

## Disruptive Technology Reconsidered: A Critique and Research Agenda

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*The popular work by Clayton Christensen and colleagues on disruptive technology serves as a springboard to examine five key issues concerning the effect of technological change on firms and industries. This article challenges and integrates current theory in this domain, and raises questions to initiate new work. The discussion is organized around the following themes: the definition of disruptive technology, the predictive use of the theory of technological disruption, explaining the success of incumbents, the implications of the theory for the merits of being customer-oriented, and the merits of creating a spin-off to commercialize the disruptive technology. Examination of these themes shows the relationship of the disruptive technology work with research in a variety of related areas. Many of these links have not been made explicit before, and several of them have been misunderstood. This article is intended to encourage further research on disruptive technology and spur debate by practitioners and scholars alike.*

It is rare that a scholarly work draws so much attention as Harvard Business School professor Clayton Christensen's work on disruptive technology. His book *The Innovator's Dilemma* (1997) has sold over 200,000 copies since its release in May 1997 and has received extensive coverage in business publications. Christensen was elevated by the business press to the status of "guru" (Scherreik, 2000). His work also has been cited extensively by scholars working in diverse disciplines and topic areas, including new product development (NPD), marketing, strategy, management, technology management, and so forth.

However, despite how widespread Christensen's work on disruptive technology has become in business circles, there seems to be a lack of constructive criticism of the core concept of his theory, namely

"disruptive technology," as well as its mechanisms and effects on firms and industries. Although Christensen's work has contributed to our understanding of the impact of technological innovations on the fates of firms and the dynamics of industries, a close reading of his book and the articles he has co-authored with his colleagues has left many questions unanswered. To promote further systematic inquiry into this field this article carefully reexamines the notion of disruptive technological change, its mechanisms, and its consequences for firms and industries. The contribution of this article is twofold. First, it will link the work on disruptive technology to a wide range of related literature streams, thus revealing new connections to be explored. Second, this article develops a research agenda that may inspire further theoretical and empirical work on the nature and effects of disruptive technological change in particular and technological change in general. Hopefully, inspired by the linkages to related literatures, a programmatic stream of research in this domain may be developed. The discussion is organized around the following themes: (1) the definition of *disruptive technology*;

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(2) the predictive use of the theory; (3) explaining the success of incumbents; (4) the implications of the theory for the merits of being customer-oriented; and (5) the merits of creating a spin-off to commercialize the disruptive technology. Table 1 presents an overview of the research questions that could inspire programmatic research in each of these themes.

## What Is a Disruptive Technology?

Before starting the reexamination of the notion of disruptive technology, it is useful to summarize briefly Christensen's notion of disruptive technology. Even though disruptive technologies initially underperform established ones in serving the mainstream market, they eventually displace the established technologies. In the process, entrant firms that supported the disruptive technology displace incumbent firms that supported the prior technology. The process is understood best by the joint consideration of the trajectories of performance offered by technological alternatives and the trajectories of performance demanded in various market segments. Initially, disruptive technologies do not satisfy the minimum requirement along the performance metric most valued by customers in the mainstream segment and thus are considered inappropriate by incumbents in the mainstream market for satisfying the needs of their customers. The products based on the disruptive technology initially only satisfy a niche market segment, which values dimensions of performance on which the disruptive technology does excel. Over time, as research and development (R&D) investments are made and the technology matures, the performance supplied by the disruptive technology improves to the point where it also can satisfy the requirements of the mainstream market. Incumbent firms, who focused R&D attention on improvements to existing technologies (i.e., sustaining technologies), have a hard time

catching up with the lead of the entrants that emerged based on the disruptive technologies. Therefore, disruptive technologies tend to be associated with the replacement of incumbents by entrants.

From the previous summary, it seems that a disruptive technology is a specific type of technological change, which operates through a specific mechanism, and has specific consequences. However, these insights need to be refined further. Therefore, my first and most essential question concerns what a disruptive technology actually is. If disruptive technologies pose a threat to industry incumbents and an opportunity to entrants, managers and scholars need to be able to distinguish disruptive from sustaining technology. What makes a technology disruptive? What are the exact criteria for identifying a disruptive technology? Christensen does not establish clear-cut criteria to determine whether or not a given technology is considered a "disruptive technology." In his review of 16 empirical studies of the impact of technological shifts on incumbent firms, Chesbrough (2001) noted the studies used inconsistent terminology; in other words, they lacked common criteria to classify different types of technologies.

A question that remains is whether a technology is inherently disruptive or if "disruptiveness" is a function of the perspective of the companies subject to it. Christensen has argued (e.g., Christensen et al., 2000; Christensen and Raynor, 2003) that the Internet is disruptive to some but sustaining to other firms, depending on whether it is consistent with their business model. For instance, the Internet is sustaining to catalog retailers and discount brokers, but it is disruptive to department stores and full-service brokers.

Another important question is at what point in time a technology becomes disruptive. Does it become disruptive once it invades an existing market and displaces another technology? For instance, at what point does digital imaging become a disruptive technology? Also, is "disruptiveness" a function of the market in which products are sold? Several markets could be subject to disruption by digital imaging, such as photo-processing labs, film manufacturers, and camera manufacturers. Does the technology become disruptive when photographers substitute film-based cameras for digital ones or when chemical photo processing labs go out of business because their services no longer are needed? In other words, is a technology disruptive only once it displaces incumbents that built their business on the prior technology?

### BIOGRAPHICAL SKETCH

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**Table 1. Themes and Questions for Disruptive Technology Research****Definition of Disruptive Technology**

- Are there different types of technological change? What would be the dimensions of a typology?
- Is disruptive technology a distinct type of technological change, and if so, how is it different?
- Is a technology inherently disruptive, or does disruptiveness depend on the perspective of the firms confronted with the technological change?
- At what point can disruption be said to have occurred?
- Do different types of technological change have different sorts of impact on firms and industries?
- What are the mechanisms by which technological change impacts firms and industries?
- Does the impact of technological disruption depend on the structure (i.e., size, heterogeneity, evolution) of the market segments?

**Predictive Use of the Theory of Technological Disruption**

- Can a theory of the impact of technological change be used to make ex ante predictions about the fates of particular firms and industries?
- Do these predictions generalize across different industries?
- Can these predictions form the basis for managerial prescriptions?
- How can a potentially disruptive technology be spotted in its early stage?
- Can predictions be made regarding the origin and likely success of entrants?

**Explaining the Success of Incumbents**

- What are characteristics of incumbents that survive and prosper in the face of disruptive technological change in comparison with those that falter?
- What innovation processes (e.g., resource allocation, culture, decision-making) characterize successful versus faltering incumbents?
- How does the legacy (e.g., in assets, operating procedures, relational embeddedness) of incumbent firms affect their ability to harness technological change?
- Where do entrants come from? What is the basis of their success?
- How do modes of resource acquisition (such as alliances, joint ventures, acquisitions, and licensing) affect the fates of entrants and incumbents?
- What is the impact of a marketing capability on the fate of incumbents when faced with a disruptive technology?
- What is the role of the competence of individual middle- or top-level managers of incumbent firms?
- What aspects of national context affect the success of incumbents relative to entrants?

**The Merits of Being Customer-Oriented under Disruptive Technological Change**

- Is a customer-oriented firm less apt to survive a technological change?
- Does the focus of customer orientation to current versus potential customers impact the fate of incumbents?
- How does the relationship with current customers drive investments in technological alternatives?
- Which customer research tools inhibit versus facilitate successful harnessing of technological disruption?

**The Merits of Creating a Spin-Off to Pursue Disruptive Technology**

- What are the advantages and disadvantages of creating a separate organization to pursue disruptive technology?
- Are these advantages and disadvantages different for the technological and commercial stages of this pursuit?
- What should be the nature of the separation between the spin-off and the mainstream organization, in terms of resource allocation, decision-processes, culture, and so forth?
- How should the relationship between the mainstream organization and the spin-off be structured (e.g., in terms of resources, governance, ownership, incentives) to minimize the interference and maximize the synergies between the spin-off and the mainstream organizations?
- Under what conditions is a spin-off the best way to pursue disruptive technology?

Another way to conceive of *disruption* is relative to the resources or competences of the innovating firms (Charitou and Markides, 2003). This notion of disruption is consistent with the distinction drawn by Tushman and Anderson (1986) between competence-enhancing and competence-destroying technological shifts. Disruptive technologies then would be those technologies that render established technologies obsolete and therefore destroy the value of the investments that incumbents have made in those technologies.

It is important to emphasize that Christensen explicitly notes that the classifications of disruptive versus sustaining and of competence-destroying versus competence-enhancing are distinct. He notes that many of the incumbents he studied had no difficulty surviving competence-destroying technological shifts, as long as the competence-destroying technologies addressed the needs of the incumbents' mainstream customers. A footnote in Christensen and Bower (1996) reads, "We contest the conclusions of scholars such as Tushman and Anderson (1986), who have argued that

incumbent firms are most threatened by attacking entrants when the innovation in question destroys, or does not build upon, the competence of the firm. We observe that established firms, though often at great cost, have led their industries in developing critical competence-destroying technologies, when the new technology was needed to meet existing customers' demands" (p. 199).

In my opinion, the core of the definition of a *disruptive technology* is this: A disruptive technology is a technology that changes the bases of competition by changing the performance metrics along which firms compete. Customer needs drive customers to seek certain benefits in the products they use and form the basis for customer choices between competing products. Benefits sought by customers determine which product attributes they value, and different customer groups (i.e., market segments) may value different attributes (MacMillan and McGrath, 2000). Competing products (or more broadly offerings, which are constituted by physical goods and/or services) offer differing levels of performance on varying dimensions. These performance levels of the product, or attribute sets (MacMillan and McGrath, 2000), are possible because of the technology embedded in the product. Customer needs determine which performance dimensions form relevant bases of competition—i.e., differentiate meaningfully between competing offerings. At any given time, a particular technology has performance constraints, which limit the current product attribute set. New products based on a disruptive technology have different attribute sets than existing products. These new products initially have lower performance on dimensions relevant to the mainstream market segment but have higher performance on dimensions valued by remote or emerging market segments. However, the performance that a technology enables increases over time, and eventually the performance levels offered by a disruptive technology meet or exceed the minimum levels demanded by the mainstream market. Disruptive technologies change the bases of competition because they introduce a dimension of performance along which products did not compete previously. For instance, in disk drives, once drive capacity exceeded the requirement of a certain market segment, size of the drive became a basis of competition.

The most powerful analytical tool provided by Christensen is a diagram that jointly portrays trajectories over time of (1) performance demanded by different market segments; and of (2) performance

provided by alternative technologies. In his framework, disruption occurs when the trajectory of performance provided by the disruptive technology intersects with the trajectory of performance demanded in the mainstream market. In Christensen's cases often only one or two performance dimensions dominate the customer's choice. For instance, in his focal example of disk drives, size and capacity are the dominant choice criteria. However, in many cases the number of performance dimensions is much higher, and customers trade them off against each other, making for a complex and recursive set of variables. For instance, for cars, key performance dimensions include speed, range, acceleration, styling, convenience of fueling, fuel efficiency, weight, towing capacity, crash safety, reliability, maintenance, durability, noise, vibration, theft risk, pollution, purchase and operating costs, and so forth. The multitude of relevant performance dimensions and their complex interrelationships may make the use of trajectory diagrams challenging.

In this vein, Adner (2002) focused attention on the demand side of this interplay between markets and technologies. He argued for the need to understand the structure of demand in order to clarify the nature and effects of disruptive technology. Building on Christensen, he developed a formal modeling approach to characterize the nature and evolution of demand in various market segments and identified which kind of market structures are susceptible to disruption. His approach potentially could be extended to include various interrelated dimensions of performance, as viewed from both market and technological perspectives.

One question that has been left unanswered is this: what are the essential characteristics of a disruptive technology, and what are ancillary characteristics? Christensen (2000) stated that "disruptive technologies are typically simpler, cheaper, and more reliable and convenient than established technologies" (p. 192). These characteristics may be typical, but not necessary, characteristics of disruptive technology. For instance, do mainstream customers never initially value disruptive technology? Does disruptive technology always mature in a low-end segment? Does disruptive technology always start with lower performance? Mini-mills started in the lower-end rebar segment, but Amazon.com started in the mainstream market. Digital cameras are more expensive than traditional film cameras to purchase but less expensive to use. Digital video discs (DVDs) always have had higher

image quality than videocassettes. If a technology does not fit these ancillary characteristics, is it then not a disruptive technology?

Perhaps some of the ancillary characteristics are essential for a technology to be disruptive, i.e., for the mechanism of disruption of industry leaders to operate. Christensen argues that because a disruptive technology initially only serves a small, low-margin market, it is ignored by incumbents that are serving more attractive segments. It seems key to the mechanism of disruption that the technology matures in the marginal market and eventually increases its performance so as to satisfy the needs of higher-end segments. This is when the disruption to incumbents takes place.

In contrast, the most recent version of the framework makes a distinction between *low-end disruptions*, which address the low end of an existing value network, and *new-market disruptions*, which create a new value network (Christensen and Raynor, 2003). A new-market disruption is “an innovation that enables a larger population of people who previously lacked the money or skill now to begin buying and using a product” (Christensen and Raynor, 2003, p. 102).

Some of the characteristics of disruptive technology may be essential, whereas other characteristics may be industry-specific. In his review of studies of the impact of technological changes on firms, Chesbrough (2001) noted that this stream of research has tended to focus on issues of internal validity, to the relative neglect of external validity. Most empirical work has been in the form of very well-documented and thorough case studies of particular industries, but the extent to which findings from these case studies generalize across industries has not been addressed. Christensen and his colleagues have done studies of many industries, ranging from hard disk-drive manufacturers to makers of excavators. In fact, in the book by Christensen and Raynor (2003) the term *disruptive technology* is replaced by *disruptive innovation*, apparently to broaden the theory’s applicability. However, as the limits of the theory of disruptive innovation continue to be pushed to include such areas as retail formats, online banking, and digital imaging, it seems that the concepts and mechanisms outlined in earlier work become increasingly stretched. It is therefore necessary for scholars to develop very careful definitions and classifications of types of technological change and to develop clear conceptual depictions of their effects and the processes by which they exert these effects.

## Can the Disruptive Technology Framework Make Ex Ante Predictions?

Christensen has been accused of cherry-picking examples to support his framework (Cohan, 2000). All of Christensen’s case studies are of disruptive technologies that did succeed. However, there are many potentially disruptive technologies that fail (e.g., the Iridium global satellite phone system; see Finkelstein and Sanford, 2000). Perhaps that is why established companies tend to be skeptical of disruptive technologies. Entrants have less to lose, and for them a disruptive technology may be the only chance to gain a foothold. Even though Christensen never claims that all (potentially) disruptive technologies succeed, his exclusive selection of those that did presents an analytical problem.

Retrospective analysis is subject to bias. Hindsight is always 20/20. Therefore, the historical case studies in “The Innovator’s Dilemma” are considered best as wonderfully rich empirical data used for theory-building purposes. The real challenge to any theory, especially if it is to be useful managerially, is how it performs predictively. In other words, can the theory be used not only to analyze cases post hoc but also to predict the outcome of cases ex ante? Barney (1997) argued that luck may be an alternative explanation for why some firms survive technological shifts, stating that “it may simply be the case that some firms are lucky in their technology choices and others are unlucky” (p. 15). Those firms with lucky choices are subsequently scrutinized, and a retrospective rationale for their success is formed. Barney (1997) recommends predictive tests to rule out luck as an alternative explanation. I encourage scholars to use the foundation provided by Christensen for theory-testing purposes.

How can we know if a technology will be disruptive, ex ante? As Doering and Parayre (2000) noted, “Significant emerging technologies are easily seen after the fact, and companies are then congratulated or castigated for their decisions to pursue them or ignore them. But rarely are the winners clear at the outset. Yet, this is the challenge managers face” (p. 75). For managerial purposes, Christensen’s framework would be most useful if it allowed a manager to recognize which technology will succeed and will become disruptive. Christensen (2000) suggested to “... graph the trajectories of performance improvement demanded in the market versus the performance improvement supplied by the technology... Such charts are the best

method I know for identifying disruptive technologies” (p. 206). For ex post case studies, using trajectory charts is fairly straightforward, given that the relevant performance dimensions have been identified and that data on performance demanded and supplied are available.

However, ex ante predictions involve predicting what performance the market will demand along various dimensions and what performance levels technologies will be able to supply. It is not clear entirely what methods exist for such prediction. One simple approach of course would be to extrapolate the historical performance trends toward the future. This may be very difficult in the case of very young technologies, or new markets, for which very little historical data exist and for which future evolution is uncertain. It seems very difficult to predict ex ante which technology will be disruptive. For instance, an article in the magazine *Scientific American* reviews many emerging information storage technologies that eventually could replace hard-disk memory (Toigo, 2000).

Further research should develop analytical tools for identifying (potentially) disruptive technologies. One potentially fruitful avenue is for researchers to examine how extant methods for technology forecasting could be applied to assess disruptive technologies. Doering and Parayre (2000) presented a technology assessment procedure that iterates among searching, scoping, evaluating, and committing. They argued that this process allows for projecting the future commercial value of scientific and engineering discoveries. The Delphi technique (Rowe and Wright, 1999) presents another avenue to obtain and to integrate expert estimates of technological and market trajectories. These technology-forecasting procedures could be tailored specifically to disruptive technologies.

As aforementioned, Christensen has been accused of “sampling on the dependent variable,” or of highlighting only technologies that eventually turned out to be disruptive. To avoid this criticism, it would be necessary to obtain an uncensored sample of emergent technologies, of which the technical performance, market applications, customer benefits, and effects on companies and industries could be tracked over time. Because the observed length of time would be extremely long, perhaps several decades, this would be of necessity a historical study. Perhaps a comprehensive list of technologies drawing from a major scientific development, such as nuclear physics or genetics, could be developed for such empirical work.

## Why Do Some Incumbents Succeed?

One of Christensen’s most interesting findings, based on many case studies across widely varying industries, is that incumbents tend to falter when faced with disruptive technologies. For instance, he found that only 4 out of 30 cable excavators embraced the switch to hydraulic technology from cable-actuated technology. Similarly, much prior research has found that innovations that ultimately transform an industry often do not originate from the industry’s leaders (e.g., Cooper and Schendel, 1976; Foster, 1986; Henderson and Clark, 1990; Utterback, 1994).

Regarding Christensen’s focal industry, the hard-disk-drive industry, McKendrick, Doner, and Haggard (2000) disputed some of his factual claims regarding whether the leaders of every technological transition (from 14-inch to 8-inch, 8-inch to 5.25-inch, 5.25-inch to 3.5-inch) were entrants or incumbents. McKendrick, Doner, and Haggard (2000) claimed that only the transition to 5.25-inch evidenced a clear disruptive technology pattern in which entrants prevailed and incumbents failed. Regarding the transition to 3.5-inch drives, McKendrick, Doner, and Haggard (2000) stated that “the real paradox is that a whole class of great firms did *not* fail despite often trailing the market in the introduction of disruptive technologies” (p. 286, italics in original). In their study of incumbent entry into new market niches in the hard-disk-drive industry, King and Tucci’s (1999, 2002) findings contradicted Christensen’s finding that incumbents exposed to disruptive technology mostly fail or exit. They actually found that firms with experience in serving prior market segments (i.e., incumbents of prior formats of disk drives) were more likely to enter new market niches. Similarly, Chesbrough (2003a) found that firms with greater prior disk drive revenues were more likely to enter new market niches, albeit later in time, than firms with less prior revenues. In other words, these studies found the opposite central tendency from that proposed by Christensen and his colleagues. King and Tucci (1999) and Chesbrough (2003a) also found that incumbents were more likely to survive in the long term (i.e., had a lower rate of exit). However, these studies did not examine the shifts in industry leadership across the different transitions and therefore did not test Christensen’s claim that incumbents lose their market leadership (i.e., dominant market share) when faced with disruptive technological change.

Therefore it seems that many, but not *all*, incumbents fail in the face of disruptive technology. Therefore the following question yet is unanswered: What determines whether incumbents fail or succeed in the face of disruptive technology? Future research needs to address what the characteristics are of incumbents that do not fail.

There are many examples of successful incumbents. For instance, Charles Schwab, an established financial industry incumbent, successfully embraced online trading. Charles Schwab is currently the leading online brokerage in terms of Internet trading revenues, which account for more than half of the company's trades (Cohan, 2000). It overtook E\*TRADE, the entrant and first mover. What led to Schwab's success? Its financial and management resources? Its superior brand? Perhaps it was its memory of its previous disruptive success when it disrupted Merrill Lynch's full-service brokerage by offering discount brokerage (Cohan, 2000). Similarly, Kodak and Fuji were among the first to embrace digital imaging technology and currently dominate the digital camera industry. Polaroid, on the other hand, faltered in the introduction of a digital camera (Tripsas and Gavetti, 2000). Currently, incumbent car manufacturers are leading the creation of nonfossil-fuel-powered automobiles and have introduced many products to market.

Recent empirical research has found that the innovative inertia of incumbent firms may have been overstated. Methé et al. (1997) found that industry incumbents and diversifying entrants could be credited with many major innovations in the telecommunications and medical device industries. Klepper and Simons (2000) found that nearly all dominant U.S. manufacturers of television sets previously were dominant producers of radios and that they took the lead in television product and process innovations. Chandy and Tellis (2000) also found that the "incumbent's curse" has been overstated. They studied the origins of a broad range of radical product innovations in office products and consumer durables across 150 years. *Radical product innovations* are defined as new products that are based on substantially new technology and deliver substantially better customer benefits relative to previous products, and *incumbents* are defined as those firms that also sold the previous generation of products. They find that after World War II, incumbents actually introduced the majority (75 percent) of radical product innovations within the two product classes they studied.

Christensen has basically two explanations for incumbent failure, which conversely could be used to explain incumbent success: the resource allocation process; and organizational resources, processes, and values (the "RPV" framework). For instance, when he points to resource-allocation mechanisms as a cause of incumbent lack of proactiveness in harnessing disruptions, then superior resource allocation systems could characterize successful incumbents. I call for research to observe directly the processes within firms, particularly using field methods. Such research could track resource allocation to sustaining and disruptive technologies over time and could detail decision-making processes. However, the most promising area for research would be to provide data specifying resources, processes, and values (called RPV by Christensen in a chapter added in the new edition of the book). A possible research question might be how the resources, processes, and values of incumbents that succeed versus fail compare. Studies in this area can draw on a rich research tradition that has examined the role of firm resources or competences for the firm's ability to deal with technological change. The remainder of this section will explore linkages to this research tradition.

A crucial consideration is how the resources required to harness the disruptive technology relate to the resources of incumbents (Charitou and Markides, 2003). Tushman and Anderson (1986) found that competence-destroying technological discontinuities were initiated by new firms, while competence-enhancing technological discontinuities were initiated by existing firms. Tushman and Anderson (1986) argued that the former kind of innovations favor new entrants at the expense of entrenched incumbents, who are "burdened with the legacy (i.e., skills, abilities, and expertise) of prior technologies and ways of operating" (p. 446). Tushman and Anderson (1986) argued that new firms, on the other hand, "... unconstrained by prior competence and history, take advantage of technological opportunities" (p. 461).

It often has been assumed that prior experience, and the routines and competences built from it, reduce the adaptability of organizations faced with technological shifts. Henderson (1993) (see also Henderson and Clark, 1990) found in the photolithographic alignment equipment industry that established firms invested more in incremental innovation, while entrants were more likely to dominate radical innovation. Henderson (1993) suggested that "... in some circumstances extensive experience with

a technology may be a substantial disadvantage ... Large established firms have an advantage over entrants in the pursuit of incremental innovation because incremental innovation builds upon their existing knowledge and capabilities, but these assets can simultaneously reduce substantially the effectiveness of their attempts to exploit radical innovation” (p. 251).

In contrast, King and Tucci (2002) argued that experience, such as that accumulated by incumbents of prior technological regimes, does not lead to inertia. As mentioned earlier, in their study of the history of the worldwide hard-disk-drive industry, they found that firms with greater cumulative production and sales experience were more likely to enter new market segments and were less likely to exit. King and Tucci (2002) thus called into question the incumbency (experience in prior markets and technologies) – inertia (lack of entry and longevity in subsequent markets and technologies) link.

Tripsas (1997) conducted another study that related preexisting firm resources to firm survival. She found that typesetter manufacturer Mergenthaler Linotype remained an industry leader for over a century, despite three waves of technological shifts. Mergenthaler’s proprietary control over its fonts, a complementary asset in the typesetting industry, buffered it from the technological shifts in its industry. The technological shifts were not competence-destroying in relation to the font libraries; i.e., this resource retained its value despite shifts in technology.

Tripsas and Gavetti (2000) studied the role of cognition in the development of competences. They showed how two prevalent beliefs among Polaroid senior managers hindered the company’s entry into digital cameras, in spite of its leading-edge digital-imaging capabilities. On the one hand, the belief in the primacy of technology led the company to invest aggressively in R&D on digital imaging. On the other hand, the belief of Polaroid managers that their company could not make money on hardware (cameras) but only on consumables (film), severely impeded the commercialization of its digital technologies.

Helfat and Lieberman (2002) synthesized prior work regarding the role of preexisting resources in explaining whether and how successfully entrants and incumbents will enter into a new field. They suggested comparing the “resource profile” of firms to the resources required by the new field. This comparison will yield “resource gaps” a firm has to overcome (i.e., when the firm lacks key resources required for entry). They concluded from their review of several empirical

studies [including the study of photolithographic alignment equipment industry by Henderson and Clark (1990)] that it sometimes has been overlooked that “... the winning firms often are diversifying entrants from another industry that bring resources and capabilities relevant to the new product generation. Successful entrants in new generations of photolithographic alignment equipment included Canon and Nikon, which used their experience in optoelectronics as a basis for diversification” (p. 752). Much of the literature has focused on startup (i.e., *de novo*) entrants, while innovations introduced by diversifying entrants (established firms that enter an industry new to them) often are overlooked (Méthé et al., 1997). Mitchell (1992) found that firms able to draw on related technical and market resources to enter a new technical field were more likely to prosper.

When addressing the challenges and opportunities generated by technological change, incumbents may not have the necessary resources. Helfat and Lieberman (2002) reviewed several means by which resource gaps can be filled, such as alliances, joint ventures, acquisitions, and licensing. Rothaermel (2001) showed that accessing resources through alliances is one way incumbents can be successful in the face of disruptive technology. For instance, in the pharmaceutical industry, leading firms have been able to maintain their position in spite of the emergence of biotechnology. Rothaermel (2001) showed how incumbents in the pharmaceutical industry access biotechnological competences for new drug development by engaging in strategic alliances with startup biotech firms. In turn, the incumbent pharmaceutical firms provide such resources as sales and distribution networks, advertising and promotion skills, and brand names. Future research could build on Rothaermel (2001) to evaluate the alternative routes for incumbents to get access to disruptive technologies, such as alliances, acquisitions, and internal development.

Afuah (2000) (see also Afuah and Bahram, 1995) also broadened the perspective beyond resources of the focal firm. He argued that to understand technological change researchers need to examine not only whether change renders obsolete the resources of the focal firm but also those of its network of customers, suppliers, alliance partners, and complementors. For instance, transition to the Dvorak keyboard would render obsolete the typing skills of customers adept at Qwerty. Rosenbloom and Christensen (1994) drew attention to the value network in which a firm is embedded, which plays a critical role in how firms deal



with disruptive technologies. In other words, to explain the success of incumbents, researchers need to look at not only the destruction or enhancement of resources of the focal firm but also at the impact of the technological change on the resources of all players in the value chain.

Emerging work in the resource-based theory of the firm offers additional avenues for research. The focus of this research is not so much on the extent to which a technological transition destroys the value of existing resources but rather on what resources the firm needs to add to its repertoire to take advantage of the new technological field. It is important to emphasize that Christensen argues that incumbents tend to fail only when the disruptive technology does not initially fulfill the needs of their mainstream customers. This is when firms lack the “customer competence” to address the market for which the technology initially can be used. A customer competence consists of resources required to serve certain customers: understanding of customer’s needs and buying process, access to sales and distribution channels, brand and firm reputation within the targeted market, and communication channels with the customers (Danneels, 2002). In an intriguing footnote, Christensen (2000) notes that “Professor Rebecca Henderson pointed out to me that this tendency always to take new technologies to mainstream customers reflects a rather narrow *marketing* competence—that although many scholars tend to frame the issue as one of technological competence, such inability to find new markets for new technologies may be a firm’s most serious handicap in innovation” (p. 58, italics in original) (see also Christensen and Bower, 1996, p. 207). Indeed, many incumbents were able to develop working prototypes of products using the disruptive technology, demonstrating that they had the R&D competence necessary to acquire a new technology. However, they faltered when they tried to market the disruptive technology to their current customers. What they were missing was a “marketing competence,” the ability of a firm to build new customer competences, i.e., to identify and build relationships with customers it has not served yet (Danneels, 2002). The failing incumbents described by Christensen lacked the marketing competence to establish the resources needed to address the market that initially was served by the disruptive technology. They lacked the skills to conduct research on a new market, to set up a new distribution and sales channel, to build a reputation in a different market, and so forth. Christensen and Bower (1996) claimed

that none of the disk-drive manufacturers was able to gain a significant share of the new market, and they discuss two example firms in particular. Seagate, traditional maker of 5.25-inch drives for the desktop PC market, for several years did not succeed in selling its 3.5-inch drives to the new laptop market. Instead, they sold most of their 3.5-inch drives to their existing customer base, the desktop PC makers. Similarly, Control Data, incumbent maker of 14-inch drives for mainframes, did not succeed in marketing its 8-inch drives to minicomputer manufacturers. Control Data sold nearly all of its 8-inch drives to the mainframe market. As emphasized by MacMillan and McGrath (2000), one of the key challenges for commercializing emerging technologies is to identify the killer applications as early as possible. This involves determining which product attributes are made possible by the new technology and then to identify which market has needs that can be satisfied by those attributes. In other words, the marketer should find customers who value the unique product attributes made possible by the technology. In the case of a disruptive technology these are not customers of the incumbent firms. Next, the firm needs to acquire access to this market. Therefore, paradoxically, the capacity to survive a technological shift may be a function of the firm’s marketing competence, in particular how adept it is at identifying and accessing customers it has not served previously. Future research could develop this notion of a marketing competence further and could explore whether incumbents with stronger marketing capabilities are in fact more adept at taking advantage of the opportunities offered by disruptive technologies.

This discussion of organizational level competence begs the question of individual level competence. What is the role of the competence of individual middle- or top-level managers of incumbent firms? Christensen and his colleagues are too kind to managers of incumbent firms, insisting on describing them as competent and at the helm of great firms. Their analysis suggests a rather passive role of managers, as having their hands tied behind their backs, being the captive of current powerful customers, at the mercy of investors, powerless peons in the process of resource allocation. I believe that individual managerial competence does play a significant role and should be an explicit focus of research into the determinants of incumbent success. Some managers do seem able to lead their firms across technological transitions.

Lastly, several researchers have found that the effects of disruptive technologies on incumbents are

contingent on national context. Chesbrough (1999a, 1999b) examined the hard-disk-drive industry in three regions: the United States, Europe, and Japan. He found that incumbents lost their leadership position across technological transitions in the United States, while in Japan incumbents maintained their dominance. In the United States startup entrants displaced incumbents (i.e., population-level change), while in Japan the hard-drive industry transitioned to new technologies by organization-level change. Chesbrough (1999a) (see also Chesbrough, 1999b) highlighted four main aspects of the institutional context that impact the fate of incumbents relative to entrants when faced with disruptive technological change. First, the mobility of qualified and experienced personnel affects whether entrants can gain access to these critical human resources or whether they are retained within incumbent firms. Second, national contexts vary in the extent to which venture capital, the main source of funding for startups, is available. Third, the exclusivity, contractual or moral, of supplier–customer relationships also tends to favor incumbents. Fourth, the region’s government industrial policy, especially in terms of subsidies and preferences in government procurement, also tends to affect the fate of incumbents. Darby and Zucker (2001) noted that the institutional environment in Japan channeled the shift from chemistry to biotechnology in the pharmaceutical industry to take place entirely as organizational change within incumbents rather than as the industry level displacement of incumbents by entrants. They focused in particular on the restrictions imposed on star scientists at Japanese universities, who were prohibited legally from holding equity interest or founding roles in new firms, an institutional factor which contributed to the lack of biotech startups in Japan.

### **What Are the Merits of Being Customer Oriented?**

Christensen’s work often has been cited as an argument against customer orientation (Day, 1999; Slater and Narver, 1998). Christensen pointed out that established firms are “held captive by their customers” and therefore miss the boat on disruptive technologies. Christensen and Bower (1996) stated, “Our conclusion is that a primary reason why such firms lose their positions of industry leadership when faced with certain types of technological change ... because they

listen too carefully to their customers” (p. 198). I believe that the implications of Christensen’s findings for the value of being customer-oriented have been misstated. Some readers have taken his findings to imply that companies should not be customer-oriented. This is a misinterpretation, for two reasons. First, one needs to make a distinction between current and potential customers. Being customer-oriented does not imply an exclusive focus on current customers. In the worst case, a firm may become what Day (1999) has called “customer compelled”—essentially bending over backward to fulfill every whim of current customers, even at the expense of the company’s short-term and long-term performance. Instead, a customer-oriented firm “can serve current customers and remain vigilant for unserved emerging markets” (Day, 1999, p. 15). In fact, Chandy and Tellis (1998) found that companies focusing on future customers, rather than on current customers, had a greater degree of radical product innovation. I interpret Christensen’s findings to mean that firms should not be focused narrowly on serving current customers and should not allocate all their resources to serving current customers.

Second, the firms portrayed by Christensen show a shallow understanding of their customers’ needs. If they had a deep understanding of their customers’ needs they would have known that their customers actually did have a broader range of product selection criteria than those upon which products competed before the disruptive technology. A truly customer-oriented firm understands the latent and unexpressed needs of its customers (Slater and Narver, 1998). Market research scholars and practitioners have developed an extensive toolkit for digging deep into customers’ needs (for a review, see Aaker, Kumar, and Day, 2000), and new techniques such as empathic design (Leonard and Rayport, 1997) are being added continually. In other words, Christensen’s findings only reject a very reactive, narrow notion of customer orientation (Danneels, 2003; Slater and Narver, 1998).

I also have observed a misguided critique of the “lead-user methodology,” the famed approach to creating new products formulated by von Hippel (1986) and colleagues. Unfortunately, Christensen and Bower (1996, p. 211) noted in parentheses that the axiom to “stay close to your customers” is supported by the research of von Hippel (1986). However, the detractors of the lead-user method fail to appreciate that lead users are not necessarily current customers

(In fact, most often they are not customers at all). In contrast, the lead-user technique may be a great way to identify promising disruptive technologies (for an illustration, see von Hippel, Thomke, and Sonnack, 1999). This misunderstanding may be blamed on a confusion of terminology. Even Christensen (2000) uses the term *lead customers* (p. 43) (see also Christensen and Bower, 1996, p. 207). I urge scholars and practitioners to be careful to distinguish “lead customers” and “lead users” and to understand the latter concept in terms of the research stream started by von Hippel over two decades ago.

### **Is Creating an Independent Organization to Pursue the Disruptive Technology Always Best?**

One of Christensen’s most influential recommendations has been that incumbents should set up a separate organization for venturing into disruptive technology. His recommendation follows logically from his explanations for the failure of established firms, which as pointed out already is twofold. First, the resource-allocation process tends to pull resources away from disruptive technology efforts to serve current customers, and therefore a spin-off with its own protected, dedicated resources is required. Second, the disruptive technology may not fit with the mainstream organization’s resources, processes, and values. For instance, he argues that it is necessary to match the size of the organization to the size of the opportunity, such that managers can get excited over the initially small market for disruptive technologies. According to Christensen and Bower (1996), in the entire history of the hard-disk-drive industry only three incumbents achieved commercial success with a disruptive technology (This conclusion is disputed by McKendrick, Doner, and Haggard, 2000). Christensen and Bower (1996) attributed the success of two out of three to their spinning out an independent organization to pursue the disruptive technology.

Cohan (2000) questioned whether setting up a separate organization is always the best solution and examines two successful incumbents who did not: Hewlett-Packard (HP) for developing inkjet printers and Schwab for developing online trading. In fact, HP did initially set up an independent organization to address the disruption. However, when the disruptive business became big and profitable enough to command adequate resources, it was folded back into the

mainstream business. The case of Schwab is also more complex than Cohan (2000) suggested. Schwab in fact did establish first a separate division (consistent with Christensen’s recommendation) called e-Schwab but later integrated this division after experiencing channel conflict (Useem, 1999). This suggests that creating a separate division may have both advantages and disadvantages. Gulati and Garino (2000), in an article on clicks-and-mortar strategies by retailers, pointed out some disadvantages of setting up an independent organization. They argued that Barnes & Noble’s decision to create an entirely separate division (barnesandnoble.com) to pursue online retailing led the company to forego synergies in purchasing, information sharing, branding, cross-promotion, and customer service. Gulati and Garino (2002) concluded that the integration versus separation decision facing traditional retailers venturing into online retailing involves a trade-off. Iansiti, McFarlan, and Westerman (2002) found that retailers that integrated their web operations with their existing business were more efficient at generating revenues than those retailers that kept them as autonomous divisions. On the other hand, Rice, Leifer, and Colarelli O’Connor (2002) found in their case studies that discontinuous innovations transitioned into an existing business unit often suffered from a misfit between the needs of the discontinuous innovation and the business unit’s existing capabilities in manufacturing and marketing. McDermott and Colarelli O’Connor (2002) concluded that “isolation may protect the project from the counterproductive forces within the mainstream, but it also cuts the project off its most important sources of learning, competences and resources” (pp. 431–32). Christensen (2002) in fact qualified his recommendation to set up an independent organization: “When a threatening disruptive technology requires a different cost structure in order to be profitable and competitive, or when the current size of the opportunity is insignificant relative to the growth needs of the mainstream organization, then—and only then—is a spin-out organization a required part of the solution” (p. 176). [An almost identical statement is made in Christensen and Overdorf (2000, p. 74)]. Many scholars and practitioners interpreting Christensen’s work have not attended to this qualification. In any case, there are solid arguments for and against a spinout organization, and more refined insights into contingencies are emerging. When resource complementarities between the new venture and the mainstream business are crucial, and these complementarities

require intracompany coordination, a more integrated approach may be advised (Iansiti, McFarlan, and Westerman, 2003).

Future research should examine under what conditions a spin-off is the best way to pursue disruptive technology and how the relationship between mainstream organization and spin-off should be structured, in terms of resources, governance, ownership, and incentives. For example, Chesbrough (2003b) studied the relationship between governance and performance of Xerox spin-off companies. He found that spin-offs with a parent company insider as chief executive officer (CEO) and a board dominated by parent company representatives realized lower market values and revenue growth than those with an outsider at the top and venture capital representatives on the board. Dominance of the parent company in the governance of the spin-off imposed the pursuit of complementarities with parent resources and therefore constrained the search for opportunities.

## Conclusion

This article started by noting that the work on disruptive technology by Christensen and his colleagues has garnered much attention by scholars and practitioners alike. However, with its success also have come some pitfalls. Christensen offers a really intricate picture of how firms react to technological shifts, and I believe that readers do not always do justice to the complexity of his argument. One can see from a search for *disruptive technology* on the web how loosely the term has come to be used and how it has become separated from its theoretical basis. Therefore, a reconsideration of the nature of disruptive technological change and its consequences for firms and industries is in order.

The work on disruptive technology served as a springboard to formulate several important issues that remain unresolved from both an academic and managerial perspective. Scholars should develop a classification of technologies to enhance understanding of how the emergence of new technologies shapes the fate of both firms and industries. I believe that disruptive technologies have a specific and distinguishable place within such a classification. To increase both the theoretical and managerial merit of the theory, predictions need to be developed and to be tested about which technologies will become disruptive and which firms will succumb versus prosper in

their emergence. Future research also should address the merits of spin-offs and customer orientation as ways to harness the power of disruptive technologies. My hope is that this article will encourage further research along these lines and will spur debate by practitioners and scholars alike.

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