J PROD INNOV MANAG 2013;30(2):209–227

DOI: 10.1111/j.1540-5885.2012.00996.x

New Market Creation for Breakthrough Innovations: Enabling and Constraining Mechanisms

Gina Colarelli O'Connor and Mark P. Rice

While the technological development associated with breakthrough innovation (BI) is truly challenging, creating markets to stimulate their use may be an even more daunting barrier to successful commercialization. Co-development partners, distribution channel agents, and ultimate users are all required to adopt new processes and to change behaviors in many cases, and the outcomes are unknown. In this paper, the processes and challenges associated with creating new markets for BIs are explored in a qualitative prospective cross-case comparison of 12 breakthrough projects under development in 10 large established companies. A number of activities that take place in implicit fashion that create both enabling and constraining mechanisms for BIs are observed. The data suggest, for example, that the earliest application choices that scientists make in the project's development ultimately affect the revenue model, that scientists are unaware of the impact of these decisions, that business model development is a very exploratory process, that criteria used to choose initial market entry points conflict with the expectations of operating units, and that the concept of a killer application can be rather dangerous to the health and well-being of a BI in its commercial infancy. It is argued that new market creation is the result of managing a specific set of events and activities, which are identified in a grounded theoretic fashion. The companies studied, however, were neither fully aware of nor systematically attentive to these activities. A framework is presented of enabling and constraining mechanisms that teams and organizations impose through the processes and decisions they take in the course of the project's development, and a series of propositions regarding the dynamics of successful new market creation for BIs is offered.

The implications of these results are far-reaching. These results show that market creation for BIs may require as much time and investment as their technical development. We do not find evidence of large established organizations' awareness of or willingness to make these investments as readily as they invest in technical development. The result is research and development labs at large established firms with stockpiles of potentially game-changing technologies. To evolve a mature BI commercialization *competency, a firm must recognize and address the implications for managerial processes, for personnel recruitment, for setting leaders' expectations, and for developing appropriate performance metrics for those responsible for market creation that go beyond technical discovery and engineering development. Implications for each are discussed.*

Introduction

While scholars and business leaders agree that breakthrough innovation (BI) is critical to a company's long-term growth and renewal (Christensen and Raynor, 2003), the management principles of operational excellence, customer satisfaction, and incremental innovation dominate large mature companies. These objectives drive practices that are contrary to what is needed for BI (Cheng and Van de Ven, 1996; Sethi and Iqbal, 2008), where routinization is ineffective, and variation creation is critical (Chandy and Tellis, 1998; Eisenhardt and Martin, 2000; Garvin, 2004). Scholars have long called for "ambidextrous" organizations (O'Reilly and Tushman, 2004), meaning those that can simultaneously manage exploratory and exploitatory innovation. Recent research has focused explicitly on the challenges and potential approaches to developing ambidexterity (Raisch, Birkinshaw, Probst, and Tushman, 2009).

While the ability to manage both the new and the current simultaneously is critical, a more fundamental problem exists. Organizations are deficient in their capabilities for managing the "exploratory" side of the ambidexterity equation. While part of organizations' problems with regard to ambidexterity lie in facilitating the ongoing balance between exploration and exploitation, a large body of evidence indicates simply that large companies do not manage exploration well. Exploration, as described in the literature on ambidexterity, includes the

Address correspondence to: Gina Colarelli O'Connor, Lally School of Management and Technology, Rensselaer Polytechnic Institute, 110 8th Street, Troy, New York 12180-3590. E-mail: oconng@rpi.edu. Tel: 518-276-6842.

development of whole new platforms of business based on novel opportunities, or potential BIs (March, 1991; O'Reilly and Tushman, 2004). Case-based descriptions of how BIs emerge consistently note the high degree of uncertainty, ambiguity, and unpredictability that besets their development paths (Morone, 1993; Norling and Statz, 1998), and the learning-oriented and discovery-driven processes required to commercialize them (Lynn, Morone, and Paulson, 1996; McGrath and MacMillan 1995; Rice, O'Connor, and Pierantozzi, 2008).

In this paper, business model development and new market creation activities for BIs in large established firms are examined. BI projects are defined as those that produce an entirely new set of performance features, an order of magnitude improvement in known features, or dramatic reduction in cost.[1] BIs either transform existing markets and industries or create new ones. This definition is a market-based one, in that the criteria have to do with the BI's impact in the market. Innovations that are new to the firm but not to the market do not, in this conceptualization, constitute BIs. This definition is aligned with Garcia and Calantone's (2002) notion of major innovation, which is characterized by high uncertainty on either the technical and/or market dimension, at both the macro (in the market place) and the micro (within the firm) levels. Further, it recognizes the organizational and resource challenges that firms face when undertaking BI.

While developing breakthrough *inventions* presents challenges for established research and development (R&D) organizations (Ahuja and Lampert, 2001), less attention has been paid to the later phases of the innovation process: successful market creation. For BI success, the initial invention is only part of the issue. Particularly when the breakthrough technology is fungible (Danneels, 2002), numerous choices arise regarding the scope of the opportunity landscape. Part of the commercialization process for BI is the creation of a new business: new markets, new revenue models, and new partners. "The market was not ready" is an explanation that has gone unchallenged in academic research.

Managerial practices, it is proposed, can be brought to bear in a proactive manner to create markets when a technological innovation enables new, valuable functions. The data reported in this paper demonstrate that conventional product launch techniques are not utilized to create new markets. A host of challenges are present in the commercialization of a BI that belies the skill sets and processes resident in most mature businesses today. The data also indicate that active management of the new market creation process is a rare event and is not approached systematically or explicitly. For the most part, firms rely on the market to ready itself.

Based on a longitudinal, prospective study of 12 projects perceived to have breakthrough potential, we report examples of passive and active management of market creation as BIs mature, and we offer a perspective on how it might be handled more effectively. We identify a set of key events that, if actively managed, could potentially set the foundation of new market creation. What emerges is that (1) market creation begins almost as soon as a project's technical feasibility is proven, (2) market creation can be proactively managed, (3) the fit of the BI within the organization's structure affects how business model development and market creation activities are managed and interpreted, and (4) markets for BIs do not necessarily evolve in ways that managers expect or that align with established performance metrics. This mismatch of expectation and reality leads to disappointment, frustration, and continued mismanagement. One objective of this paper, therefore, is to signal that the activities,

[1] This definition was arrived at through a review of the literature and in conjunction with members of the Industrial Research Institute, a professional organization of R&D leadership of Fortune 1000 firms (see http://www.iriweb.org/). The IRI sponsored this research. Our definition is prospective rather than retrospective.

BIOGRAPHICAL SKETCHES

Dr. Gina Colarelli O'Connor is a professor of marketing, director of the Severino Center for Technological Entrepreneurship, and academic director of the Radical Innovation Research Program at Rensselaer Polytechnic Institute's Lally School of Management and Technology. She researches, teaches, and consults on the topic of managing for breakthrough innovation in large established organizations. Professor O'Connor's teaching and research interests lie at the intersection of corporate entrepreneurship and radical innovation, marketing, and commercialization of advanced technology. The majority of her research efforts focus on how companies link advanced technology development to market opportunities and how they build capabilities for breakthrough innovation. She has published more than 50 articles in refereed journals and books. Four of her papers have won the best paper of the year award in *JPIM*. She is coauthor of the book *Radical Innovation, How Mature Firms Can Outsmart Upstarts*, published by HBS Press in 2000, and is the lead author of *Grabbing Lightning: Building a Capability for Breakthrough Innovation*, published in 2008 by Jossey-Bass, and named one of the best business books of the year by *Business&Strategy* magazine.

Dr. Mark P. Rice is the dean of the School of Business at Worcester Polytechnic Institute and holds the Harry G. Stoddard Endowed Professorship in Management. Rice is coauthor of *Radical Innovation: How Mature Companies Can Outsmart Upstarts*, and his research on corporate innovation and entrepreneurship has been published widely—in academic and practitioner journals including *Sloan Management Review*, *Organization Science*, *R&D Management*, *Journal of Marketing Theory and Practice*, *IEEE Engineering Management Review*, *Academy of Management Executive*, and *California Management Review*. Dr. Rice holds BS and MS degrees in mechanical engineering and a PhD in management from Rensselaer Polytechnic Institute.

skills, and expertise that facilitate market creation are not being addressed by managers or scholars. Another is to identify enabling and constraining mechanisms that affect new market creation.

Through the lens of these data, a better understanding of how BI challenges the business model development and market-creation activities of large companies can be developed; an outcome that should attract increased research attention and lead to improved innovation management practice.

Relevant Theory

Scholars from the fields of entrepreneurship, marketing, and strategy have contributed to an increasingly rich theoretical base for understanding agent-driven organic growth. The framework of market-driving behavior as well as opportunity creation theory, exploratory learning theory, and effectuation theory are particularly relevant to the research question.

Market-Driving Behaviors of Firms

The concept of market-driving behavior (Jaworski, Kohli, and Sahay, 2000) offers an institutions-based lens on how firms can create new markets for BIs. Market-driving behaviors are defined as firm-level activities that affect two distinct dimensions of the market: (1) its structure and (2) its behavior. Summarily, *market structure* can be shaped in three ways: through deconstruction (eliminating players in the value chain or value network), construction (shaping markets by adding players to the value chain with complementary offerings or by enticing new organizational forms and agents to enter the value network), and functional modification (shifting the tasks of current players through forward or backward integration or through disintermediation). *Market behavior* can be shaped either directly, by building or removing constraints in the buying experience, or indirectly, by creating new customer and competitor preferences or by reversing current customer and competitor preferences. While these definitions offer an interesting taxonomy of new market creation outcomes, they do not explain the mechanisms by which managers actually enact such changes. Three theories address how decisions are made that may or may not result in "market-driving" outcomes.

Opportunity Creation as a Theory of Entrepreneurial Action

Offered as an alternative to the predominant view of entrepreneurs as *discoverers* of existing opportunities that they then exploit (Shane, 2003), *creation theory* recognizes that opportunities are not always objective phenomena created by change in a market, but rather may be endogenously created by the actions of people seeking ways to develop new offerings (Alvarez and Barney, 2007; Baker and Nelson, 2005). The seeds of opportunities do not necessarily lie in previously existing industries or markets that experience an exogenously driven change. Rather, the entrepreneur's beliefs and actions are their source. Entrepreneurs rely on their networks, on technological discovery, and on their own action. They act, observe how the market responds, and adjust accordingly.

Given the very high levels of uncertainty regarding the relationship of actions to outcomes (Cheng and Van de Ven, 1996), entrepreneurs use learning-based project management approaches, which are rooted in the experimentation (Eisenhardt and Martin, 2000). The results of such experiments are difficult to interpret, depend on very small sample sizes (e.g., customer partners), and may even be misleading. Decisions are made using biases, heuristics, and logical incrementalism based on beliefs and small bits of incoming information (Hayward, Shepherd, and Griffin, 2006). Therefore, redefinition of markets, customers, and business models are considered the norm rather than an error or exception, as they may be in a discovery theoretic view. Thus, opportunities are emergent, or revealed, rather than discovered (Alvarez and Barney, 2007).

The creation theory of entrepreneurial action highlights differences in how opportunities emerge for highly uncertain offerings compared with a "discovered" mismatch between market needs and current offerings. It incorporates cognitive components, process components, learning orientation, and decision-making styles. How creation actually unfolds in an organization, however, may inhibit much of this activity. By surfacing organizational processes that impede or enable new market creation through empirical observation, we may gain insight into the veracity of this theory as applied within the established organizational context and shed light on how management practice may benefit.

Exploratory Learning Theory

The activities required to develop major technological innovations into commercial businesses have long been regarded as exploratory rather than exploitatory in nature (March, 1991; McGrath, 2001). Exploratory activities can be characterized as those in which high variety is required rather than discouraged and in which multiple market possibilities are generated and tested in an experi-

mental manner (Geroski, 2003; Lynn et al., 1996). Recent theoretical development in exploratory learning (Danneels, 2007; Eisenhardt and Martin, 2000; Miller, Fern, and Cardinal, 2007) suggests that to deal with the unfamiliarity of new domains, firms may be better off relying on frequent experiential actions that promote early insights than on well analyzed and heavily resourced commercialization attempts.[2] Exploring as much of the entire landscape as possible prior to committing to any single direction is regarded as key to advancing organic growth options through innovation (McGrath, 2001).

Exploratory learning theory notes the problems of path dependence on the part of managers, which may limit the initial choices they make (Gruber, 2010). Some scholars, however, question the deterministic nature of path dependence as described in the literature, and they note that human agency plays a role (Garud and Karnoe, 2001). Aligned with opportunity creation theorists, they propose the contrasting perspective of *path creation*, highlighting that entrepreneurs actively shape new markets and create opportunities where none may have previously existed (Luksha, 2008; Read, Dew, Sarasvathy, Song, and Wiltbank, 2009; Zahra, 2008). This literature treats entrepreneurial action as "free wheeling" and informal, completely opportunistic, and working outside the strategic boundaries of the firm (Zahra, 2008).

Exploratory learning has focused on identifying appropriate processes to enhance effectiveness and efficiency of learning. The most distant reaches of a domain, for example, are proposed as providing the best learning opportunities (McGrath, 2001; Miller et al., 2007), as they are the least familiar. Those experiments that are conducted far from the well-known technological domains within the firm's portfolio often generate more novel solutions and insight than those experiments conducted through an incremental approach (Ahuja and Lampert, 2001; Bhardwaj, Camillus, and Hounshell, 2006; Sorensen and Fleming, 2004). While the theoretical criterion of domain distance may be useful, the literature does not address at an empirical level the issues and challenges that teams face as they make those decisions. A prescription of "distant" search can neither explain nor inform actual decision-making processes and the perspective of those making the decisions (Lovas and Goshal, 2000). In fact, the literature considers distant search as random (Bhardwaj et al., 2006), echoing Zahra's (2008) prescription of "freewheeling" activity and countering the concepts of opportunity creation (Alvarez and Barney, 2007) and market-driving activities (Jaworski et al., 2000).

Additionally, the ability for an innovation team to execute on a distal application may be hampered by the lack of political support needed within the organization (Zahra, 2008). The literature recognizes and clearly describes organizationally based routines and traps that prevent successful exploration (Ahuja and Lampert, 2001; Danneels, 2007), but consideration of substantive approaches to circumventing those challenges at the project level is only beginning to emerge.

Finally, empirical research to date is equivocal as to the real value of distal search or the appropriate process for maximizing its potential. Bhardwaj et al. (2006) show that search for applications in distant domains is not, in fact, freewheeling, but it is more aptly characterized as a "moving, anchored process." They find that the firm first selects a broad domain where search will be conducted and then chooses a search anchor within that domain to guide further search for growth possibilities based on positive feedback. The combination of search process and content searched influences the particular growth possibilities discovered and created.

While Bhardwaj et al. (2006) describe the process from a behavioral perspective, they do not report on the political considerations of the approach as recognized by the actors engaging in the new market creation activity. They do not explain the criteria used to select anchor points, nor the impact of those criteria on project progress. Thus, while they shed light on an ongoing process, there remains much to learn regarding these processes and decision-making dynamics.

Effectuation Theory

Whether freewheeling or moving-anchored, local or distant, exploratory learning theory as described above suggests that multiple market possibilities are generated, and options are placed in an experimental manner (Geroski, 2003; McGrath, 2001). Project teams deploy their technologies into new markets to "probe" and "learn" and then, on the basis of that learning, may redirect into a new space or reconfigure their technology (Danneels, 2002; Lynn et al., 1996). This dynamic is

[2] We distinguish exploratory learning from recent augmentations to phase gate practices referred to as "spiral processes," in which product development teams cycle quickly through the stages from opportunity to testing so that ideas are winnowed in successive passes, in the interest of speeding them to market in the most efficient manner (Hauser and Griffin, 2005). We do not see these as related to exploratory processes. They are still mechanisms aimed at increasing efficiency rather than maximizing insight. There is no mention of engaging with markets that are unfamiliar to the firm, of unearthing new and perhaps unanticipated applications for the innovation, or at discovering new aspects of the value proposition: key issues that exploratory learning theory highlights, and that are key to our arguments in the paper. We thank an anonymous reviewer for pointing out the spiral processes concept.

challenged, however, by effectuation theory, which notes that the act of exploration presumes knowledge of the universe of market possibilities, and then the election of one over the others to explore (Sarasvathy and Dew, 2005). While such a practice may be appropriate for the search for a market that may be new to the firm but existent nonetheless, the creation of a wholly new market is different; rather than searching and selecting from among all possible markets, rather it is a series of transformations on extant reality.

Transformation processes create new markets through the development of an effectual network, a chain of stakeholder commitments over time. Effectuators (actors working to create a new market) may or may not begin with an opportunity. They start with what and whom they know, and begin acting upon whatever they can afford to do. Effectuation theory recognizes the existence of bounded rationality and partial knowledge. Rather than beginning with an opportunity, the theory suggests that the available set of human and institutional resources, brought together in the form of commitments, shape the opportunity. The commitments that are made help bound the uncertainty inherent in the new market creation challenge.

Similar to opportunity creation theory, the end product of the effectual process is inherently unpredictable at the beginning. But rather than based on the actor's belief about an opportunity's possibilities (as in the case of creation theory), the unpredictability of the outcome in effectuation theory is due to the fact that the process is actor centric: the new market that is created is an outcome of the interaction between network actors. Network member recruitment is characterized as quite passive. There is no screening or evaluation of potential network members to determine who *should* join. Rather, membership is determined on the basis of who *can* join subject to a set of global and local constraints at the time. Effectual transformation, then, theorizes that the new market's characteristics are determined more by who enters the network, via self-selection, than by active recruitment of members who are aligned with the network members' commonly held vision or beliefs of the new market possibilities.

Given the importance of stakeholders and their commitments, along with the recognition of team members' bounded cognition, it becomes important to consider how firms might move from the "blind leading the blind" processes described by effectuation theory to a logic of activities and decision criteria that may enhance the new market creation process. Characteristics of project team members and activities designed to develop a breadth of stakeholders to explore the boundaries of an opportunity space are emerging issues that may help overcome the limits of bounded cognition. While effectuation theory is rich in its description of a potential pattern of events, it does not address how managers might improve the market creation process.

Taken together, these theoretical perspectives suggest that scholarly understanding of new market creation activities and decisions from within the firm, based on potential breakthrough opportunities, is in its infancy. Insight into the internal dynamics of these decisions may help scholars and practitioners understand the context in which BI teams make such decisions that either nurture or constrain the opportunity, and may help develop an approach for managing market creation in a purposeful way. Our research question of interest is "what are the dynamics that prevent and promote new market creation based on potentially breakthrough technological innovation?" The research study reported here allowed us to observe BI project teams in the act of new market creation. From this vantage point, we were able to gain insights into the dynamics of these activities and the challenges BI teams faced in enacting them.

Methodology

Research Process

This study is part of a longitudinal research program centered on understanding the management processes associated with BI in mature firms.[3] The unit of analysis was the BI project. Data collection began in 1995 and proceeded formally through 2000; periodic follow-ups on project performance have been conducted since then. The nature of this inquiry dictated a prospective, longitudinal research design and a multiple case study methodology (Eisenhardt and Graebner, 2007; Yin, 1994). The research process as described by O'Connor, Rice, Peters, and Veryzer (2003) for conducting longitudinal, multidisciplinary, and qualitative research was followed.

The interview protocol was based on a review of the literature, company reports and documents, and discussions among research team members and members of the Industrial Research Institute. The protocol evolved as the research team learned to adopt the respondents' vocabulary and see issues from their perspective. Questions pertinent to this paper centered on (1) the origin of the project and its place in the company's evolving strategy;

[3] The research was funded by a generous grant from the Sloan Foundation.

(2) the roles of individuals on the project team, at leadership levels, and in the receiving unit that would ultimately be expected to commercialize the project; (3) how much team members interacted with the market during the project's maturation; (4) how team members gained confidence in the project's potential for success; (5) how and when team members began to think about money-making opportunities; (6) which team members were responsible for business model aspects of the project; (7) how choices were made about what the value chain should look like and what new agents were required to comprise a complete value chain and associated set of partners; (8) how team members in the receiving unit evaluated the project; (9) how team members in the receiving unit considered and evaluated application market opportunities; and (10) how managers in the receiving unit were evaluated given the uncertainty inherent in the market-creation process.

Building and Qualifying the Sample

Upon hearing the study proposal, members of the Industrial Research Institute (IRI) volunteered their firms to participate and nominated projects for inclusion. R&D managers were asked to consider projects that had been assigned personnel and a budget, and that might affect the market in the ways described in our operational definition of BI (offered either new to the world performance features, significant improvement in known features, or a dramatic reduction in cost). This operational definition was used to qualify project teams into the study. Objective performance measures could not be used because the research design was prospective. Projects were still under development throughout the observation period, so market performance was unknown and in some cases still is. We tried to maximize the diversity of the sample across technological environments to increase the possibilities for comparison and theory development (Glaser and Strauss, 1967).

Twelve projects in 10 diversified firms were enlisted, including Air Products, Analog Devices, DuPont, General Electric, General Motors, IBM, Nortel Networks, Polaroid, Texas Instruments, and United Technologies Corp. All of the innovations involved multiple technologies. Table 1 provides descriptive data for each.

Although the maturity of the projects varied when they were first qualified, all were far from commercialization. While they resided in R&D at the beginning of the study, several came from operating units. By the study's end, 6 of the 12 projects were commercialized (Table 1). Of the six projects that were not commercialized, four had been killed, and two were still under development in some form (just beginning production or gaining first revenues). Four of the six commercialized projects had spawned new businesses. The others were considered less than successful.

Data Collection and Analysis

To guard against post hoc rationalization (Van de Ven, 1986), a prospective approach to data collection was used. Each company hosted at least two site visits and granted access to staff—senior managers, project managers, and team members—who could provide historical and current information. A company-designated liaison chose interviewees who had pertinent knowledge and could provide diverse perspectives about the project. At least three people, usually more, were interviewed to reduce the risk of bias (Eishenhardt, 1989; Yin, 1994). Interviewees included senior R&D managers, project managers (the most consistent point of contact over the 5-year period), program managers in the receiving businesses, commercial development specialists, senior scientists, technical specialists, manufacturing specialists, original inventors, and design specialists. A total of 94 people were interviewed, some multiple times over the 5-year observation period, for a total of 186 interviews. While these were the primary source of data, internal documents including internal presentations, timelines and resource data, and white papers from the early phase of each project were also examined.

Data collection occurred in three phases. In phase I, on-site interviews were conducted with one or two members of the team to qualify the project and to document the chronology of events. In phase II, a day-long site visit, key team members were interviewed. Phase III consisted of annual interviews via conference call during which team members were asked about changes, problems, and solutions. All interviews were taped and transcribed.

A cross-case comparison method was used to elicit key themes (Glaser and Strauss, 1967; Miles and Huberman, 1994; Yin, 1994). This allowed us to understand the phenomena beyond each firm's context (Eisenhardt and Graebner, 2007). A representative set of interviews was coded, to establish common themes. From the themes, seven categories emerged that were used to classify the remaining interview data. Each interview was reduced, analyzed, and coded separately by each author independently, and the results were compared. This pattern of coding and data reduction was repeated two more times, a procedure suggested by Miles and Huberman (1994,

Table 1. Project Age, Status in the Commercialization Process, and Key Challenges

Case Number	Project Status–End of Observation Period	Key Challenges	Project Outcome as of Mid-2009
1 1982	Has identified and pursued three applications; two have proven nonbeneficial through early experiments: technology's limits have been identified as a result.	Find a money-making application. Figure out how to produce reliably. Problems with bringing manufacturing partners up to competency level.	Not yet: still promising. Large-scale test unit up and running.
2 1975	In the marketplace. Four platforms currently, profitable in one application domain. Expanding rapidly into new geographic markets and new applications.	Development of the marketplace required that this firm take on new competencies to show the market how the technology could be used.	Highly successful. Has achieved market dominance in several applications, and finally launched in the "killer app."
3 1984	Three platforms underway; one currently in the marketplace and generating profits. Pursuing new applications.	Regulatory challenges stalling intro. into major markets. Problems bringing mfg partners up to competency level.	Highly successful. Market leader for many apps. Two competitors have gained market share. New manufacturing facility built in 2008.
4 1988	Project terminated. Learning transferred.	Severe technical challenges.	Failed.
5 1985	Three apps identified, only one pursued. Embedded into mainstream product line as next generation in the line's evolution.	Early user did not perceive the "breakthrough"—no other applications were pursued.	Moderately successful.
6 1982	Initially envisioned "killer app" has not materialized. Many niche apps. Has become the standard for at least one industry. Has not met revenue targets after 3 years in the strategic business unit.	Difficulty in hiring enough specialized engineers to expand the competency base quickly enough to capture new part of the value chain.	Highly successful. Has become highly profitable in several application spaces, but never hit the envisioned killer app.
7 1992	Not yet in the marketplace. Just found a manufacturing partner.	Could not find a partner willing to take on the manufacturing challenges.	Entered production 2008 with a mfg partner. Partnered with OEMs to find apps.
8 1989	Entered market 1997. Explored many applications. Most were rejected by the operating unit. Achieved forecast in 2000.	Struggling with business model and apps. Anticipated regulations that would create instant need never emerged. Searching in global markets with stricter regulations.	Moderately successful niche opportunity. Technical progress too slow to warrant other apps, but caused firm to establish new product family/strategic business unit based on this techno-market space.
9 1993	Project killed	Partner failed to deliver funding.	Failed.
10 1986	In the marketplace in one application; partnering in order to explore several unrelated application markets.	Cost/profitability. Search for high-volume apps because biz model is based on high volume.	Highly successful. Involved in more than eight application areas. Highly successful.
11 1996	Sales much lower than envisioned. Have only pursued one application.	Identifying and committing value chain partners.	Failed. Market never materialized; sold the intellectual property.
12 1995	Project killed. Three apps were pursued. Senior management changed hands, focus on short-term profits.	First customer withdrew due to financial crisis. Technical, economic uncertainties underestimated.	Failed.

p. 57). Once these groupings by code were collected into separate files, each file was reviewed by both authors to look for similarities and differences in the patterns of activity across the cases for each code. Observations and emerging themes were cross-checked with other researchers on the academic team.

Addressing anonymity issues. In reporting the results, firms' and projects' identities are disclosed at times (where member firms have approved); examples are disguised in other situations. We elect to identify projects where possible to provide the reader richer and more specific details regarding technologies and markets in question. Greater specificity of the examples, we believe, helps elaborate the concepts more deeply.

Results and Propositions

Market creation and business model development are nonlinear, exploratory processes, much like the initial market-learning process for BI described elsewhere (Danneels, 2002; Lynn et al., 1996; O'Connor, 1998).

Table 2. Key Company and Customer Issues Associated with Each Project (Projects Sorted by Fit with Business)

Project Identifiers	1	6	9	10	11	2	4	5	7	8	3	12
Success level (from Table 1)	NY	H	F	H	F	H	F	M	NY	M	H	F
Organizational structure constraints												
1. Fit with Business (Outside the current strategic intent, in the White Spaces, aligned with Current business)	O	O	O	O	O	W	W	W	W	W	C	C
2. Existing (E) or New (N) Receiving unit	E	E	N	N	N	N	E	E	E	E → N	E	E
Generation and choice of applications to pursue												
3. Idea generation active (A) or constrained (C)	A	C	C	C	C	A	C	A	A	A	C	A
4. Applications pursued serially (S) or in parallel (P)	S	S	S	S	S	P	S	S	S	P	S	P
5. New markets targeted (Yes, No)	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	N	Y
6. Defines a new market (allows completely new capabilities)	Y	N	Y	Y	Y	N	Y	Y	N	Y	N	Y
Discovering the business model/stimulating the value chain												
7. New market infrastructure needed	Y	N	Y	N	Y	Y	Y	N	N	N	Y	N
8. New method of delivering benefits	Y	N	Y	Y	Y	Y	N	N	N	N	Y	N
9. Expanding to new part of value chain	Y	Y	Y	Y	Y	Y → N	N	N	Y	Y	Y	N
Priming the market												
10. New sales force (na: not applicable, product never entered market)	Y	Y	na	Y	Y	Y	na	N	N	Y	N	N
11. New usage patterns required	Y	N	Y	N	Y	Y	Y	Y	N	N	Y	Y

NY = not yet; H = highly successful; F = failed; M = moderately successful.

High market and organizational uncertainty require an exploratory, experimental approach (McGrath, 2001). But the data reveal a set of decision points or sets of activities that, we propose, must take place from a business model/market creation standpoint for a BI to be fully leveraged by the company. While this is clear in principle from observing the 12 cases, in practice, not all project teams were fully aware of or actively managed every activity. In many instances, our learning came from the gaps in activity rather than its presence. The implication is that once project teams become aware of them, new market creation may be more actively and strategically managed. The six specific activities that emerged from the data analysis include (1) generating possible applications for the technology and choosing one or more to pursue; (2) discovering the business model; (3) stimulating the value chain; (4) priming the market; (5) entering the market; and (6) evolving with the market. In addition, it is noted that specific path-dependent organizational assumptions constrained a full-fledged investment in these activities in the sample firms. This issue is discussed first, followed by a description of each of the six new market creation activities and associated challenges firms face in accomplishing them. A set of propositions regarding appropriate new market creation processes is offered, informed by our observations of these 12 cases.

Organizational Structure Constraints

Three categories of fit were observed between a project and a firm's current strategy and businesses (Table 2). The first is a project *within the scope of a current business*: BIs that strengthen the firm's position in familiar markets with technologies that advance the state of the art. The appropriate receiving unit is clear, and the infrastructure for contacting customers, understanding markets, and developing forecasts is understood, as it is assumed that current customers and business models are appropriate for the new BI opportunity. In our sample, 2 of the 12 projects fit this category (identified as C for current business in Table 2). In both, the new technology also enabled new performance features, which ultimately raised questions about appropriate markets, business models, and organizational fit.

The second category occupies the *white spaces between current lines of business* (W in Table 2). These projects were viewed as opportunities to help consolidate a firm's position within current strategic boundaries. They may require new business units or be force fitted into a current business unit, but they do not stretch a firm's current boundaries. Five of the 12 projects fall into this classification. A third category is *innovations outside the firm's strategic intent* (O in Table 2). These projects expand the current strategic frame even beyond what would be envisioned or supported by executive leadership. Five of the 12 cases were outside the strategic scope of the firm at the time of their initiation and early development.

In the latter two categories, the market is increasingly removed from the firm's familiar terrain and, in fact, may not even exist, thereby introducing significant market uncertainty. The firm has the opportunity or perhaps the

need to define and establish a new value chain, and to determine which parts it will reserve for itself and which it will outsource to others. While these latter two categories are riskier and more uncertain, they have the potential to stretch the organization in new directions that offer rich platforms for growth.

Cases 3 and 12 are projects within current lines of business that were transitioned to existing operating units for commercialization. Table 2 shows that some "white space" cases (4, 5, 7, and 8) and "outside" cases (1 and 6) were also shifted to existing operating units for commercialization. All projects that transitioned to current businesses, whatever the category of fit, were faced with pressures to conform to current market and operating models. Of the four remaining projects that were transitioned to newly formed business units, one case (2) was a white space opportunity, and the other three cases (9, 10, and 11) were outside the strategic intent of the company. Case 8 was originally transferred to an existing unit, but as a result of (1) the business unit (BU)'s negligence in investing to build the business and (2) senior leadership's recognition that a platform of related opportunities existed, the company elected to create a new business unit to commercialize the innovation.

BI businesses transferred into current operating units. For BI opportunities that are aligned with the firm's existing markets and organizational structure to be successful, the receiving unit must be willing to cannibalize its current businesses (Chandy and Tellis, 1998). Our data validate the importance of that willingness and of the systems that enable this to happen in a managed fashion. However, we also observed that R&D project teams are willing to suboptimize commercial opportunities to achieve fit with current operating models, distribution channels, and market expectations to reduce the receiving unit's reluctance to accept the handoff.

R&D project teams tried to reduce this reluctance in several ways. One approach was to delay introducing game-changing features until the business unit and its market had the chance to become familiar with the new product. An R&D manager in case 3 offered the initial form of the innovation as a replacement for current devices, with one or two interesting new features.

> *Initially most of the products are going in as replacements. Fundamentally, we're still taking images in the same way. It's digital instead of film, but you know, the basic paradigm is the same. Some of the new applications we're talking about will make a bigger change. The change that's happening now is the digital, the remote reading. There are a lot of changes associated with just going to digital. But the next generation will make even bigger changes.*

In fact, it was the digital attributes coupled with a second technology that the R&D team saw as the game-changing leap, but they elected not to force it on the business because they did not believe that the business could absorb so much change all at once.

In cases that were a force fit (i.e., those listed in Table 2 as O or W on line 1, but that were targeted for an existing BU as noted on line 2), the perceived risk was reduced by allowing the unit to follow its current business model. This not only diminished the potentially disruptive impact of the BI's game-changing features but also undermined its breakthrough potential. One manager dubbed this the theory of constrained innovation: "Convince the BU that what you're doing is not anything different from what they're already familiar with." One project leader said:

> *To the greatest extent possible, our projects try to stick with known business models and routines to help get the SBU to adopt. We have to make this first introduction fit as well as we can into the existing business structure because all the business people who tend to be much more focused on making money in the present want a technology that can fit into that. As a development engineer, my responsibility is to try to take a new technology and make it fit into that paradigm. If I can't, then I have to go to another paradigm.*

This "tyranny of the current business model" dominated a number of decisions in that case and quite possibly suboptimized the technology's impact on the market.

In case 5, the R&D manager's vision of the technological and benefit potential of the BI was frustrated when a test of the prototype did not go well. Rather than looking for other applications, he handed the BI over to the business unit, which embedded it in the next generation of products. While it is impossible to tell if the innovation was truly a breakthrough since it was not managed as such, only one application attempt was made in this case, in contrast to multiple trials in others (see Table 2). The project team knew from the outset which organizational receiving unit would likely be targeted to receive and grow for the opportunity, thus causing them to limit their search for and development of applications that fell outside the scope of that BU's business model. The consideration of a BI as one that falls within the current lines of business, then, not only may *reduce the risk* of helping it reach a launch stage by reducing

company resistance but also may *increase the risk* of under-leveraging its full potential as a new-to-the-world offering.

Several cases that transitioned into operating units *did* reconsider the business model. Throughout the development of case 6, the project champion and business development champion partnered with companies that could teach them about aspects of the value chain in which their company did not participate but which the team considered important for the firm to enter. Once the project moved to the business unit, the team was allowed to make acquisitions, hire specialized talent, and move into new markets to build the new business. But oversight at senior levels repeatedly overrode the business unit's decisions in this case. At one point, the program manager in the business unit almost dropped the project because it did not hold enough short-term promise. The project's eventual success can only be attributed to tight management at the highest level. In other cases, new manufacturing partners were considered, and in one case, an entirely new distribution channel was developed. All of these instances, though, were enabled by senior-level oversight and proactive management.

The five cases that did ultimately form new organizational units (Table 2) all deviated significantly from familiar business models. They explored new markets, developed their own sales forces and revenue models, and integrated into parts of the value chain in which the firm had not previously participated. Recognizing the need to actively consider new business models appears to be critical if the project is to be leveraged as a breakthrough opportunity. Projects that fit neatly within current businesses are challenged by presumed constraints on options that could, in fact, lead to much more profitable opportunities. Those in the white spaces and outside the strategic intent of the firm face the same issues if force fitted into an operating unit unless senior management ensures this freedom. If BIs are allowed to grow as their own businesses, they are more able to adopt the exploratory processes necessary for new market creation.

P1: The choice of operating home for the new business may impact the new market-creation activity that fully leverages a BI opportunity.

New Market Creation Activities

Irrespective of organizational home, six activities emerged as crucial to the new market creation process. We present our observations about key management practices and constraints from the case data and offer a set of propositions regarding their link to BI success.

Generation and choice of applications to pursue. We observed that research scientists make decisions in the early phases of technology development that affect the ultimate revenue model of the innovation. As soon as applications are conceptualized, technology development paths are set, and business model options are constrained. For the most part, the critical nature of this act is lost on development scientists.

Half of the cases actively sought ideas for applications before settling on an initial set to pursue (Table 2). Of those six cases, one has failed. The rest are either still under development or moderately to highly successful. In one case (12), the team limited the search to brainstorming. In the others, ideas were sought from outside the team. Of the six teams that did not initially generate multiple possible applications to pursue, half failed. The other half, however, were all highly successful; the technology was developed in response to a well-known problem: those problems that interviewees termed "holy grails" of their industries. For five of the six teams that generated multiple ideas, new business development groups existed in R&D, and it was those groups that helped develop a list of potential applications. In the sixth case, ideas were generated but were quickly relegated to the background while a single application was pursued. The R&D director who led that team said, "My job is to demonstrate market enthusiasm for this technology in one or possibly two market spaces. I do not have time to go running down others."

The election to pursue application options serially or in parallel did not emerge as an explicit consideration in any of the interviews. Only 3 of the 12 cases (Table 2) pursued applications in parallel: an approach to learning quickly when uncertainty is high. Of those, two cases are rated as successful, compared with four of the nine that explored applications serially.

Familiar versus new markets. Application choices reinforce mental models about appropriate markets, and because they usually come from the firm's past experience, teams are driven to familiar markets first. Case 5, for example, explored alliances with a number of partners, some that were far from known markets. But ultimately, a partner was chosen with whom the company already had a strategic alliance. While past experience increased the trust and strengthened the relationship between the two firms, relying on that relationship did not serve the objective of exposing the project team to markets that might benefit most from the innovation, which is critical to leveraging a BI's potential (Danneels, 2007; O'Connor, 1998). The markets that stand to benefit

most from BIs may be unfamiliar to the firm (Christensen and Raynor, 2003). If there is no mechanism that encourages choosing those application markets, the team may not learn the true potential of the innovation, technical development may be driven in inefficient directions, and the innovation may be shelved or suboptimized. Table 2 shows that all but two projects ultimately did target unfamiliar markets, and two thirds of them created or defined entirely new markets, regardless of which application they pursued first. Recognizing that this is the natural course for BIs may help streamline application exploration by decreasing the tendency of project teams to stick with known markets.

In several cases (1, 2, 6, 7, 8, and 11), application choices were made proximate to the time a business development manager joined the team. In these cases, a more proactive approach was taken toward the initial application decision. As a senior technical manager said, "This project didn't really gain credibility until it was clear there was some commercial direction to it . . . when they assigned commercial people to it." In case 6, the inventor and the business development manager chose which of several interested partners to work with based on the partners' willingness to include them in design issues, so they could learn about and eventually co-opt that part of the value chain. In their desire to move away from simply supplying an innovation that would quickly become a commodity, they made application choices that ultimately led to a new line of business, acquiring a firm, hiring more than 200 employees with new skills, and other ramp-up activities. Adding a business development manager to the team allowed them to invest in finding optional applications and business models.

These examples illustrate the varied degrees of market creation expertise deployed to the task of generating and choosing initial applications to explore. From these data, it appears that passively managed projects, that is, those that do not specifically consider business ramifications due to a lack of market-creation competency on the team, allow current organizational relationships and familiar markets to dominate their thinking.

P2a: BI teams that generate numerous application ideas early in the project's life have a higher chance of success than those that do not, due to the increased likelihood of finding unexpected value perceived in unfamiliar markets.

P2b: BI teams that choose initial applications based on the firm's past experience with customers, markets, or alliance partners may have a higher probability of suboptimizing the innovation's market impact than do those that choose according to which application markets may benefit the most from the innovation.

P2c: A BI project is likely to identify and explore more application areas when a person with new business creation skills is present on the team once the discovery is characterized scientifically than if such a person is added later.

Discovering the business model. A business model comprises agreements among value chain members about who will perform which function, and how economic rewards will be allocated for performing those functions. The most acceptable business model for a BI from the market's perspective may differ dramatically from those with which the firm is familiar. Table 2 (lines 7–9) shows that 10 of the 12 cases faced business model considerations because a new market infrastructure was needed (line 7, six cases) because the technology provided new benefits that disrupted current value chain members (including the innovating firm) (line 8, six cases), or because the firm had strategic reasons for expanding into new parts of the value chain (line 9, eight cases). These observations align with Jaworski et al.'s (2000) notions of constructionist, deconstructionist, and functional modification market-shaping activities.

Our data reveal that business model considerations appear as soon as the initial application choice is made, and the technology must be formulated into a product. Assumptions are made about which aspects of the value chain the firm will engage in and which it will leave to others. The researchers who made these decisions were, in many cases, unaware of the impact of their assumptions and decisions on the product's ultimate commercial value. Case 5, for example, offered the opportunity to create a new application, but one that entailed a different business model that would have required the firm to partner with new suppliers in a markedly different way. The technical team opted not to pursue that application. Ultimately, the innovation was marginalized when market trials demonstrated that its perceived value was insufficient to overcome the perceived costs of adopting the innovation. Much of that value would have come from other suppliers, so the technical team's decision to work with familiar partners in familiar ways may have undermined the innovation's chance of success. The same thing occurred in case 4. Real value necessitated new markets and partners. A new market infrastructure was also required, but rather than invest in that infrastructure, the firm chose to market the innovation as an upscale addition to its current product line.

For the 10 firms in the sample that did consider new business models (Table 2, lines 7–9), the process was iterative and full of surprises. Case 11's technology, for example, allowed software to be rented and downloaded over the Internet, a true breakthrough in the mid 1990s. But appropriate value chain agents did not yet exist (e.g., payment mechanisms over the Internet) or required proof that the end market would deliver before they invested. These barriers, each discovered through conversations and other market-based experiments, caused the team to change its business model at least four times. Every one of them differed dramatically from the company's predominant business model. The vice president of marketing reflected on how far this business model of "pennies per rental" was from the company's typical revenue model: "Yes, if people don't rent, we don't make money. It's a fascinating model for a product company." As one of the team's engineers said, "It's an incredible rate of change, and every week it's changing. We change our business model every five days!"

The team responsible for case 1 realized after exploring the market that they needed to adopt an entirely new business model. The new application was for a market with hundreds of thousands of users, each of whom required daily replenishment. The established replenishment system was built on a strong infrastructure of distributors. The BI would essentially replace the need for replenishment and eliminate the distributors. While it clearly offered a game-changing benefit, it was an entirely new business model for the firm and the market. The commercial development manager said, "We got dragged kicking and screaming into this one. It is counter to the culture of how we do business."

These examples demonstrate that the experimental approach that applies to technology development may also apply to business model development and new market creation. Attributes that were initially valued in the market can become less valued than those that were not even recognized as distinguishing features of the technology at first. As the marketplace evolves, so does the technology. The market's structure may not yet be apparent, and the potential contribution and willingness to participate of each value chain member is difficult to foresee. Designing the business model, then, may require systems thinking and mechanisms for envisioning the entire value chain, or perhaps more appropriately, alternative structures of the value chain. Each value chain scenario may require that the technology development path takes a different course. Each of these requirements may be disrupted by ongoing norms of the established company in which the BI team resides.

P3a: Successful new market creation based on BIs requires business model development processes that are experimental in nature.

P3b: Business models and technology development for BIs may coevolve: one does not take precedence over the other.

P3c: Companies that constrain business model exploration and adoption will experience fewer successful BIs than companies that embrace new business model exploration and adoption.

Stimulating the value chain. In several of the sample cases, the project team had to first conceptualize a value chain, then devise a business model that encouraged companies to fill positions in that chain. The implication is that the innovating firm may have to demonstrate the opportunity to other potential value chain agents, through temporarily integrating forward or backward into parts of the value chain which it does not necessarily expect to stay in over time. Thus, the structure of the value chain may evolve as the market evolves.

Case 3's development, for example, was approved contingent on partnering with a manufacturer, as the receiving business unit did not want to manufacture the product in-house. Eventually, a partner was found, and a deal was struck. Five years later, however, that partner was producing only the crudest model of the product. Achieving acceptable yields from the manufacturing process itself required innovation, and the partner was unable to develop a workable process quickly enough. In the meantime, the R&D team, which had developed the manufacturing process along with the technical design of the product, was producing the more complex product lines in an R&D fabrication facility that had been mothballed after an earlier experiment. The R&D manager reflected on the complexity of this problem:

They [the manufacturing partner] invested in the factory. We have a very complicated business arrangement with them, but they basically hold title to the factory . . . But we have a lot of [our] people out there with a lot of technology invested, and ultimately what we had hoped for was a supplier relationship. And we're having to support that a lot. And that may lead to a change in the business arrangement. I don't know. Who knows what'll happen?

Texas Instruments' (TI) digital signal processing (DSP™) business decided on several courses of activity early in their project to stimulate the value chain. A new

chip called a digital micro-mirror device (DMD) enabled advances in display technology for projectors. TI might have simply provided the chip to projector manufacturers for inclusion in their own applications. But the project director believed that the market would not fully understand the capabilities of the DMD technology. He opted to manufacture the complete projector engine, including the lamp, the lens, the housing, the power device, and other necessary components so that the chip's delivered benefit would be readily apparent and usable. This severely limited the applications TI could pursue and took energy from the goal of increasing manufacturing yields; the team had to acquire new competencies associated with lamps, optics, and other components. Three years after the product was introduced, TI reverted to supplying chips only. According to the director of new business development, the market had evolved enough so that specialists in optics, lamps, and power sources could understand the possibilities of the DMD and could design the necessary components better than TI could. TI's mission—to stimulate the market—was fulfilled. These examples lead us to propose that:

P4: To successfully leverage a BI opportunity, the innovating firm may need to temporarily create the value chain itself to demonstrate the benefits of the innovation to potential value chain agents, stretching it into arenas where it is not naturally strong.

Priming the market. We observed that market creation and development can take as much time, effort, and investment as technical development does, but firms do not recognize that the skills, competencies, and expectations for doing this are specific, and different from what they currently expect of R&D, any sales group, or a program manager. In BI projects, the time and money needed for market development are grossly underestimated. It can also be unclear who is responsible for market development. The R&D team sees its responsibility as finding one or two application markets and demonstrating that value is perceived in those domains, as the research directors for cases 3, 5, and 8 told us. But that is different from generating a list of qualified buyers and a reliable sales forecast. In several cases the project team stated that the high cost of technology development made investing in market creation impossible. One research manager, describing decisions about the technology development path, said that he worked hard to align the technology with the presumed receiving unit's current business models and customers. In justifying his decision, he stated: "The reason I want to do that is that . . . by the time we're done, we'll spend $60 million inventing the technology. I don't want to spend another $60 million inventing a business." The implication is that investments in technology development may remain unexploited given the firm's unwillingness to engage in market creation activities and investments alongside exploratory technology development.

Market-priming activities. Early market-priming activities, we observed, may conflict with conventional practices of maintaining secrecy before a product is launched. In the sample cases, early market learning occurred when scientists gave papers about their discoveries at professional conferences as early as possible, anticipating that listeners would be scientific counterparts in other industrial firms that might be able to use them. In two cases, partnerships resulted from these priming activities that revealed the potentiality of an as yet imperfect and undeveloped technology. However, in at least three cases, scientists indicated that they were not allowed to give papers for fear of providing too much intellectual capital to competitors.

A second market priming mechanism we observed is advertising in technical journals. A manager for case 8 described his practice of advertising new discoveries in professional and trade publications and encouraging inquiries. One ad run in two such publications generated nearly 100 inquiries and resulted in 30 application ideas; 11 of which they pursued. None of these were application ideas the team had thought of themselves.

A third market-priming mechanism is an extended product trial by an interested user. Nearly every project team described these "learning" partners. Scholars define trial-and-error learning as an adaptive process in which innovators continue on a given course if the outcomes are positive and change if the outcomes are negative (Polley and Van de Ven, 1996). Program managers called this technique learning by using. The project manager for case 10 explained:

The difficulty that we've been struggling through is the fact that there wasn't anything of comparable price performance, so we had "evangelize." We had to take reference designs to the users. We had to determine how the hardware, and the software, and then the platform system . . . gets done and it took us about a year longer than we really thought it would. The educational process and finding those early adopters that will actually give it a try are the biggest challenges. The market doesn't like new stuff. Most people are followers. Further applications . . . are arising because we're now advertising our product, and companies are coming up with application ideas.

Table 3. Envisioned Market Entry Applications versus Actual Entry Applications

Project	Envisioned Killer Application	Actual Entry Application
GE Digital X-Ray	Chest scanner	Breast scanner
UTC Otis's Multidirectional Elevator	Will enable mile high buildings	Moves prisoners underground
TI Display Projection System	Mass market projection equipment	Large screen theater projection systems
Air Products	Large fabrication plants	Hospital medical equipment
IBM's Silicon Germanium Chip	Cellular telecommunications	Global positioning systems satellites
DuPont's Biodegradable Polymer	Disposable diapers	Various packaging applications

Thus, as the technology is exposed to the marketplace, the marketplace tends to reveal applications for the technology. Firms' lack of willingness to expose technology in imperfect or raw form may prevent this dynamic from occurring.

Finally, instead of formal market launches of BIs, we observed smaller entries into niche markets, which were, in fact, market-priming mechanisms. Case 11's team described their concept launch as "whispering in people's ears," with the goal of generating excitement about possible applications. The case 6 team's goal was to announce a new client-partner each month. These are like pre-announcements oriented toward education and familiarizing potential customers with the technology and its possibilities. Managers for cases 6 and 11 mentioned that a well-known brand name reduced prospective customers' perceived risk of trying the innovation.

P5a: Investment in market-priming activities is associated with a BI project's commercial success.

P5b: A policy of closed communication and protection of intellectual property for purposes of maintaining competitive advantage, through lack of interaction with the market, is negatively associated with a BI's success.

Market entry and internal expectations. A project's transition from R&D to an operating unit can be fraught with mismatched expectations. The promise of a large market may be unmet early on since initial applications often generate lower revenues than expected. We observed operating units applying inappropriate resources to market development and inappropriate metrics for success to gauge these efforts.

In several cases, the probing and learning (Lynn et al., 1996) begun by R&D was repeated by the business unit because program managers were either unaware or skeptical of R&D's conclusions regarding market application choices. Referring to the R&D manager, the program manager in the business unit for case 6 admitted:

He kept dreaming—everybody kept dreaming. As a matter of fact, for years, we carried plans that are called the home run plan. . . . We'd show [senior management] a plan and they'd say, oh cripes, after four years it's only going to be $250 million? What do you need to make it a billion dollars? And so we'd tilt it up, we'd look at more applications, we'd look at how to get bigger shares of existing applications, and we kept the skunk works on the other stuff because even though it wasn't going to be gigantic, we knew it would demonstrate the building of the technology. I knew in my blood that the biggest application would take ten years. We knew that in the xxx industry the value proposition was clear but companies that are in that industry will not take risk on new technologies . . . [so we went to an industry that was not stable, that was in turmoil].

While the vision of a "killer app" drove these projects at first, getting started in the market was another story. In every project, after numerous application probes were analyzed, a small number was targeted for development. This required a shift from probing to developing a focused strategy for entering niche application markets to create initial sales. As managers began to select entry markets to pursue, they were fraught with conflict. On the one hand, they felt pressured to produce gamechangers, especially after millions of dollars had been invested. As part of an operating unit, they were measured on their short-term results, not potential. On the other hand, markets were not educated, and technical bugs remained. One manager who received a project from R&D was stunned to realize how much technical work remained, in addition to marketing: "I can't believe they've given it to me when it's so early in its development."

In nearly all cases that reached the point of market entry, the markets chosen as entry points, when revenue ramp-up was less important than rapid, inexpensive learning, were not the kind of "killer app" markets envisioned for the technology when it was initially funded (Table 3). In most cases, the promise of the "big" market that had motivated the team and senior management evaporated once the market-entry strategy was tested.

Importantly, these niche markets that perceived benefits first did not have the size required for conventional "go" decisions in most of our sample firms. In four cases (1, 6, 7, and 8) only the intervention of senior management saved the project. Case 6, for example, was nearly dropped from the business unit's product portfolio plan because the projected sales for the first application did not meet the required target for a new product launch. The initial champion, a respected scientist with strong ties to corporate leadership, had to intervene to save the project's budget and to modify its metrics to reflect reality. Today, the product is an industry standard and a critical part of the revenue stream, but a misunderstanding of how markets develop nearly caused its demise. Five of the 10 sample cases that transitioned into operating units were either returned to R&D after it became clear that so much work remained, or their program managers were either fired or removed from the project because they could not meet expectations for sales growth. These examples indicate that unrealistic expectations of market size for BIs in their early stages may severely hamper continued investment in their growth or even label them as failures prior to the time that they could actually be exploited by the firm.

In contrast, some project managers sold senior management on the idea of an interim performance metric: increased market activity. For case 6, this meant one announcement per month about development work for new clients. For case 10, it meant the number of new products, new customers, and new relationships. These projects were held to performance standards, but their metrics are based on market activity rather than financial activity. As one program manager said,

> *When you're thinking of a startup, you can't measure things by internal investment or profits, you've got to measure revenue growth, even if that revenue growth in the beginning is not set, and you haven't accounted for expenses. If somebody's willing to pay you a quarter of a million dollars to write a design on your chip . . . that should be an indication that they're serious.*

These market-based metrics drove managers to search for unconventional customer partners and drove initial entry market choices:

> *I either had to show a revenue stream right away or demonstrate the value proposition through customer engagement. I figured there'd be two types of questions. One is "When is this thing going to start returning on the investment?" and two is "When can you prove that this thing will really do what you say it will do?" And I figured it was easier to do the latter. . . . So we started to engage some companies that were more liberal in their thinking in terms of using new technologies, companies that were more interested in getting ahead than they were in keeping the status quo, and we went to them with the technology and tried to engage them in projects.*

We observe that, in most of these cases, a number of smaller entry applications led to killer businesses. Even when killer apps were explored (in two cases), they did not become profitable for a very long time.

> *P6a: Successful BIs may not enter the market via a killer application, but instead via a series of smaller, niche applications.*

> *P6b: Early market entry metrics that focus on stimulating market activity rather than on revenue and profits will help enable a BI's success within an operating unit.*

Market Evolution Activities

Lasers were first used in measurement, navigation, and chemical research (Moore, 1994). Over time, their market broadened to include music recording, surgery, printing, fabric cutting, and communications. The same evolution can be seen in our sample. At GE, the Digital X-ray team began to focus on a number of new initiatives once the market began to understand the technology's potential. Research scientists from other firms now contact GE with application ideas. At Analog Devices, the project moved from providing chips to the automotive market at low prices and high volume but no profit to selling chips profitably for personal computer games. It then shifted to box games like Nintendo and Sony PlayStation® where volume and margins are even higher. Subsequently, they began receiving inquiries to use their sensors in sporting goods and other applications where vibrational changes need to be noted. Texas Instruments opened an office specifically for the purpose of evaluating the numerous unsolicited inquiries about new applications for its DMD technology.

The implication is that business unit leadership's expectations must be managed to ensure that small successes are heralded as part of a larger program of innovation in a BI portfolio domain. Instead we observed projects that were criticized for not generating large revenues via a single killer application. Multiple paths to the market rather than one killer application appear to be the more likely scenario as revealed in the data. This result ran counter to management's expectations in many of our cases. While the innovating firm learns about the market,

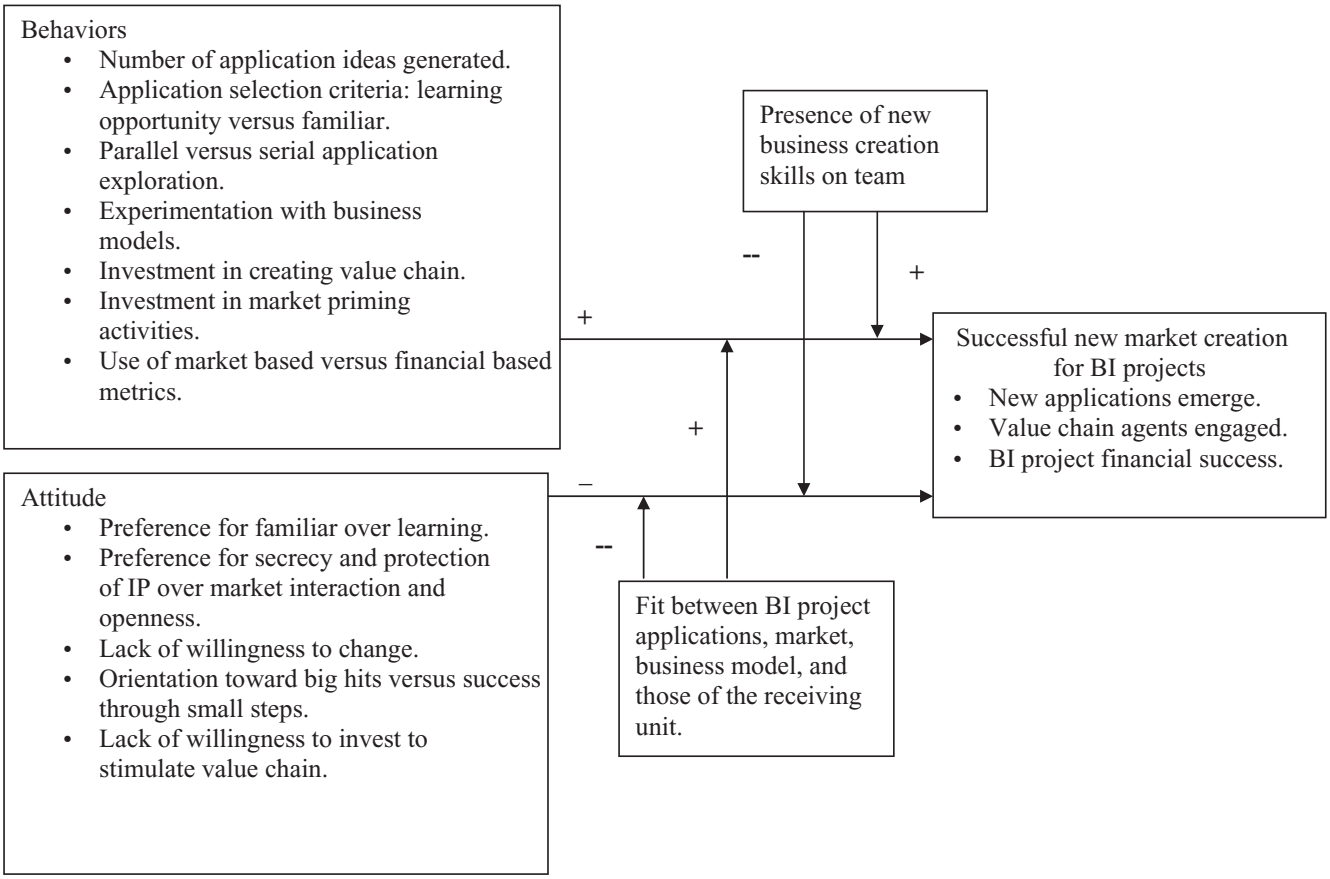

Figure 1. Conceptual Model of Enablers and Constraints Associated with New Market Creation for Breakthrough Innovation

the market learns about the technology. This interaction leads to application migration and, if understood, can be managed to create new markets never previously envisioned.

P7: New market creation for BIs is more likely to occur through small steps via "application migration" over time than through an initial large volume-killer application.

Discussion and Implications

Through observing these 12 projects as they are managed by their teams and those who oversee them, a perspective emerges regarding attitudes and practices that promote as well as hinder the market creation process, summarized in the conceptual model in Figure 1. The data suggest that economic opportunities arise and are perceived and elaborated via interactions between firms and potential customers, but also intra-organizationally—between team members and other organizational actors, and inter-organizationally—between firms and emerging agents in the value chain. These interactions appear to begin early in the technology development process as the numerous choices that many BI technologies offer require a socially constructed market that coevolves with the technology (Humphreys, 2010; Lee and Paruchuri, 2008). We argue that new market creation is the result of managing a set of events and activities that appear linear, but are not. They include (1) generating application possibilities for the technology and choosing which to pursue, (2) discovering the business model, (3) stimulating the value chain, (4) priming the market, (5) initial market entry, and (6) managing market evolution. Each one may involve constructionist, deconstructionist, and/or functional-modification activities to shape markets, and direct or indirect market behavior shaping activities, as described by Jaworski et al. (2000).

Table 4 shows the extent to which market-driving behaviors were exhibited over the course of these projects' development. Each project was challenged with at least one and, in most instances, many elements of market-driving behavior. The data reveal that these behaviors can be viewed as opportunities for proactive managerial practice, critical to new market creation. All

Table 4. Market-Driving Behaviors Faced by Project Teams

Project Identifiers	1	2	3	4	5	6	7	8	9	10	11	12
Success level (from Table 1)	NY	H	H	F	M	H	NY	M	F	H	F	F
Shaping market structure												
Deconstructionist activities	Y	Y	Y	Y	Y	Y	N	Y	N	Y	Y	N
Constructionist activities	Y	Y	Y	Y	Y	N	N	N	N	N	Y	N
Functional modification activities	N	Y	Y	N	Y	Y	Y	N	Y	Y	Y	N
Shaping market behavior												
Change constraints in buying priorities	Y	N	N	N	Y	N	N	N	Y	N	Y	N
Create new customer/competitor preferences	Y	N	Y	Y	Y	Y	Y	Y	N	Y	N	Y

these activities occur within the constraints of the match or mismatch of the BI opportunity with the firm's current markets and organizational structure.

These results show that market creation for BIs may require as much time and investment as their technical development. We do not find evidence of large established organizations' awareness of or willingness to make these investments as readily as they invest in technical development. The result is R&D labs at large established firms with stockpiles of potentially game-changing technologies. To evolve a mature BI *commercialization* competency, a firm must recognize and address the implications for managerial processes, for personnel recruitment, for setting leaders' expectations, and for developing appropriate performance metrics for those responsible for market creation that go beyond technical discovery and engineering development. Significant research agendas exist in each of these areas as well.

Implications Regarding Managerial Processes

The data demonstrate that market development and technology development in the uncertain domain of BI are intertwined. As the project team explores applications, the market learns about the technology. They evolve in tandem, and each directs the other. Rather than a linear process directed at a clear market opportunity, a more multidimensional, chaotic process is called for, with broad exploration followed by focused experimentation that in turn opens new spaces for exploration.

Managers may need to find ways to teach the market about the technology early and often, rather than maintaining secrecy. Formal product launches may be less common than invitations to customers to codevelop the innovation, a practice that hedges the firm's risk of publicly announcing a product that may not yet be ready for mass commercialization. Questions to consider include how firms might encourage potential customer organizations to explore BIs, and how might firms select such exploration partners. The data reported herein suggest that firms select co-development partners using criteria that prioritize learning and market creation over large volume sales potential. Another question that arises is what messages and positioning of the innovation are most appropriate given that higher risk is involved in its trial and adoption on the part of the user. A third implication is that markets may emerge more slowly than managers are used to, so mass market communications may take place later in the development cycle than managers expect.

Implications Regarding Market Creation Personnel

The highly ambiguous nature of market creation for BIs demands specific skills and characteristics of those responsible for creating markets: they are frequently more intuitive than analytical, more divergent in their thinking, and more focused on opportunity than execution (O'Connor and McDermott, 2004). Organizations that prize operational excellence and process efficiency, and that are tightly linked to financial markets are not typically attractive to such people. In our sample, respondents described this as a critical problem. In more than one case, team members who transferred from R&D to the receiving unit to help with market creation were ultimately fired or moved for failing to meet imposed sales expectations. The kind of people required for probing and learning, building new business models, and creating markets are frequently weeded out. The challenge for firms is to attract, mentor, and retain them, and to develop rewards that fit their needs. The challenge for scholars is to define ways to do this despite the incompatible values. We found that team members view large organizations not just as bureaucracies but as fertile environments for scope-change innovation due to their knowledge capital, market access, and power: enabling mechanisms that small startups lack. More work is needed to understand the perspective of organizational entrepreneurs and to attract and retain this necessary talent.

Implications for Performance Metrics and Expectations Management

These data indicate that creating new markets takes time and requires a major investment of resources. Market creation is usually the responsibility of the receiving business, which creates conflicts because business units are measured by speed, operational excellence, and profitability. Senior managers' expectations can also be unrealistically heightened by the big market potential of the BI, causing disappointment, frustration, and even failed careers. Given this mismatch, who should be responsible for market development and creation?

If business units are responsible, the mismatch in performance metrics, budget allocations, review processes, and evaluation criteria must be reconsidered for BIs, especially white space initiatives that stretch the business unit beyond its conventional markets and processes. When business units fall under intense time and profit pressure, organizations may consider ways to provide a relief valve for the fledgling BI portfolio. Organizational structure arrangements such as incubation and acceleration groups (O'Connor and DeMartino, 2006) within the firm that accommodate the reality of new markets and their emergence, and that measure success in alignment with those realities are one proposed solution. If management understands the realities of how BIs wind their way to the market, appropriate metrics can be applied rather than those that have caused potential BIs to be de-funded before the market can fully interact with them to identify niche applications that ultimately enable the big business.

Implications for Theory and Research

Opportunity creation theory requires empirical elaboration. Effectuation theory may offer a description of what happens in the course of normal human interaction, but market creation could become more purposeful, and, indeed, scholars point to the human agency associated with corporate entrepreneurship (Zahra, 2008). Exploratory learning process theory has documented cases and the beginnings of some prescription for management practice, but it suffers from a lack of groundedness in the organizational context that serves to constrain it. A rudimentary conceptual model based on the propositions offered herein is shown in Figure 1. Empirical testing of the links between practices and market creation outcomes are sorely needed. Building on this conceptual model, we hope to stimulate innovation scholars to identify the tools, skills, and managerial practices that drive markets so that firms can best leverage their breakthrough technologies into new business platforms.

Conclusions

The data reported in this paper provide a glimpse into the inner workings of new market creation for BI in large established firms. It complements the theoretical work on the opportunity creation theory of entrepreneurial action, the process-based empirical and theoretical work on exploratory learning theory, and the theoretical work on effectuation to arrive at a grounded theoretic view of new market creation within the constraints of the large established organization. The description of practices, their pitfalls, and observed enabling mechanisms is a significant first step. The propositions offered will hopefully drive a research agenda in this important domain.

Our objective is to stimulate dialogue, thought, and empirical work on new market creation. Others have documented failures in this arena (Christensen and Raynor, 2003) and conclude that disruptive innovations should be separated from the mainstream because of the disconnects in expectations and performance metrics discussed above. An alternative is to better understand these disconnects and devise ways to leverage the assets of the firm. By describing what actually happens in large companies and by identifying the elements of new market creation that are seemingly applied in an ad hoc fashion in the companies studied, we set the stage for others to test these propositions so that ultimately, successful approaches can be recognized and applied more systematically, and disconnects can be replaced with logical management practice.

References

Ahuja, G., and C. M. Lampert. 2001. Entrepreneurship in the large corporation: A longitudinal study of how established firms create breakthrough inventions. *Strategic Management Journal* 22: 521–43.

Alvarez, S. A., and J. Barney. 2007. Discovery and creation: Alternative theories of entrepreneurial action. *Strategic Entrepreneurship Journal* 1 (11): 11–26.

Baker, T., and R. Nelson. 2005. Creating something from nothing: Resource construction through entrepreneurial bricolage. *Administrative Science Quarterly* 50: 329–66.

Bhardwaj, G., J. C. Camillus, and D. A. Hounshell. 2006. Continual corporate entrepreneurial search for long-term growth. *Management Science* 52 (2): 248–61.

Chandy, R. K., and G. J. Tellis. 1998. Organizing for radical product innovation: The overlooked role of willingness to cannibalize. *Journal of Marketing* XXXV: 474–87.

Cheng, Y.-T., and A. Van de Ven. 1996. Learning the innovation journey: Order out of chaos? *Organization Science* 7 (6): 593–614.

Christensen, C. M., and M. Raynor. 2003. *The innovator's solution: Creating and sustaining successful growth*. Boston, MA: Harvard Business School Press.

Danneels, E. 2002. The dynamics of product innovation and firm competencies. *Strategic Management Journal* 23 (12): 1095–121.

Danneels, E. 2007. The process of technological competence leveraging. *Strategic Management Journal* 28: 511–33.

Eisenhardt, K. M. 1989. Building theories from case study research. *Academy of Management Review* 4 (4): 532–50.

Eisenhardt, K. M., and M. E. Graebner. 2007. Theory building from cases: Opportunities and challenges. *Academy of Management Journal* 50 (1): 25–32.

Eisenhardt, K. M., and J. A. Martin. 2000. Dynamic capabilities: What are they? *Strategic Management Journal* 21 (10-11): 1105–21.

Garcia, R., and R. Calantone. 2002. A critical look at technological innovation typology and innovativeness terminology: A literature review. *Journal of Product Innovation Management* 19: 110–32.

Garud, R., and P. Karnoe. 2001. *Path dependence and creation*. Mahwah, NJ: Lawrence Erlbaum.

Garvin, D. A. 2004. What every CEO should know about creating new businesses. *Harvard Business Review* 82 (July–August): 18–21.

Geroski, P. 2003. *The evolution of new markets*. Oxford: Oxford University Press.

Glaser, B. G., and A. L. Strauss. 1967. *The discovery of grounded theory: Strategies for qualitative research*. New York: Aldine de Gruyter.

Gruber, M. 2010. Exploring the origins of organizational paths: Empirical evidence from newly founded firms. *Journal of Management* 36 (5): 1143–67.

Hauser, T., and A. Griffin. 2005. Research on innovation: A review and agenda for marketing science. *Marketing Sciences Institute* Special Report 05-200.

Hayward, M., D. A. Shepherd, and D. Griffin. 2006. A hubris theory of entrepreneurship. *Management Science* 52 (2): 160–72.

Humphreys, A. 2010. Megamarketing: The creation of markets as a social process. *Journal of Marketing* 74: 1–19.

Jaworski, B., A. K. Kohli, and A. Sahay. 2000. Market-driven versus driving markets. *Journal of the Academy of Marketing Science* 28 (1): 45–54.

Lee, G. K., and S. Paruchuri. 2008. Entry into new and uncertain product-markets: The role of associative rhetoric. *Academy of Management Journal* 51 (6): 1171–88.

Lovas, B., and S. Goshal. 2000. Strategy as guided evolution. *Strategic Management Journal* 21: 875–96.

Luksha, P. 2008. Niche construction: The process of opportunity creation in the environment. *Strategic Management Journal* 2: 269–83.

Lynn, G. S., J. G. Morone, and A. S. Paulson. 1996. Marketing and discontinuous innovation: The probe and learn process. *California Management Review* 38: 8–37.

March, J. G. 1991. Exploration and exploitation in organizational learning. *Organization Science* 2 (1): 71–87.

McGrath, R. G. 2001. Exploratory learning, innovative capacity, and managerial oversight. *Academy of Management Journal* 44 (1): 118–31.

McGrath, R. G., and I. MacMillan. 1995. Discovery driven planning. *Harvard Business Review* 73 (July–August): 44–54.

Miles, M. B., and A. M. Huberman. 1994. *Qualitative data analysis* (2nd ed.). Thousand Oaks, CA: Sage.

Miller, D. J., M. H. Fern, and L. B. Cardinal. 2007. The use of knowledge for technological innovation within the diversified firm. *Academy of Management Journal* 50: 308–26.

Moore, W. L. 1994. Radical innovations: What can be learned form the past? In *And now for something really different*, MSI conference proceedings, report 94–124, December.

Morone, J. G. 1993. *Winning in high tech markets*. Boston, MA: Harvard Business School Press.

Norling, P., and R. J. Statz. 1998. How discontinuous innovation really happens. *Research-Technology Management* 41 (3): 41–44.

O'Connor, G. C. 1998. Market learning and radical innovation: A cross case comparison of eight radical innovation projects. *Journal of Product Innovation Management* 15: 151–66.

O'Connor, G. C., and R. DeMartino. 2006. Organizing for radical innovation: An exploratory study of the structural aspects of RI management systems in large established firms. *Journal of Product Innovation Management* 23: 475–97.

O'Connor, G. C., and C. M. McDermott. 2004. The human side of radical innovation. *Journal of Engineering and Technology Management* 21: 11–30.

O'Connor, G. C., M. P. Rice, L. S. Peters, and R. W. Veryzer. 2003. Managing interdisciplinary, longitudinal research on radical innovation: Methods for the study of complex phenomena. *Organization Science* 14 (4): 353–439.

O'Reilly, C. A., and M. L. Tushman. 2004. The ambidextrous organization. *Harvard Business Review* 82 (April): 74–81.

Polley, D., and A. H. Van de Ven. 1996. Learning by discovery during innovation development. *International Journal of Technology Management, Special Issue on Unlearning and Learning for Technological Innovation* 11 (7/8): 871–82.

Raisch, S., J. Birkinshaw, G. Probst, and M. L. Tushman. 2009. Organizational ambidexterity: Balancing exploitation and exploration for sustained performance. *Organization Science* 20 (4): 685–95.

Read, S., N. Dew, S. D. Sarasvathy, M. Song, and R. Wiltbank. 2009. Marketing under uncertainty: The logic of an effectual approach. *Journal of Marketing* 73: 1–18.

Rice, M. P., G. C. O'Connor, and R. Pierantozzi. 2008. Implementing a learning plan to counter project uncertainty. *Sloan Management Review* 49 (2): 54–62.

Sarasvathy, S., and N. Dew. 2005. New market creation as transformation. *Journal of Evolutionary Economics* 15 (5): 533–65.

Sethi, R., and Z. Iqbal. 2008. Stage-gate controls, learning failure, and adverse effect on novel new products. *Journal of Marketing* 72: 118–34.

Shane, S. 2003. *A general theory of entrepreneurship: The individual-opportunity nexus*. Northampton, MA: Edward Elgar.

Sorensen, O., and L. Fleming. 2004. Science and the diffusion of knowledge. *Research Policy* 33: 1615–34.

Van de Ven, A. H. 1986. Central problems in the management of innovation. *Management Science* 32 (5): 590–607.

Yin, R. K. 1994. *Case study research*. Thousand Oaks, CA: Sage.

Zahra, S. A. 2008. The virtuous cycle of discovery and creation of entrepreneurial opportunities. *Strategic Entrepreneurship Journal* 2: 243–57.