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The Fuzzy Front End of New Product Development for Discontinuous Innovations: A Theoretical Model

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The fuzzy front end of the new product development (NPD) process, the time and activity prior to an organization's first screen of a new product idea, is the root of success for firms involved with discontinuous new product innovation. Yet understanding the fuzzy front-end process has been a challenge for academics and organizations alike. While approaches to handling the fuzzy front end have been suggested in the literature, these tend to be relevant largely for incremental new product situations where organizations are aware of and are involved in the NPD process from the project's beginning. For incremental new products, structured problems or opportunities typically are laid out at the organizational level and are directed to individuals for information gathering. In the case of discontinuous innovations, however, we propose that the process works in the opposite direction—that is, that the timing and likelihood of organizational-level involvement is more likely to be at the discretion of individuals. Such individuals perform a boundary-spanning function by identifying and by understanding emerging patterns in the environment, with little or no direction from the organization. Often, these same individuals also act as gatekeepers by deciding on the value to the organization of externally derived information, as well as whether such information will be shared. Consequently for discontinuous innovations, information search and related problems/opportunities are unstructured and are at the individual level during the fuzzy front end. As such, the direction of initial decisions about new environmental information tends to be inward, toward the corporate decision-making level, rather than the other way around.

In order to cope with the special and complex nature of decisions made at the fuzzy front end of NPD for discontinuous innovations, this process is detailed as a series of decisions occurring over three proposed interfaces: boundary, gatekeeping, and project. The difference between each interface lies in the nature of the decisions made: At the boundary and gatekeeping interfaces, the primary impetus is individual-level decision-making; at the project interface, decisions occur at the organizational level. By articulating these processes in the form of a model, we achieve two objectives: (1) We outline a more detailed and comprehensive approach to understanding the nature of the front-end decision making process for discontinuous innovations; and (2) we detail specific propositions for future research on each stage of the process.

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"Everything is vague to a degree you do not realize until you have tried to make it precise."

Bertrand Russell

Introduction

One area where a significant degree of uncertainty continues to reside within organizations, and is mirrored by equal uncertainty in academia, is at the "fuzzy front end" of the new product development (NPD) process (Moenaert et al., 1995). This is true particularly for discontinuous, or new-to-the-world, types of innovations. Part of the reason for this uncertainty and concomitant lack of focus is the nature of practice and research in the social and business sciences, which have focused heavily on quantifiable outcomes and measures. Specifically in the NPD arena, scholars have aimed at understanding and at improving those project-level and corporate-level processes, which are observable in the form of activities and outcomes. As such, research areas in new product development such as project evaluation, market analysis, new product launch, success/failure, product design, and testing have been investigated in some detail. In contrast, the fuzzy front end of the NPD process, particularly for discontinuous innovations, has been elusive to investigators. This, we believe, is due largely to a predominantly surface-level understanding of the decision-making activity of individuals within organizations where, as proposed in this article, much of the fuzzy front-end process for discontinuous innovation tends to occur. This article seeks to clarify the nature of the fuzzy front end of the NPD process for discontinuous innovation by examining the decision-making process and information flow that comprise this phase. This study also proposes potential avenues for future research in the form of specific research propositions.

BIOGRAPHICAL SKETCHES

Dr. Ulrike de Brentani, professor of marketing in the John Molson School of Business at Concordia University, has research interests in the areas of new product/service development, new product evaluation, and product/service marketing in the business-to-business sector. She has received several Awards of Academic Excellence for her research, which has been presented in the form of refereed research articles at international conferences and is published in refereed journals, including *Journal of Product Innovation Management*, *Journal of the Academy of Marketing Science*, *International Journal of Research in Marketing*, *Journal of Business Research, European Journal of Marketing*, *Industrial Marketing Management*, *Journal of Marketing Management*, and *International Journal of Bank Marketing*. Her current research program deals with performance of new product and service development programs for global markets.

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What Is the Fuzzy Front End?

The *fuzzy front end*, a term first popularized by Smith and Reinertsen (1991), is considered to be the earliest stage of the NPD process and roughly is meant to denote all time and activity spent on an idea prior to the first official group meeting to discuss it, or what they call "the start date of team alignment." Another way of thinking about this concept is to highlight the fuzzy front end as that territory leading up to organizational-level absorption of the innovation process (Cohen and Levinthal, 1990).

While a concentrated effort toward better understanding the fuzzy front end has been undertaken in earnest only during the last decade, scholars of NPD have discussed "up-front activities" in a generic way for more than 20 years (Crawford, 1980). For example, it can be seen that there clearly are early and late activities comprising the fuzzy front end, regardless of level of innovation (incremental or discontinuous). In the case of early fuzzy front-end activities, authors speak of problem/opportunity structuring and/or identification/recognition (Leifer et al., 2000; Urban and Hauser, 1993); information collection/exploration (March, 1991); and "up-front homework" (Cooper, 1996). These activities, however, have tended to be described in somewhat nonspecific terms. Late fuzzy front-end activities are seen as involving aspects of idea generation and concept development (Cooper, 1990; Urban and Hauser, 1993), continued information collection, and informal or prescreening (Crawford, 1980; Crawford and Di Benedetto, 2003) with possibly some initial fund allocation for exploring a new idea (Cooper, 1990; Cooper and Kleinschmidt, 1986).

Impetus for Research Focusing on the Fuzzy Front End of Discontinuous Innovation

Because the activities and decisions comprising the fuzzy front end are the starting point for all NPD processes and, therefore, determine the direction of any new product path, it is clear that a better understanding of the activities and decisions comprising this starting point ultimately could lead to competitive advantage. Additionally, according to Smith and Reinertsen (1991), of all the actions firms can take to improve their NPD process, those taken at the fuzzy front end give the greatest time savings for the least expense. This is related to the relatively low cost of generating several potential ideas compared to the cost of actually implementing any one idea (Urban and Hauser, 1993). Several studies have provided evidence of a link between new product performance and time spent on up-front activities (Cooper and Kleinschmidt, 1995; Kuczmarski & Associates, 1994; Urban and Hauser, 1993); thus, a search for better processes in support of the fuzzy front end appears to be called for in order to help firms achieve greater success in their efforts to develop new products.

As noted already, uncertainty at the fuzzy front end is greatest for discontinuous innovation. This makes the research stream focusing on discontinuous new product development important, particularly given that although discontinuous innovations claim to be the root of only 10 percent of all new products (Griffin, 1997), there is strong evidence that when successful, these types of new products pay off more than proportionally (Cooper, 1990; Ettlie, 2000; Ettlie and Rubenstein, 1987; Kleinschmidt and Cooper, 1991; Mansfield and Wagner, 1975). Thus, a study of the fuzzy front end with a focus specifically on discontinuous innovation appears to be warranted.

Khurana and Rosenthal (1997), Moenaert et al. (1995), and Reinertsen (1999) have laid some of the groundwork for a better understanding of the fuzzy front end by examining key fuzzy front-end issues and their particular impact on product innovation success. Specifically, Khurana and Rosenthal (1997) focused on the importance of structured strategy for dealing with new product opportunities at the fuzzy front end; Moeneart et al. (1995) examined the importance of communication at the research and development (R&D)–marketing interface for ensuring better concept development at the fuzzy front end; and Reinertsen (1999) investigated the importance of optimizing the fuzzy front-end process by speeding up decision-making and screening, all to a view of improving chances of success. With the exception of the Moenaert et al. (1995) research, however, which had a heterogeneous sample of innovation types, past studies have focused primarily on incremental innovations (e.g., product evolutions, improvements, adaptations, and so forth) where decisions and activities tend to be more explicit and structured and where corporate-level strategy is usually a precursor to the ideation process (Booz et al., 1982; Urban and Hauser, 1993). Moreover, these types of decisions and activities (e.g., early interaction between R&D–marketing or prescreening) typically only are relevant to the later stages of the fuzzy front end for more discontinuous innovations—that is, once radical new ideas have moved within the sphere of corporate consciousness. This leaves an important gap regarding understanding of what happens in the early stages of the fuzzy front end for discontinuous innovation where management influence and control have been shown to be most elusive.

Building on the work of NPD scholars from the marketing literature and of technology and of innovation management (TIM) scholars from the management literature, a major goal of this article is to develop propositions about the nature of the fuzzy front end at the discontinuous end of the innovation spectrum. In doing so, the authors hope to offer a more complete model of the fuzzy front end of discontinuous innovation and thereby to help both academics and organizations to understand, to research, and to manage better this complex and important phase of the innovation process.

Three Perspectives of Innovation and How They Relate to the Fuzzy Front End

Various perspectives have been used to study innovation. Differences in these become most apparent when comparing TIM literature with NPD literature. The TIM literature, which has drawn heavily on the work of economists, has taken two perspectives: (1) the environmental, where industry, institutional and country aspects are viewed as impacting innovation; and (2) the individual, where roles such as championing, boundary spanning, and gatekeeping are examined for their impact on the process of innovation. The NPD literature, while also looking at some innovation process activities at the individual level, has used primarily an organizational perspective

focusing on product-, project-, and firm-level processes that contribute to the organization's success in creating, in developing, and in marketing new products. In order to gain insight into the problem of decision-making at the fuzzy front end of discontinuous innovation and to suggest a conceptual model for this process, we examine how these key perspectives impact the fuzzy front end.

First Perspective: The Environment

The first perspective, held primarily within the TIM literature, posits that discontinuous innovation is an environmental-level phenomenon. Characteristically, TIM authors supporting this perspective assess innovation at a macro-level, using historical industrial analyses to examine the long-run nature and economic impact of discontinuous innovations (e.g., Abernathy and Utterback, 1978; Arthur, 1988; Baum and Singh, 1994; Burt, 1992; David, 1985; Dosi, 1988; Eldredge and Gould, 1972; Kuhn, 1962; Mowery and Rosenberg, 1998; Schumpeter, 1939).

TIM authors from the organizational ecology stream (Baum and Singh, 1994; Lambkin, 1988) have demonstrated that, while organizational species change little during most of their history, random events can foster rapid speciation, thereby punctuating or interrupting this stability and resulting in concentrated periods of change and new paths for evolution (Eldredge and Gould, 1972). The new paths created during periods of disequilibrium (Holland, 1995; Van de Ven et al., 1999) represent the potential beginning of fuzzy front-end firm-level involvement with a given new technology life cycle. Periods of disequilibrium often spring from new combinations of old elements, which in turn usually reside in fairly different knowledge bases (Goodman and Lawless, 1994; Mowery and Rosenberg, 1998; Usher, 1929). As a result, the fuzzy front end for firms involved with discontinuous innovation is often a period where individuals within the firm are marrying new information with previous knowledge, and it is this process within the fuzzy front end that has not been understood well—that is, the process where individuals link corporate-level and individual-level knowledge with new information from their environment.

Further, a common thread, which links the components of this theoretical framework together beyond the macro-level perspective, is a belief that innovation systems essentially are deterministic. In other words, innovations are seen as moving along technological trajectories or paths that are difficult for individuals or firms to impact once in motion (Arthur, 1988; David, 1985; Dosi, 1988). The underlying structure of path-dependent processes is based on network effects. Network effects, in the innovation realm, mean that decision-makers react to decisions of other decision-makers, because they affect the chance that the initial choices made within the network are or will turn out to be advantageous (Burt, 1992). In other words, the benefit of adopting a technology varies directly with the number of others who adopt the technology (Hunt and Morgan, 1996; Katz and Shapiro, 1985). For understanding the fuzzy front end, this perspective suggests that the environment plays a critical role in the very early decisions made by individuals exposed to early technology information. This likely is related to individuals looking to the environment both to gain more information about a new technology and to see what the general adoption pattern seems to be before bringing it to the attention of others within the firm. To understand this better, generic technology(ies) (in addition to base science) can be thought of as being adopted or used by firms and then as being developed into application technologies specific to the firm. Generic technologies are those required to manufacture the products and are held widely by all participants that get involved in the industry. Application technologies are those that distinguish the organization from the competition and that are developed systematically within the firm building on generic technologies (Goodman and Lawless, 1994). This is important to the discussion at hand, because an underlying assumption is made that firms and individuals within those firms can and do influence technological trajectories, particularly through their fuzzy front-end processes, which put an application "spin" on a generic technology. By doing so, firm members affect the way that a generic technology ultimately impacts the marketplace through competitive product delivery.

The idea that the fuzzy front end involves processes of information gathering and adoption from the environment is based on the assumption that the environment external to the firm is the primary source of new ideas for discontinuous innovations and that even in-house ideas ultimately have some input from external sources (Allen, 1977; Burgelman and Sayles, 1986; Crossan et al., 1999; Ettlie, 1976; Macdonald and Williams, 1994; Roos, 1996). This perspective is summarized by Quinn (1985), who states that

technology tends to advance through a series of random insights frequently triggered by gratuitous interactions between the discoverer and the outside world. These interactions provide the new combinations of old elements as described previously (Usher, 1929). In the case of discontinuous innovation, old elements usually come initially from an individual in the firm who has the idea to combine one or more technologies, which previously were unrelated in an important way. In other words, new-to-the-world products that expand the market tend to be initiated from outside the current industry but through individual and firm-level processes (Utterback, 1994).

Second Perspective: The Individual

A second perspective, considered relevant in both the TIM and NPD literatures, focuses on the role of individuals in supporting and forwarding innovations within networks and firms, particularly during the fuzzy front end of discontinuous innovation. This perspective deals with such individual activities as championing, boundary spanning, gatekeeping, and pattern recognition.

TIM authors supporting the individual-level perspective have focused on the study of champions of innovation (e.g., Achilladelis et al., 1971; Burgelman and Sayles, 1986; Chakrabati, 1974; Howell and Higgins, 1990; Howell and Shea, 2001; Schon, 1963). NPD studies, which have drawn from marketing and management sciences, also have focused on champions in both incremental (Cooper and Kleinschmidt, 1986, 1987; Gupta and Wilemon, 1990; Kim and Wilemon, 2002; Markham, 1998; Zirger and Maidique, 1990) and radical (Colarelli O'Connor and Veryzer, 2001; de Brentani, 1995, 2001; Leifer et al., 2000; Maidique, 1980; Veryzer, 1998) scenarios. A champion generally is defined as an individual who informally emerges in an organization and makes a decisive contribution to an innovation by actively and enthusiastically promoting its progress through critical stages, particularly those early on in the process (Achilladelis et al., 1971; Burgelman and Sayles, 1986).

The champion role most closely linked with the initiation of the process of innovation at the fuzzy front end is that of the "gatekeeper" (Allen, 1977; Davis and Wilkof, 1988; Macdonald and Williams, 1994). Gatekeepers are individuals who direct information along one path rather than another, much as a gate functions in electronic circuitry (Davis and Wilkof, 1988), and who decide whether or not (and to what extent) to share information from the environment with others. In this way, gatekeepers indirectly "champion" ideas for new product innovations at the fuzzy front end.

While gatekeeping has received substantial attention in both the TIM and NPD literatures, another individual role that has been studied extensively in the TIM literature but not to the same extent in the NPD literature is "boundary spanning." Boundary spanners have been described as persons who operate at the periphery or boundary of a permeable organization, performing organizationally relevant tasks and relating the organization with elements outside it (Aiken and Hage, 1972; Leifer and Delbecq, 1978; Keller and Holland, 1974, 1975). These individuals are responsible primarily for information exchange between the organization and its task environment, or boundary-spanning activity. Recent research in the TIM literature has come back to this important boundary-spanning role played by individuals, with a new focus on "X-teams" (Ancona et al., 2002). X-teams are those with high levels of external activity, extensive ties inside and outside the company, expandable tiers of responsibility, flexible membership, and execution mechanisms, which facilitate getting the job done. As evidenced by the findings by Ancona et al. (2002), X-teams greatly improve the dispersal of innovation throughout the organization.

Some authors (Tushman and Scanlan, 1981) have made a distinction between boundary-spanning *activity* (activities performed by all individuals in contact with the environment) and boundary-spanning *individuals* (those persons who are linked strongly externally and internally so they can gather and can transfer information). For the purposes of this article, all individuals who perform boundary-spanning activity are boundary-spanning individuals, and boundary-spanning effectiveness is a question of degree. In other words, there may be boundary-spanning individuals who are not effective in their role because they do not have strong networks or are not effective collectors and disseminators of information. This is an important reason to understand better the role of the boundary-spanning individual and of whether there is anything that can be done by organizations to aid them in their role and level of effectiveness.

A more in-depth understanding of how individuals are involved in the early stages of the fuzzy front-end process has been provided by researchers looking at

the importance of "pattern recognition" to these processes (Roos, 1996; Veryzer, 1998). Pattern recognition is, importantly, the jump-start to all discontinuous NPD processes feeding into ideation. Song and Montoya-Weiss (1998) suggest that this observation regarding pattern recognition particularly is salient because past research (Song and Parry, 1997a, 1997b; Urban and Hauser, 1993; Zirger and Maidique, 1993) suggests that NPD is a process of uncertainty reduction and is shaped by the degree of uncertainty managers perceive. Information coordination in support of uncertainty reduction, which aids success with incremental new product activities (Fisher et al., 1997; Gatignon and Xuereb, 1997; Gupta et al., 1986; Souder, 1988; Takeuchi and Nonaka, 1986), is difficult to achieve in the case of discontinuous innovation. As such, pattern recognition at the individual level may take on an even greater role in directing information search.

Third Perspective: The Organization

A third perspective that has been the subject of much research in the NPD literature involves organizational-level processes (product, project and firm) in the creation, development, and marketing of new products. This perspective views the issue of new product "radicalness" according to variations on Ansoff's (1957) typology (Balachandra and Friar, 1997; Booz et al., 1982; Kleinschmidt and Cooper, 1991; Roberts and Berry, 1985; Veryzer, 1998). The primary view in this perspective is that the nature of discontinuity is based on perceptions of both what is new to customers (i.e., the market) and what is new to organizations (i.e., technologies, new product forms). But with discontinuous innovation, we suggest that newness to organizations and that the marketplace actually occurs quite a bit downstream in the innovation process from where newness for a given generic technology originates. We propose that newness in the environment and then newness to individuals in firms actually precede newness for the organization and market. Further, it is newness at the environmental and at the individual level where much of the early fuzzy front-end process for discontinuous innovation occurs (Burgelman and Sayles, 1986; Colarelli O'Connor and Rice, 2001; Crossan et al., 1999; Rogers and Shoemaker, 1971). As a result, much of the early-stage fuzzy front-end process is not well understood or managed at the organizational level. Organizational impact on the fuzzy front end with discontinuous innovation has been investigated only for the later stages of the front end, such as informal screening, managing the R&D–marketing interface, and structured strategy, as was mentioned earlier. For the very early stages of the fuzzy front end, organizational influence has not been understood well and largely has been dismissed as ineffective. According to some researchers (Drucker, 1999; Mowery and Rosenberg, 1998; Veryzer, 1998), the individual decision to share information with others at the organizational level often has tended to have a negative impact by slowing the process down, typically creating a situation where the level of involvement by the firm builds at an extremely slow rate—i.e., in the order of 10 to 20 years for discontinuous innovation. Adding to this, the lack of involvement or understanding by upper management (where strategic, structural, and resource planning occurs), the process may come to a near standstill (Burgelman and Sayles, 1986; Fusfeld, 1978; Khurana and Rosenthal, 1997). The sharing of information at the organizational level is, however, an essential part of building collective intuition (Eisenhardt, 1999). It is important therefore to see whether there are any structures or processes (Davenport, 1993) that can be put in place to help organizations better manage, where possible, the early stages of the fuzzy front end of discontinuous innovation.

Combining the Perspectives

Each of these three perspectives is important to an understanding of the innovation process overall and at the fuzzy front end of this process in particular. The TIM perspective aids understanding of the key roles played by individuals such as boundary spanners and gatekeepers, as well as the impact of environmental variables in creating discontinuous innovation scenarios. The NPD literature, on the other hand, contributes to exposing how both individual-level and organizational-level variables relate to and impact the front-end activities of innovation. Balachandra and Friar (1997) support this observation of the different perspectives between the literatures and the empirical studies that constitute them.

In sum, these literatures suggest that the fuzzy front end of discontinuous innovation involves all three levels—environmental, individual, and organizational—and, in order to understand innovation more fundamentally, these perspectives must be

telescoped together, as is proposed here. According to the literature, the individual acts as an important conduit for funneling environmental-level changes into organizational-level processes through their boundary-spanning and gatekeeping roles. Additionally, by looking at the contextual factors (i.e., discontinuous versus incremental innovation), which this study proposes lead to different problem-solving approaches (i.e., individual versus corporate information search, and unstructured versus structured problem or opportunity solving), how discontinuous and incremental innovations differ structurally in the fuzzy front end may be understood better. These proposed differences in problem structure initiation are highlighted in the next section of this article.

Differences in Problem Structure Initiation: Incremental versus Discontinuous Innovation

One major distinction made in the literature regarding levels of innovativeness is between incremental and discontinuous innovation. Incremental innovation typically involves product improvements using existing technologies and targeted toward existing markets. In contrast, according to Garcia and Calantone (2002), discontinuous innovation entails "radically new" innovations (i.e., those requiring changes to existing technological and to marketing infrastructures) and "really new" innovations (i.e., those requiring market discontinuities or technology discontinuities, but not both).

As such, while incremental innovation reinforces the capabilities of established organizations, discontinuous innovation forces firms to use new problem-solving approaches to develop new technical or commercial skills (Burns and Stalker, 1961; Ettlie et al., 1984; Garcia and Calantone, 2002; Hage, 1980; Tushman and Anderson, 1986).

A key reason why firms may need to develop new problem-solving approaches under new-to-the-world NPD scenarios is related to some important differences in the underlying processes of information flow and innovation movement for discontinuous compared to incremental innovations. Most notably, it is suggested here that incremental and discontinuous innovations differ extensively in the way in which problems are structured and in which information searches are initiated at the fuzzy front end of new product development.

The Case for Incremental Innovation

For incremental innovations, problems can be identified or can be structured by the "organization" (i.e., a small group of individuals, a project team, a strategic business unit, or the entire corporation) and can be sent out to individuals for information gathering in the environment as required (Urban and Hauser, 1993). The organizational- and learning-theory literatures, while holding many views on how individuals and organizations may relate knowledge, are fairly clear on some key aspects of this relationship (Stacey, 2001). First, there is one level of explanation called the "individual mind" and another called the "organization," which is a social structure or institution. Second, knowledge creation in organizations occurs through information sharing from individual minds to organizations. Third, it is possible for humans to transmit mental contents to each other, which can be a basis of shared understanding within the organization. As such, for incremental new products—e.g., simple evolutions, modifications, or adaptations of current products—structured problems typically are laid out at the corporate level or are shared within a social structure in the organization for further analysis and recommendation. This approach is plausible in the incremental NPD case because technological or market conditions can be anticipated, can be studied, and can be communicated quite readily at the organizational level. Indeed, the impetus for incremental innovation often occurs within the corporate sphere of decisions (Crawford, 1980; Tushman and Anderson, 1986) and is directed outwardly to boundary spanners for information gathering. For example, idea-generation techniques such as brainstorming, perceptual mapping, preference modeling and benefit segmentation (Tushman and Anderson, 1986), as methods of identifying new product opportunities, often build on extant platforms within the firm (Clark and Wheelwright, 1993) and almost always are issued from the organizational level outward to boundary-spanning individuals to perform information search tasks. In other words, the organization actually is involved in directing the information search efforts of individuals throughout the entire NPD process for incremental new products (Urban and Hauser, 1993).

H1a: In situations of incremental innovation, problems or opportunities tend to be identified and/or structured by the organization and to be directed to individuals for information search.

The Case for Discontinuous Innovation

For discontinuous innovations, we propose that information typically is unstructured and is brought into the organization by individuals without such activity being explicitly directed by other persons in the organization. Venture groups in organizations may be directed generically to "find something new"; however, the problems or opportunities are not identified or structured by the organization. This proposition regarding the way discontinuous innovations move into firms corresponds to the research findings of Burgelman and Sayles (1986) and of Colarelli O'Connor and Rice (2001), where one or two individuals are found to be the drivers of discontinuous innovation within firms. Such an individual either may be a conduit for information regarding technology specifically (Allen, 1977) or for information, which will impact the ability to link advanced technologies to market opportunities of the future (Colarelli O'Connor and Rice, 2001). Hence, Colarelli O'Connor and Veryzer (2001) distinguish between two types of individual drivers—inventors and ruminators—where inventors are those individuals who play a technology-visioning role and ruminators are those who play a market-visioning role.

Inventors and ruminators usually are responsible for the emergence of new technology within the sphere of the organization because they occupy positions where they either work directly with the new technology or are involved with markets where there is a possibility of an application for the technology (Allen, 1977; Roberts, 1977). Because such individuals are in a position to recognize and perceive new patterns and changes in the environment, they also usually have the ability to impact the movement of ideas to others in the firm. Indeed, much of the early-information search in the case of discontinuous innovation may be driven by these key individuals, without involvement or knowledge of larger groups of people, particularly those operating at higher levels in the organization. As such, the role of the individual takes on a heightened importance (Burgelman and Sayles, 1986; Colarelli O'Connor and Rice, 2001; Colarelli O'Connor and Veryzer, 2001; Crossan et al., 1999; Rogers and Shoemaker, 1971), particularly during the early stages of the fuzzy front end of new product development, prior to project formalization. Burgelman and Sayles (1986) provide a quote from a bench scientist supporting this concept: "Sure, there are times when research ideas come down from above. An R&D manager may read something in *Scientific American*, and that gets him interested in the topic. Of course, by the time it appears there, it's already out of vogue in the real scientific world" (p. 25). This suggests that problems and opportunities are "emergent" and flow from the "bottom up" in the organization (Bower, 1970; Burgelman and Sayles, 1986). In other words, idea or information flow is likely to begin with individuals operating at the technical level, moving upward to small groups or teams that operate at the product level and then moving on to the project-level for implementation (Colarelli O'Connor and Veryzer, 2001; Crossan et al., 1999). Project formalization ultimately leads to a flow of ideas to the organizational level. Burgelman and Sayles (1986) note this process they have coined "up from below": "Understandably we think of strategy formulation as top management work. Most employees, even quite high-level managerial employees, take the goals of the business as a given. But in the high-technology world, strategy often revolves around the innovation activities of relatively low-level technical and business people. To be sure, their decisions will require ratification by top management. Nevertheless…the reality is that those closer to the emerging technology will seek to define the business opportunity" (p. 31). Thus, in the case of discontinuous innovation, we see that the individual is an important conduit for funneling information about environmental-level changes into organizational-level processes. This study suggests, therefore, that the impetus for discontinuous innovation occurs in the opposite direction as that for incremental innovation. Specifically, individuals interacting with the external environment on the firm's boundary are proposed to be the ones engaged in perceiving and in some of the thinking about the environmental changes and/or situations to which they are exposed. They therefore also likely will initiate additional information search to elaborate and further to understand to what they have been exposed. Thus, the problem structure is not explicit at the corporate level, as in the case of incremental new products; rather, it is structured at the individual level. As such, the directionality of initial decisions regarding new environmental information is inward, toward the corporate decision-making level, rather than the other way around.

H1b: In situations of discontinuous innovation, problems or opportunities tend to be identified and/

or to be structured by individuals. Further information search also is directed and is conducted by individuals.

Decision-Making Process at the Fuzzy Front End of Discontinuous Innovation

It is proposed in this article that information flow with respect to discontinuous innovation moves from the environment to key individuals within the firm and eventually toward the corporate decision-making level. These propositions, in conjunction with the literature review, indicate that there potentially are three critical decision-making interfaces—boundary, gatekeeping, and project—that occur during the fuzzy front end for discontinuous innovations. A brief summary is given here and will be elaborated upon in the following sections.

The first proposed interface, called the *boundary interface* here, is proposed to occur between the environment and a boundary-spanning individual. This interface seems typically to involve a flow of information inward from the environment to the individual. Decision-making at the boundary interface is at the individual level and is classified as boundary spanning.

The second interface, called the *gatekeeping interface* here, is proposed to occur between a gatekeeping individual and the organization. This interface typically would involve a flow of information inward from the individual to the organization. Decision-making at the gatekeeping interface is also at the individual level and is classified as gatekeeping. Gatekeepers are frequently the same individuals as the boundary spanners; however, their role has shifted.

The third interface, called the *project interface* here, is proposed to involve a flow of information from the organization to a specific project, which is being considered during the first screening phase. Decision-making at the project interface usually rests with senior managers at the organizational level.

Figure 1 depicts the model of the fuzzy front end in terms of the proposed three interfaces (boundary, gatekeeping, project) involved in the fuzzy front end for discontinuous innovation, the key roles played at the interfaces by individuals, and the general flow of information in the discontinuous case. The interfaces and roles are described in the following section.

The Boundary Interface

The term *interface* has been used in the public vernacular since the 1960 s, when the computer industry began using it to designate the point of interaction between different elements of a computing system (e.g., the interface between a computer and a printer). In this article, the term interface denotes a point at which independent systems or diverse

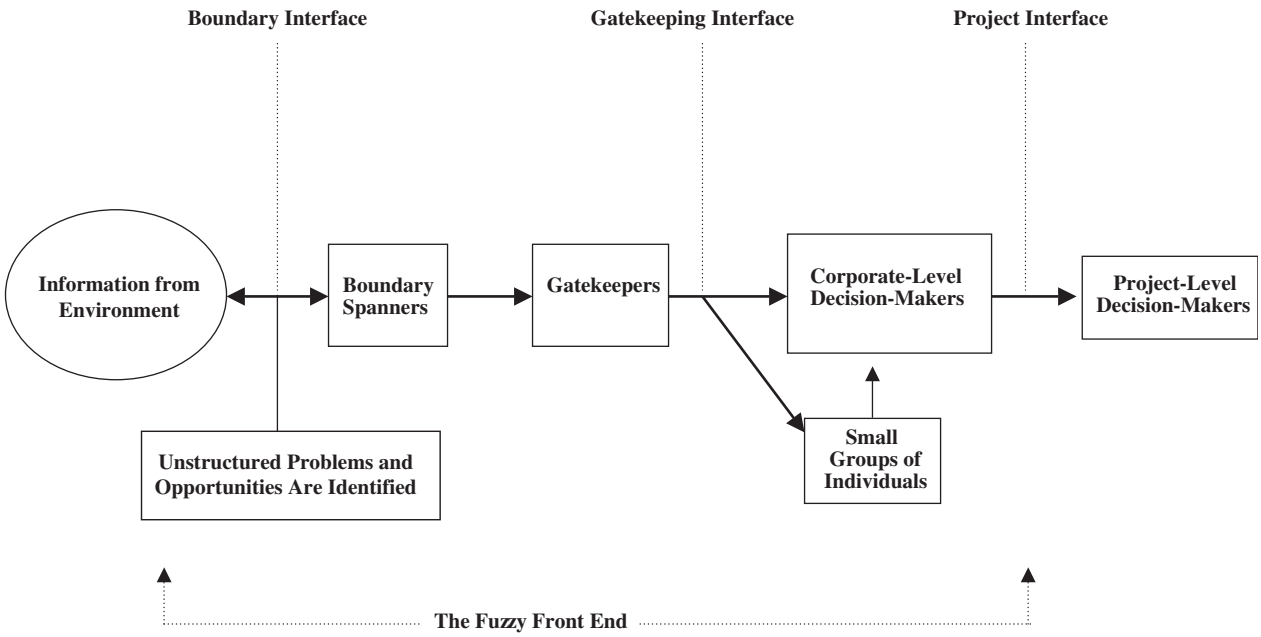

Figure 1: Fuzzy Front-End Information Flow and Decision-Making Process: Discontinuous Innovations

individuals or groups interact. With the boundary interface, the interacting systems are proposed to be the organization's environment and an organizational boundary-spanning individual who interfaces with that environment. In effect, the individual, the organization, and the environment are part of a network of interactions and knowledge exchange. Thus, the role of the organization is described in relation to its environment, it is largely the individual within the organization, playing an external contact role, who is responsible for organizational-level involvement in the network. Such individuals are boundary spanners, as they link the organization with their external environments (described in detail previously) (Aiken and Hage, 1972; Ancona et al., 2002; Keller and Holland, 1974, 1975; Leifer and Delbecq, 1978).

The Individual and the Environment: Role as Boundary Spanner

As has been described, new information from the environment is the most important input to organizational processes of innovation. How does such information enter and interact with the organization? This is an important question because "organizations do not intuit." Rather, "this is a uniquely human attribute that organizations do not possess" (Crossan et al., 1999, p. 525). "Intuition" at its core is pattern recognition (Roos, 1996). Pattern recognition is a form of distinction making, which effectively allows individuals to separate potentially relevant from irrelevant background information through processes of perception (quick identification, clear understanding, and interpretation ability), reconstruction (representation ability, creative imagination, inference, synthesis), and classification (evaluation) (Bunge, 1962). In the case of discontinuous innovation, we propose that it is the individual's ability to make a distinction regarding an unaddressed market need or a new technology path—due to some recurring elements in the environment—that is the starting point for building new organizational knowledge. That is, the individual recognizes patterns in the environment by perceiving new information in the environment, thereby marking its existence and attempting to determine and to classify the factual content of this information in relation to information already known.

H2: In situations of discontinuous innovation, information and idea flow moves from the environment to a boundary-spanning individual across an interface, called the boundary interface, stimulated by the encounter or perception (i.e., intuition) of information in the environment.

The Gatekeeping Interface

With the gatekeeping interface, the interacting systems are proposed to be a "gatekeeping" individual who interfaces with his or her organization. Several authors have demonstrated that, while invention occurs primarily at the individual level, innovation requires a social context in which to unfold (Higgins, 1995; Marquis, 1969; Schumpeter, 1939; Van de Ven, 1986). In other words, "invention" is a cognitive process, while "innovation" is a social process. This distinction is important to the discussion at hand because few authors, with the exception of Burgelman and Sayles (1986), Colarelli O'Connor and Rice (2001), Crossan et al. (1999), and Rogers and Shoemaker (1971), have attempted to make a linkage between invention, as an essentially cognitive process at the individual level, and how it feeds into the larger process of innovation at the social or organizational level. The gatekeeping interface is proposed to involve this important process of information flowing from the individual to the organizational level.

The Individual and the Organization: Role as a Gatekeeper

The gatekeeping interface is the point at which information flows from the environment are evaluated in terms of their relevance to the organization. This initiation of knowledge sharing across organizational boundaries appears to be primarily an individual decision process or initiative referred to as "gatekeeping" (Allen, 1977). Specifically, Allen's (1977) work found that R&D projects perform best when gatekeepers maintain high levels of communication with colleagues outside their organization. Effectively, this means that successful gatekeepers are also good boundary spanners. It is proposed that individuals who play both the boundary-spanning and the gatekeeping championing role in organizations are especially important under discontinuous new product development scenarios. By bringing new ideas into the organization via their gatekeeping function, these individuals play an all-important "championing" role

for new-to-the-world products. This proposition is supported by research in both the TIM (Allen, 1977; Burgelman and Sayles, 1986) and the NPD (Macdonald and Williams, 1994; Markham, 1998; Veryzer 1998) literatures. Therefore, it is proposed in this study that after perceiving patterns in the environment in their boundary-spanning role, some individuals begin to examine the value of sharing this information with others within the organization. It is at this stage that they begin to play the role of gatekeeper by moving information to the organization across the gatekeeping interface. Questions and decisions at this interface involve individuals determining what this new environmental information means for both themselves and for the organization (value construction) and, based on this, whether or not and how to share it at the organizational level. These activities represent the gatekeeping functions for the individual.

The literature regarding gatekeepers deals primarily with the ''technological gatekeeper'' who, according to Nochur and Allen (1992), ''is a high technical performer who connects an organization with outside sources of technology. He keeps up with new technical developments outside the organization by reading the more technically sophisticated literature and by communicating with external technical experts. Further, because of his proven technical competence he is frequently consulted on technical matters. As a result, the gatekeeper is a very efficient channel for transferring technical information into an organization from external sources'' (p. 265). As proposed previously, gatekeepers typically also occupy boundary-spanning positions, implying that, in the case of technological gatekeepers, they not only will fulfill technical responsibilities for the organization but also will be involved formally or informally with research groups from outside the organization. The literature also speaks of ''marketing gatekeepers,'' who play an important sensing role, their function being to mirror the role of the technological gatekeeper in sensing, collecting, and channeling both market and technical information (Roberts, 1977).

Related to this idea that there are two types of gatekeepers, it is important to note that in discontinuous innovation situations there may be two main waves of information gathering and decision-making activity, or more generically ''opportunity recognition'' (Colarelli O'Connor and Rice, 2001), across the boundary and gatekeeping interface, prior to the project interface. With the first wave, a technical person, or the ''inventor'', plays the role of both boundary spanner and technical gatekeeper for technical information and decisions regarding the discontinuous innovation. With the second wave, either a technical or a marketing person, also known as the ''ruminator,'' will play the roles of boundary spanner and marketing gatekeeper. It also is possible that the inventor and ruminator is the same individual. There are two main distinctions between these two ''waves.'' One is that technical gatekeeping activity typically precedes marketing gatekeeping activity with truly discontinuous innovation (Roberts, 1977). Another is that while both types of gatekeepers play an important role in information sharing at the organizational level, the nature of the value creation between the two waves is substantially different. While the technical gatekeeper is likely to provide information regarding the technical value of the new technology, it is the marketing gatekeeper who will prove a business context or market value for the situation. In other words, gatekeepers importantly determine what new environmental information means for the individual and organization in terms of value construction. For example, while it is well known that the invention and development of the yellow Post-It at 3 M took place in the corporate lab of Dr. Spence Silver in 1968, the impetus for this development has been described as a result of the ''aha'' experience of Art Fry much later on. According to the 3 M website, www.3m.com, ''Many 3Mers know the famous story of how Fry came upon the Post-It Note concept out of frustration at how his scrap paper bookmarks kept falling out of his church choir hymnal. In a moment of pure 'Eureka', Fry realized that Silver's adhesive could make a wonderfully reliable bookmark. The broader concept of the Post-It Note soon followed, along with paper tapes and labels using Silver's adhesive.'' This recognition led to an understanding of how the glues that Silver had been developing for years could be utilized. Thus, without the external context for understanding, the semi-adhesive glues they had been developing had no meaning.''

Colarelli O'Connor (1998) supports this notion of multiple roles in the fuzzy front end. In the early stages, the ''technology voice'' is stronger, while in the later stages the ''market voice'' becomes louder because with truly discontinuous innovation, markets may not have emerged yet or may not have been created. Colarelli O'Connor found that assessments of market potential, size, and growth were not at issue during early stages but only came into play once

attention was turned to finding applications for a given technology. This is critical to understanding the multiple roles played during the fuzzy front end by individuals with various backgrounds: initially, those involved with the technology context creation and later, those involved in the business context creation.

H3: In situations of discontinuous innovation, information and ideas flow from an individual playing a boundary-spanning role to an individual playing a gatekeeping role (often the same person) to the organization itself. This movement of ideas or information across an interface, called the gatekeeping interface, is stimulated by value construction and information sharing.

The Project Interface

The project interface represents the interface between the organization and a commitment to a specific project. Typical questions at this interface likely entail determining how best to evaluate the new ideas given the organization's extant NPD strategy, how to get more information, and how to proceed with the first formal screen. Once decision-makers at the organizational level become aware of the new ideas being forwarded by individual gatekeepers, they are able to begin the function of integrating information regarding these new ideas into the new product development strategy of the organization.

One key way in which organizations achieve defensible competitive advantage (Goodman and Lawless, 1994) is through their new product selection strategies. The first step identified in most models of the NPD process is the strategy step (Booz et al., 1982; Cooper, 1990; Griffin, 1997). Following this, idea generation usually is seen as the next step in most new product development models. In the discontinuous innovation case, however, and from a pure decision-making perspective, it has been proposed in this article that these steps actually are reversed. In other words, in the discontinuous case, the idea-generation process is an ongoing one at the individual boundary-spanning level and, at some point in time—when individuals share their information with the firm (gatekeeping)—ideas begin the process of being captured within the formal decision-making process of the firm, or its "strategic web." A strategic web can be thought of as a porous and adaptable outline within which an organization has decided to play strategically in terms of markets, applications, technologies, and products.

The Organization: Information Integration within the Strategic Web

In order for a discontinuous innovation actually to reach the project level—that is, to be considered as a potential NPD proposal for formal screening by the firm or to become part of the product innovation charter (PIC) of the firm (Crawford, 1980)—information about the innovation first must become part of the "strategic web" of the organization.

To elaborate this point further, new product development strategy sometimes has been referred to as the *strategic arena* (Crawford, 1980; Cooper, 1993) or *strategic envelope* (Sharma, 1999), within which new ideas either fit the organization's requirements or not. Cooper (1993) defines the strategic arena as the specification of the arena in which the game will be played; that is, it defines the types of markets, applications, technologies, and products on which the firm's new product efforts will focus. Sharma (1999) defines the strategic envelope as all acceptable projects with a common technology or market theme. It is felt in this study that conceptualizations of how radical new product ideas fit with ongoing strategy is too constrained and is not open enough to radical ideas, particularly those that do not make sense in the light of current competencies or markets on which the organization is focused.

The notion of *emergent strategy* (Burgelman, 1984; Mintzberg, 1979; Mintzberg et al., 1996) captures strategy as an unplanned, bottom-up process, often arising from autonomous actions of individuals deep within an organization. This view, however, does not explain how the emergent strategy relates, or could possibly relate, to a firm's stated strategy. Thus, this study proposes the concept of the *strategic web*, which connotes that a newly emergent strategy or set of ideas somehow must mesh with the old. The web is linked to the current, or stated, strategic context, but it also is porous and can grow as required.

H4: In situations of discontinuous innovation, information and idea flow moves from the organization to the project level across the project interface, stimulated by information integration within the strategic web and an evaluation of how to proceed with the formal first screen for radical new ideas.

Summary and Conclusion

The focus of this article has been to develop a more detailed and concrete view of the fuzzy front end of the new product development process for discontinuous innovations. To date, most NPD process models in the literature focus on the nature of activities and decisions undertaken by the firm at or after a project has received the green light. In other words, these models deal with new product ideas or innovations that already are part of the stated new product strategy of the firm. This is because incremental innovations, which form the bulk (90 percent) of all new products, typically are initiated at the organizational decision-making level, which overlays and guides the project level of the NPD process. Moreover, even when the focus of discussion is discontinuous innovation, researchers have tended to invoke NPD processes, which are relevant for incremental projects. It is proposed here that discontinuous innovations move into the organization in a different way. They tend to originate in the environment and are initiated by individuals operating as boundary spanners and gatekeepers for the firm. It is this process of identifying, understanding, and acting on emerging patterns in the environment that is the essence of the "fuzzy front end" and that, so far, largely has eluded articulation in the form of NPD process models.

A model of the fuzzy front end of the NPD process for discontinuous innovation is proposed here. This model attempts to articulate the NPD process for discontinuous innovations as a series of first, individual-level and second, corporate-level decisions, which occur over three key interfaces: the boundary interface, the gatekeeping interface, and the project interface. The first two interfaces, leading up to the third—i.e., the decision to invest in a given project or not—essentially comprise the fuzzy front end. By providing a focus on the nature of decisions at the fuzzy front end for discontinuous innovations, it is hoped that a more fully integrated model of the fuzzy front end may be developed to account for all levels of product innovativeness. By providing a more comprehensive understanding of the research that has been conducted to date and by providing greater insight into the nature of the fuzzy front end by developing a series of testable propositions, key challenges and potential managerial interventions for improving the process may be addressed in future research.

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