 and 6 integrated both variable types. For the significance test of our models, we used $p < 0.1$ as a reasonable threshold owing to our small sample size and a large number of variables. We used industry-clustered errors to account for industry differences such as medical industry, electronics, communication, and so forth. Across all models, disruptive innovations from the B2B sector were neither more nor less likely to stem from users versus producers.

We found support for Hypothesis 1—that in environments with high turbulence in customer preferences, disruptive innovations tend to originate from users rather than from producers. That is, preference discontinuities were positively and significantly associated with user innovations in all models (mean results across models 1, 3, 4, and 6: regression coefficient = 3.52, p-value = 0.01).

We also found partial support for Hypothesis 2, which predicted that in environments with high technological turbulence, disruptive innovations are less likely to originate from user innovators than from producer innovators. Two out of four models supported this prediction (mean results across models 1, 3, 4, and 6: regression coefficient = −4.25, p-value = 0.09).

The data supported Hypothesis 3, which predicted that, in environments with weak appropriability, disruptive innovations tend to originate from users. Indeed, environments with strong appropriability were negatively and significantly associated with user innovations in all models (mean results across models 1, 3, 4, and 6: regression coefficient = −0.63, p-value = 0.01).

To summarize our findings concerning the *environmental variables*, we saw that users were more likely to be the source of disruptive innovation in environments with high turbulence in customer preferences, with low technological turbulence (partial support) and weak appropriability regimes. Thus, differences in industry context were clearly associated with innovator type, that is, disruptive innovation from user innovators versus producer innovators.

To investigate the relationship between the nature of the innovation and the innovator type, we first tested Hypothesis 4, whereby disruptive innovations involving high functional novelty were more likely to be developed by users than producers. We found support for this hypothesis across all models (mean results across models 2, 3, 5, and 6: regression coefficient = 1.95, p-value = 0.00).

We also found full support across all models for Hypothesis 5, which stipulated that disruptive innovations involving high technological novelty are more likely to be developed by producers than by users (mean results across models 2, 3, 5, and 6: regression coefficient = −1.04, p-value = 0.02).

Finally, two out of four models confirmed that product innovation is negatively and significantly associated with being a user. This partly confirmed Hypothesis 6—that users are particularly likely to be the source of disruptive process as opposed to product innovations (mean results across models 2, 3, 5, and 6: regression coefficient = −1.46, p-value = 0.07).

To summarize our findings regarding the *nature of the innovation*, we found that users are more likely to be the source of disruptive innovations with high functional novelty, low technological novelty, and process innovations rather than product innovations (partial support only). Thus, innovation characteristics are clearly associated with the most likely source of innovation.

To check our results' robustness, we incorporated regression weights for low-level and high-level publications to account for possible differences in legitimacy and trustworthiness.[8] Empirically, since precision is the inverse of the variance, we increased the uncertainty of lower-level publications by assigning them less weight (and thus trustworthiness) in the regressions. Specifically, we assigned high-quality publications twice the weight. We deemed all publications from journals ranked 4 or higher on the ABS list to be of high quality and put all remaining sources in the lower group. A rerun of our main regressions with the according weights left our results materially unchanged.

6 | DISCUSSION

In this article, we have investigated the sources of disruptive innovation by harnessing the complementarities in the literatures on disruptive innovation and user innovation, two influential research streams in the innovation research. In line with the user innovation literature, we distinguished between two sources of innovation—user innovators and producer innovators. We derived and tested six hypotheses, relating the characteristics of the innovation environment and the innovation to the likely source of disruptive innovation. Our empirical investigation relied on a sample of 60 disruptive innovations that we identified from a systematic literature search and content analysis and coding by three to five independent coders.

We found that 26 of the sample's disruptive innovations originated from user innovators, and the same number from producer innovators. As hypothesized, we found that users were more likely to be the source of disruptive innovations in environments with high turbulence in customer preferences and weak appropriability regimes. In technologically turbulent environments, disruptive innovations were more likely to originate from producer innovators. Concerning innovation characteristics, disruptive innovations featuring high functional novelty were more likely to be developed by users, while innovations incorporating high technological novelty tended to come from producers. Finally, we found that users are more likely to be the source of disruptive process innovations, while producers are more likely to develop disruptive products and services.

[8]We thank an anonymous reviewer for suggesting this test.

6.1 | Contributions to the literature

To our best knowledge, this study is among the first to build deep connections between the literatures on disruptive innovation and user innovation. By advancing and testing hypotheses about the sources of disruptive innovation, we have sought to reconcile and extend these two influential research streams.

Unlike most of the disruptive innovation literature, which is typically case-based and qualitative (see Danneels, 2004; Danneels, 2006; Sood & Tellis, 2011; Yu & Hang, 2010), we employed a content analysis approach that levered and aggregated extant case work. We sampled cases identified in the disruptive innovation literature to investigate the emergence of disruptive innovations, as well as key explanatory factors. This methodological approach allowed us to contribute to several aspects of the literature on disruptive innovation:

First, our study contributes to the understanding of the early development phases of disruptive innovations, which to date were largely neglected in the literature (Christensen et al., 2018; Kumaraswamy et al., 2018, p. 1029). This is an important gap, given that the ongoing debate on the ex ante identification of disruptive innovations and the disruptive susceptibility of value networks (Keller & Hüsig, 2009; Klenner et al., 2013) hinges on a thorough understanding of the origins of disruptive innovation. By linking contextual conditions such as environmental dynamism and appropriability to the likely source of innovation, we have extended this branch of theorizing.

Second, we contribute to the body of work that seeks to show that "not all disruptive innovations are the same" (Markides, 2006, p. 24) and to understand the drivers and consequences of these differences. For instance, using a new measure of disruptiveness, Govindarajan and Kopalle (2006) uncovered that disruptiveness and radicalness go hand in hand in some cases, but not in others. Our findings can explain some of this variance by connecting it to the innovation's source, adding granularity by distinguishing between functional and technological radicalness. These insights also integrate the literature on radical innovation and disruptive innovation by showing how the type of radicality—functional or technological—is likely associated with different sources of disruptive innovation.

Our study also contributes to the user innovation literature. Intuitively, one might expect users to be a frequent source of disruptive innovation owing to their in-depth need information (Riggs & von Hippel, 1994; von Hippel, 1994) and lack of concern over their innovation's cannibalizing effects on incumbents' product sales. However, to our knowledge, this intuition has never been tested for disruptive innovations.

There are some case studies of path-breaking innovations by users that could be termed disruptive (even if the authors did not make that connection), for example, the airplane, the personal computer and open source software (e.g., Meyer, 2007). A few other studies from a small number of domains such as sports equipment (Baldwin et al., 2006) and juvenile products (Shah & Tripsas, 2007) show, without considering disruptiveness, that users played a major role in creating new market niches which subsequently grew in importance. Our study is among the very first to investigate path-breaking, disruptive user innovations in a quantitative way. We found that, across a broad range of industries, users were behind many well-known cases of disruption. This extends our understanding of the empirical significance of this source of innovation for game-changing innovations.

Our study is also one of the very few (one of the few exceptions is Flowers et al., 2010) quantitative studies of user innovation to span multiple industries and to have used information on the industry context. Thus, it could uncover contingency factors that favor either source of innovation, that is, users or producers. Thereby, we have contributed to theory-building on the contextual conditions that favor user innovation, an under-explored issue in the literature (Bogers et al., 2010).

Finally, our article builds connections between the literatures on user innovation and disruptive innovation, which have mostly developed separately. By highlighting overlaps in the investigated phenomena and developing shared theoretical foundations, this article can support cross-fertilization between those research streams. For instance, the disruptive innovation literature has a lot to offer on the processes by which path-breaking innovations gain hold in a market, which could help user innovation researchers understand, for example, diffusion patterns and barriers. A similar argument can be made vice versa.

6.2 | Managerial implications

Our findings inform managerial practice in incumbents concerned with the discovery of and defense against disruptive threats. In practice, the timely identification of future disruptive innovations is a key challenge (Christensen, 2011). Disruptive changes positively affect industry growth, but materially change industry structures (Gilbert, 2003). Firms seeking to profit from disruptive innovations must be able to identify such potential disruptions early on.

Of course, it remains impossible to predict with certainty an innovation's disruptiveness; any identification process will therefore be imperfect. Nonetheless, it is crucial to have guiding principles for effective search strategies, particularly since companies face constraints in terms of resources and attention (West & Bogers, 2013). By examining key contextual factors that influence the source of disruptive innovation, our research provides guidance on where to look for such innovations. For example, in environments with changing customer preferences and weak appropriability, producer firms are particularly likely to profit from scouting for users' disruptive ideas. In such environments, producer firms can collaborate with external lead users or can draw on individual users (Schweisfurth & Raasch, 2015) or user units (Block et al., 2016; Roy & Cohen, 2015; Roy & Sarkar, 2015) within the firm's boundaries. Similarly, if incumbents in a given industry anticipate that upcoming disruptive threats are more likely to offer a very different functionality rather than a path-breaking technology, they should look to the user domain.

6.3 | Limitations and future research

Our analysis has some limitations, a key one being sample size, which limited us in adding more control variables. We have relied on a sample of 60 successful innovations preidentified in the literature as disruptive. This allowed us to rely on accepted classifications of cases as disruptive innovation, and to study "typical" cases of actual disruption, in line with the extant literature. At the same time, this indicates that our findings should not be generalized to attempted disruptive innovation, for instance, which we did not observe.

Relatedly, we cannot be sure that our case sample, drawn from a systematic search of the management literature, is representative of disruptive innovations generally—our sample is only a subgroup of the whole population of disruptive innovations. We do not know the criteria along which the authors of previous disruptive innovation studies selected their cases (but doubt they had anything to do with user involvement). Follow-on research could profitably employ different sampling frames, for example, identifying disruptive innovations in a predefined set of industries and then tracing back their origins; pairing this sample with a control group of sustaining innovations to compare the sources of disruptive versus sustaining innovations; or collecting data on a great many innovation attempts by users and producers in an industry and studying which go on to be disruptive and why.

Further, we acknowledge that the interrater reliability levels for two of our measures, technological turbulence and functional novelty, are relatively low. This may raise concerns regarding the confidence in the results associated with these measures. The low reliability could be attributed to the subjective nature of assessing these constructs, which may have led to inconsistencies across raters. To mitigate the potential impact of these limitations, future research could employ more objective or standardized measures for technological turbulence and functional novelty, or utilize larger samples to reduce the likelihood of measurement errors.

Our methodological approach, while well-suited for exploring general relationships, falls short in capturing the intricacies of the specific processes driving disruption by users. We acknowledge that a more direct assessment of the mechanisms in question could enhance the robustness of our conclusions and provide a deeper understanding of the processes governing user-driven innovation. Future studies could profitably build on our findings and employ research methods that can more effectively capture these complex and dynamic processes.

Our study of the sources of disruptive innovation offers a first step toward more research to explain different development and commercialization pathways as well as performance trajectories of disruptive innovations. Based on the literature on user innovation, we would expect disruptive innovations from users versus producers to follow different development trajectories, for instance concerning diffusion patterns, IP protection, and locus of commercialization (de Jong et al., 2015; de Jong & von Hippel, 2009). To date, it is not well understood why performance trajectories evolve in different speeds and shapes. One reason may be that the locus of invention affects the pace and pathway of disruption. (For instance, one may speculate that technology trajectories based on producer invention are steeper than those based on user ideas, since, according to our findings, they are more likely to involve technological novelty.)

Similarly, our work speaks to emerging research that focuses on the disruptors and the strategies they use in commercializing disruptive innovations (Ansari et al., 2016). For future research, it may be promising to investigate whether user and producer disruptors follow different strategies. For instance, one could expect that producer disruptors seek to establish coalitions with incumbents (Ansari et al., 2016), while user disruptors focus on building coalitions with user communities (Hienerth & Lettl, 2011).

Lastly, we have only examined the main effects of environmental-related and product/process-conditions for user-driven disruptive innovation. Future research could investigate how these factors interact in spawning and shaping disruptive innovation.

6.4 | Conclusion

For this study, we took the most seminal cases of disruptive innovation from the literature and traced them back to the actor who built the first functional prototype. It was surprising to find that the number of disruptive innovations originating from user innovators—innovators motived by personal necessity—equaled the number of such innovations by producer innovators motivated by profit. In our view, this finding enriches our understanding of disruptive innovation and highlights the complementarity between the disruptive and user innovation literatures. In addition, our findings on the conditions for disruptive user versus producer innovation to thrive, invite us to build a more contingent understanding of the sources and pathways of disruption.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

ETHICS STATEMENT

The authors have read and agreed to the Committee on Publication Ethics (COPE) international standards for authors.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Preißner, Stephanie, Christina Raasch, and Tim Schweisfurth. 2024. "When Necessity is the Mother of Disruption: Users versus Producers as Sources of Disruptive Innovation." *Journal of Product Innovation Management* 41(1): 62–85. https://doi.org/10.1111/jpim.12709