Managing the Front End of Innovation—Part I

Results From a Three-Year Study

Senior management commitment, vision, strategy, resource commitment, and culture are the keys to front-end success.

Peter A. Koen, Heidi M. J. Bertels, and Elko Kleinschmidt

OVERVIEW: An IRI Research-on-Research project looked at effective practices in the front end of innovation through a study of practices in 197 large US-based companies over a three-year period. The research team used a holistic framework that evaluated front-end activities through the lens of the New Concept Development (NCD) model. Analysis of the data revealed that organizational attributes—senior management commitment, vision, strategy, resources, and culture—were of most importance to front-end performance, explaining 53 percent of the variance in performance among participating companies. All of the organizational attributes had correlations ranging from 15 percent for senior management commitment to 24 percent for vision, which suggests that all of the organizational attributes are important to a company's front-end performance.

KEYWORDS: Fuzzy front end, Front end of innovation, Organizational attributes

The innovation process may be divided into three parts: the front end of innovation, the new product development process, and commercialization. The front end is often envisioned as a linear process of three stages separated by management decision gates. In the first stage, pre-work is done to discover new opportunities. In the second, scoping stage, quick and inexpensive assessments of the marketing and technical merits of the project are carried out. A detailed business case is constructed in the final stage.

The front end is a critical component of the innovation process; choices made at the front end will ultimately determine which innovation options can be considered for development and commercialization. Yet, the front end is comparatively little studied. Meta-analyses have identified over 250 articles on new product development, the second step in the innovation process, published since 1979 (Henard and Szymanski 2001; Evanschitzky et al. 2012). In contrast there have been few studies of the front end. Khurana and Rosenthal (1998) published the first comprehensive study of the front end based on case studies of 10 incremental and 2 radical projects. They found that successful organizations follow a holistic approach, one that addresses the front end within a broader organizational context, and that success depends on both organizational attributes and project-specific activities. An earlier Industrial Research Institute (IRI) ROR project team extended Khurana and Rosenthal's work by

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ROR Profile

Front End of Innovation—Survey, Probe, and Intervention of Effective Practices

Identifying effective practices in the front end of innovation for sustained growth and profitability

Goal: To determine the key front end skills and activities that a company needs to be proficient in to achieve robust growth and sustained profitability

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creating a holistic framework for the front end, called the New Concept Development (NCD) model (Koen, Ajamian, Burkart et al. 2001). That work also introduced the term "front end of innovation," intended to replace the more expressionistic term "fuzzy front end," coined by Reinertsen (1985), with its implications that the front end is mysterious, lacks accountability, and cannot be managed.

The work of the current ROR group builds on the previous studies of the front end of innovation to further dispel the fuzziness previously attributed to the front end by identifying specific activities and organizational attributes that contribute to front-end success. The three-year project, launched in 2004 with support from the National Science Foundation, used the NCD model as a lens to identify the most effective practices in managing the front end of innovation. This is one of the largest studies to date with a specific and exclusive focus on the front end in large, US-based corporations.

The results thus far identify both organizational attributes and innovation activities essential to front-end success. However, specific organizational attributes—senior management involvement, vision, strategy, resources, and culture—are more than two times as important to front-end success as activities or such project-specific attributes as team composition and collaboration practices. This article focuses on those essential organizational attributes; the contributions of team composition, collaboration practices, and specific front-end activities will be discussed in a later article.

The New Concept Development Model

The NCD model divides the front end into three distinct areas: the engine, the wheel, and the rim (Figure 1). The engine, at the center of the model, provides power to the front end of innovation. The engine consists of two separate segments—organizational attributes and teams and collaboration. The wheel, the inner part of the model, comprises the five activity elements of the front end: opportunity identification, opportunity analysis, idea generation, idea selection, and concept definition. The third element, the rim, includes

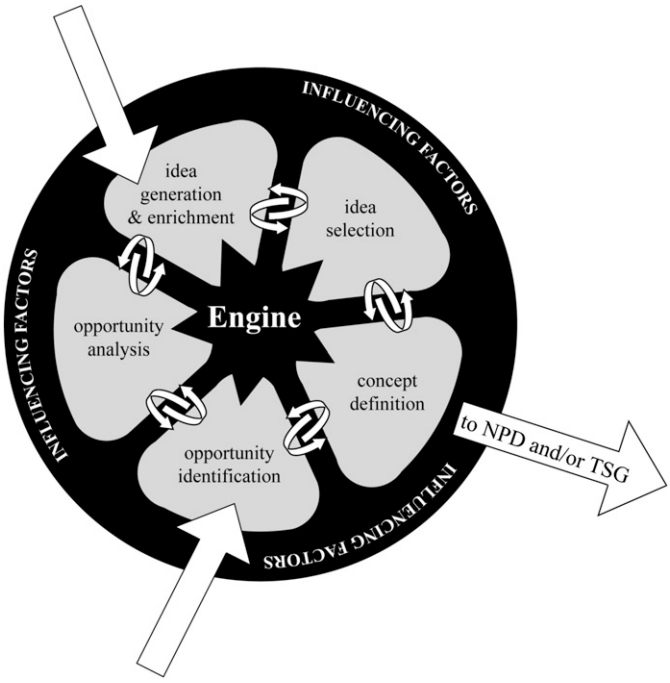

FIGURE 1. The NCD model (Koen, Ajamian, Boyce et. al. 2002; used with permission)

the environmental factors that influence the engine and shape the five activity elements. These include the company's organizational capabilities, competitor threats, customer and worldwide trends, regulatory changes, and the depth and strength of enabling sciences and technology.

In contrast to linear, staged-and-gated processes, the model is circular to indicate that ideas flow, circulate, and iterate across and among the five elements. The arrows pointing into the model represent the starting points for projects and indicate that projects may begin in either opportunity identification or idea generation and enrichment. Projects leave by entering into the new product development or technology Stage-Gate process.

Background: Front End Of Innovation Research

There have been eight empirical studies that specifically focused on the front end (Table 1). These studies have some limitations that we tried to overcome in this study. All but two (Bacon et al. 1994; Khurana and Rosenthal 1998) were done in relatively small companies. (Studies that focused on start-ups of fewer than 10 employees were excluded.) Furthermore,

Earlier studies found that successful organizations follow a holistic approach, and that success depends on both organizational attributes and project-specific activities.

all but one (Khurana and Rosenthal 1998) looked at the outcome of a single project in the front end, typically the last one launched by the survey respondent. And, of the studies that included larger firms, the focus was mostly on incremental projects. Those studies that included radical projects combined the results from both incremental and radical projects. Studies

TABLE 1. Empirical studies of front-end practices

Authors	Sample	Type	Method	Dependent Construct	Major Conclusions
Bacon et al. (1994)	6 Fortune 100 companies in U.S.	Case	Asked managers to compare success/ failure insights across 7 successful and 5 unsuccessful incremental projects.	Success and failure	Quality of product definition entering the subsequent development process was linked to overall product success.
Moenaert et al. (1995)	40 Belgian companies w/ median sales of $62 million	Survey	Analyzed 40 successful and 38 failed incremental projects.	Paired comparison between successful and failed projects in the same company	Successful front-end project teams minimized project uncertainty by enhancing exchange between marketing and R&D.
Khurana and Rosenthal (1998)	12 multinational companies, 8 from US and 4 from Japan	Case	Studied 10 incremental and 2 radical projects and the business unit practices.	Activities that preceded the Stage-Gate decision and the types of problems the companies faced	Successful organizations follow a holistic approach that integrates product strategy, portfolio, concept development, business justification, resource planning, and executive decision making.
Langerak, Hultink, and Robben (2004)	126 Dutch firms with mean sales of $31 million	Survey	Analyzed front-end organizational practices of firms that had introduced new products in the last 12 months.	17-item construct based on overall new product performance	Strong correlation was found between product performance and both strategic planning and idea generation, but no correlation was seen between idea screening and business analysis. Market orientation was positively related to proficiency of strategic planning and idea generation, but not to product performance.
Verworn, Hersttat, and Nagahira (2008)	475 Japanese companies with 5–70,000 employees	Survey	Analyzed development process for the last product brought to market, including both incremental and radical projects in combined analysis.	2-item construct that measured degree of agreement between planned and actual financial and personnel resources and 5-item effectiveness construct that evaluated how well project met profit and customer targets	Correlation was found between reduction of market and technical uncertainty and effectiveness. Reduction of technical uncertainty was correlated with efficiency, but not with reduction of market uncertainty.
Verworn (2009)	175 German companies with 5–6,700 employees	Survey	Analyzed development process for the last product brought to market, including both incremental and radical projects in combined analysis.	2-item construct that measured degree of agreement between planned and actual financial and personnel resources and 3-item construct to measure satisfaction with process, results, and team	All of the front-end constructs were correlated with fewer project changes and better team communication. Reduction of technical uncertainty was correlated with efficiency, but not with reduction of market uncertainty.

continued

TABLE 1. *continued*

Authors	Sample	Type	Method	Dependent Construct	Major Conclusions
Poskela and Martinsuo (2009)	133 Finnish companies with >50 employees	Survey	Evaluated the role of management control in the front end.	4-item strategic construct that measured degree to which a new product opens up new opportunities or markets	Input control (selecting people to run the project, defining goals for the project) and market and technology novelty were correlated with success. No correlation was found between success and either strategic vision or informal communication.
Martinsuo and Poskela (2011)	107 Finnish companies with median 350 employees (author estimate)	Survey	Evaluated the Stage-Gate decision criteria for most recently completed front-end project.	4-item construct based on competitive potential and 4-item construct based on future business potential	Technical and strategic, but not market, criteria correlated with future business potential of projects with high complexity and novelty.

by Lynn, Morone, and Paulson (1996) and O'Connor and DeMartino (2006) have shown that the processes and procedures required for successful radical innovation are significantly different from those for incremental projects, limiting the applicability of this combined data. In addition, all of the studies, except Khurana and Rosenthal (1998), relied on data collected from single respondents, which is less desirable than multi-respondent data.

Further, many of the studies struggled to determine success measures for the front end of innovation. For example, Verworn, Herstatt, and Nagahira (2008) used efficiency—defined as whether human resources were sufficient and the project was within budget—and effectiveness—defined as the extent to which the product met profit, sales, market share, and customer expectations. In a subsequent paper, Verworn (2009) used the efficiency measurement and added overall satisfaction of the R&D managers with the new product team, the process, and the results obtained. Poskela and Martinsuo (2009) used future business potential—the extent to which the new product opens up new markets and increases market and technology know-how—as a front-end success proxy. In a later paper, Martinsuo and Poskela (2011) again used future potential and added competitive potential, which measures the potential competitive advantage achieved by the product. In other words, all of these studies used different success measures and most looked only at the success of respondents' last completed projects.

Designing the Survey

This project had its genesis in regular meetings held by IRI's Process Effectiveness Network (PEN). In the middle of 1998, eight members of the PEN team, all owners of their companies' product development processes, met for two days to discuss best practices for the front end. The team found the task of identifying best practices to be impossible, since there was no common language or definition for key elements of the front end. This realization led to the creation of the NCD model (Koen, Ajamian, Burkart et al. 2001) to provide a common language. The PEN group then developed a set of commonly used methods, tools, and techniques based on the literature and the team members' own experiences (Koen, Ajamian, Boyce et al. 2002).

Best practices, however, remained elusive. In order to find answers, a Research-on-Research (ROR) working group was formed in 2002. The goal of the project was to develop a survey instrument based on the NCD model that could be used to gather quantitative data on front-end practices from a large sample of companies. The ROR team members, many of whom had been members of the original PEN team, were R&D managers from 10 companies, all with intimate knowledge of the front end.[1]

Working from the NCD model, the team identified key constructs (question sets that measure the variables affecting front-end performance) to measure an organization's behaviors and attributes with regard to each part of the NCD model.[2] When possible, already existing and validated question sets were used. When the construction of the survey was completed, team members took the survey and provided feedback. The survey was revised and administered to colleagues from the companies of team members, who were asked to evaluate each item for clarity, specificity, and representativeness. After a second revision in response to these critiques, the survey instrument was reviewed by three academicians knowledgeable in front-end research.[3] In order to assure the highest possible validity, the team

[1] Heather Alderman, Christina Bramante, Scott Boyce, Robin Dvorak, Cindi Hartz, Kathy Herald-Marlowe, Michael Incorvia, Peter Koen, Elko Kleinschmidt, Drew Kugler, Ken Lauer, Rita Pilate, Linda Pruden, Rebecca Seibert, Jeff Stirrat, and Brenda Tollett.

[2] A construct is a collection of questions that all measure the same topic and are designed to elicit the same response. This is the preferred way of enhancing response reliability, as individual survey questions may contain random measurement error. Constructs may measure either dependent or independent variables. Dependent variables, in this study, are the front-end outcomes. Independent variables are things that the company can change—for example, front-end resources and culture—to affect the dependent construct (front-end performance).

As previous researchers had, the team struggled to determine a reliable measure of front-end performance.

took a number of specific steps in designing the survey, collecting data, and conducting data analysis:

- *Separate constructs were developed for incremental and radical projects.* To account for the differing success criteria for incremental and radical projects, we developed separate question sets for incremental and radical projects. Following the well-known designations from Booz, Allen, and Hamilton (1982), incremental product and service activities were defined as cost reductions, improvements to existing product lines, and repositioning efforts and radical product and service activities were defined as additions to existing product lines, new product lines, and new-to-the-world products.
- *All constructs included multiple questions*. Multiple-item scales are generally recognized as psychometrically superior to single-item scales (Nunnally 1978, 243). Single-item scales cannot adequately measure multifaceted variables, such as those governing front-end performance and are more susceptible to random measurement error. However, multi-item scales are more complex and it is important to ensure that all items in such a scale do, in fact, measure the same construct—that is, that the scale is internally consistent. Coefficient alpha is a measure of the internal consistency of a multi-item scale (Henson 2001). It can be determined by measuring Cronbach's alpha (Cronbach 1951), a coefficient that ranges from 0 to 1. A low Cronbach's alpha, for example less than 0.6, would indicate that the item questions are not measuring the same underlying construct. A Cronbach's alpha greater than 0.6 is considered acceptable for exploration purposes, 0.7 is considered adequate, and 0.8 is considered good (Kline 1999). We calculated Cronbach's alpha for all constructs in the instrument, with encouraging results. Only the strategy construct had a coefficient alpha below the 0.7 threshold (coefficient alpha = 0.69). As a further measure of internal consistency, we also report the average variance extracted (AVE), which measures the amount of variance captured by the construct in relation to the amount of variance due to measurement error (Fornell and Larcker 1981). All constructs had an AVE higher than 0.5 with exception of the culture construct (AVE =0.49).
- *Data were collected from multiple respondents within the same business unit.* Just as multi-item constructs boost reliability by approaching the question from different angles, gathering data from multiple respondents allowed us to compare responses to assess the reliability of the data. Measuring the consistency of responses across multiple employees from the same business unit—inter-rater reliability—determines whether answers of different respondents from the same business unit were more similar than could be explained by chance.[4] All of the constructs used met or exceeded accepted standards for inter-rater reliability.
- *Data were analyzed at the business-unit level.* Different businesses will have different product life cycles and different requirements with regard to frequency and radicalness of new products. Furthermore, strategizing and execution for front-end innovation often take place at the business-unit level (see Brown and Eisenhardt 1997). To accommodate these differences, we evaluated the innovation process on a business unit level, rather than on a corporate or product level.
- *Data was controlled for firm size and R&D spending.* Firm size, which has long been recognized to be an important factor in performance (Porter 1980), was included as a control variable. The second control variable was R&D spending as a percent of revenues, which should also affect performance, as it seemed that increasing levels of R&D investment should increase both the scope and number of projects, and hence performance. A recent study by Jaruzelski, Loehr and Holman (2012) questioned this assumption, indicating that there is "no long-term correlation between the amount of money a company spends on its innovation efforts and its overall financial performance" (2). The relationship between innovation and R&D spending remains a controversial topic. Nevertheless, we did control for R&D spending in our analyses.
- *Regression models were created to explain the results.* Most best-practice studies report results for responses to single independent questions from participants in top, middle, and bottom quartile performance segments. Regression models offer a fuller picture than these methodologies, providing a measure of the extent to which the independent constructs (in this case senior management commitment, vision, strategy, resources, and culture) share variance with the dependent variable (front-end performance) and allowing assessment of whether relationships between the independent and dependent variables are statistically significant.

[3] Helpful comments and feedback on the survey were provided by Dorothy A. Leonard, William J. Abernathy Professor of Business Administration, Emerita, Harvard Business School, best known for her work in culture and creativity; Richard R. Reilly, Professor of Technology Management at Stevens Institute of Technology, an expert in teams and statistics; and Eric Von Hippel, Professor of Technological Innovation, MIT Sloan School of Management, best known for his work in lead user and user-centered innovation.

[4] The ICC(1) and ICC(2) statistics (Shrout and Fleiss 1979) were used in calculating inter-rater reliability. ICC(1) indicates the amount of variance in a variable attributable to group membership, and ICC(2) assesses the internal consistency reliability of the group means (Castro 2002). The analyses indicated that a significant proportion of the variance of the measure could be explained by membership in a particular business unit.

TABLE 2. Variables constituting survey constructs for organizational attributes

Construct	Variables	No. of Items	Cronbach's Alpha	AVE
Performance in the Front End (*Dependent*)	The degree to which: 1. Products in the front end generate sustainable competitive advantage. 2. The business unit delivers on front-end strategic objectives. 3. The business unit has a balanced portfolio across products, technologies, and risk.	3	0.79	0.61
Senior Management Commitment (*Independent*)	The degree to which senior management: 1. Plays a central role in project reviews. 2. Participates in making key decisions in project reviews. 3. Champions major new front-end projects. 4. Is strongly committed to front-end activities. 5. Plays an integral role in most front-end projects.	5	0.91	0.65
Vision (*Independent*)	Organization's vision is stable over time for: 1. Markets. 2. Technology. 3. Front-end projects.	3	0.88	0.57
Strategy (*Independent*)	Organization's strategy is well defined for: 1. New markets. 2. Disruptive businesses.	2	0.69	0.66
Resources (*Independent*)	Organization has sufficient resources for: 1. Opportunity identification. 2. Idea generation. 3. Idea selection. 4. Concept definition.	4	0.87	0.67
Culture (*Independent*)	People in the organization: 1. Trust each other, are open and honest. 2. Have time to consider and test new ideas. 3. Do not set traps for each other. 4. Discuss and consider opposing opinions. 5. Receive new ideas in an attentive and professional way.	5	0.79	0.50

As previous researchers had, the team struggled to determine a reliable measurement of front-end performance. Estimates of financial expectations for front-end projects would be unreliable and difficult to obtain, since companies consider them to be confidential. In the end, we developed a construct defined as 1) the degree to which the products in the front end are able to generate a competitive advantage, 2) the extent to which the business unit delivers on its front-end objectives, and 3) the degree to which the business unit's portfolio is balanced across products, technologies, and risk levels.

A comparison of this construct to the well-accepted 13-item construct developed by Cooper and Kleinschmidt (1993) to measure overall new-product development success found a significant correlation (r=0.62) (Bertels, Kleinschmidt, and Koen 2011), giving the team further confidence that the construct is valid. A perfect correlation was not expected, since some attrition can be anticipated as products move from the front end into product development. As further evidence of validity, 54 percent of the business units that scored in the top 5 percent on this performance measurement came from corporations listed in either Thomson Reuters's Top 100 Global Innovators (Thomson Reuters 2012) or *Business Week*'s 50 Most Innovative Companies (Einhorn and Arndt 2010) or both.

Responses were solicited from IRI member companies, participants in an executive training program, and attendees at a conference focused on the front end of innovation. A benchmarking report comparing the respondent's business unit with top- and bottom-quartile companies was provided as an incentive to participate. The overall response rate was 75 percent.

Complete data were obtained over a two-year period from 197 business units with median annual sales revenue of $1.05 billion and an average R&D investment of 4.0 percent of revenues. The sample includes business units from several industries, including telecommunications (10.3 percent), chemical (8.6 percent), food (8.6 percent), pharmaceutical (6.9 percent), medical devices (6.0 percent), consumer goods (5.2 percent), manufacturing (2.6 percent), and petroleum (2.6 percent).

The analysis that follows is based on data for the whole sample. We would expect that effective practices in the front end would be industry dependent. However, we did not have sufficient sample size to analyze practices by industry segment with adequate statistical power. In future

Taken together, constructs for organizational attributes explain 53 percent of the variance in performance in the front end.

Popular opinion often emphasizes the importance of activities over organizational factors.

years, as we collect additional data, we hope to be able to report on industry-specific practices.

The Engine of Front-End Innovation: Organizational Attributes

Organizational attributes were captured in five constructs (Table 2):

- *Senior management commitment:* the degree to which senior managers are involved with front-end activities.
- *Vision*: the aspirational direction for future products. Vision is distinct from strategy. A vision provides both the lens through which employees can envision entirely new products or services and meaningful constraints for what those new products might be. For example, Apple's vision, as presented in its 2011 10K report, is to bring "best user experience to its customers through its innovative hardware, software, peripherals and service" using "its unique ability to design and develop its own operating system, hardware, application software and services" to create new products and solutions that offer "superior ease-of-use, seamless integration and innovative design." Ideas for the next transformational or breakthrough product are typically not in the company's product portfolio. This construct was developed from Lynn and Akgün (2001).
- *Strategy:* the degree to which strategy is congruent with vision and provides a meaningful roadmap for investing in both incremental and radical innovation initiatives. Apple's strategy defines the product roadmap (iPod, iPhone, and Mac computer) as well as product enhancements and services (iTunes and Apple stores) that will be supported within the strategic time horizon.
- *Resources:* the extent to which sufficient funds are directed to the front end.
- *Culture:* patterns of behavior, attitudes, and feelings within an organization. This construct uses a shortened version (Isaksen and Lauer 2002) of the well-accepted Situational Outlook Questionnaire (SQQTM) developed by Isaksen, Lauer, and Ekvall (1999).

A regression analysis revealed the significance of the relation of each of the various organizational attributes with success in the front end (Figure 2). Taken together, these constructs explain 53 percent of the variance in business-unit performance in the front end. The regression coefficients for all of the independent constructs were significant ($p<.001$), ranging from 15 percent for senior management involvement to 24 percent for vision, which suggests that all of the organizational attributes are important.

In the hard sciences, the variance explained in the dependent variable would be expected to approach 99 percent for well-constructed experiments. However, in this case, that would mean that a company with high levels of senior management involvement, vision, strategy, resources, and culture would be nearly assured of success. Product attributes, market competitors, and a favorable environment—as well as all of the other attributes—would not be required. In this kind of setting, defined by human choices and individual interpretations of the relative importance and precise meaning of the various factors, it is considered good when one can explain 20 percent of the variance in the dependent variable. Our result—53 percent of the variance in front-end performance explained—far exceeds this value, offering strong evidence of its importance in explaining success in the front end. The variance in front-end performance was 30 percent or less explained by the other parts of the NCD model (Table 3), suggesting that organizational attributes are the most important factor in success in the front end. This is a major insight, as popular

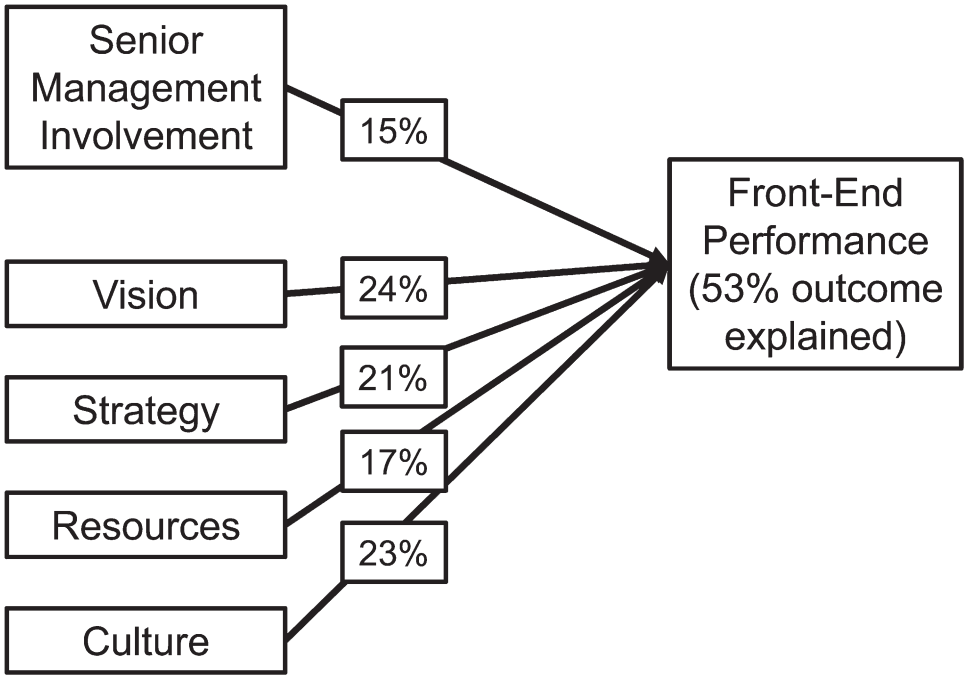

FIGURE 2. Results of regression analysis for organizational attributes constructs

opinion often emphasizes the importance of activities, such as identifying unmet customer needs, conducting market research, and developing a solid business plan, over organizational factors.

These results are consistent with Khurana and Rosenthal's (1998) conclusion that a holistic approach is critical to front-end success, defining a holistic approach as one that "effectively links business strategy, product strategy, and product specific decisions. Forging these links requires a process which integrates such elements as product strategy, development portfolio, concept development, overall business justification, resource planning, core team roles, executive reviews and decision making" (57).

These results also align with Lafley and Charan's (2008) discussion in *The Game Changer*, in which they argue that successful innovation must be "integrated into how you run your business; its overall purpose, goals and strategies, structure and systems, leadership and culture" (10). Successful innovation can only occur, Lafley and Charan insist, when the key elements—leadership, vision, strategies that include stretch goals, a supportive culture—and their enabling structures and processes are all organized together.

Senior management commitment is reflected in unwavering support for front-end activities, in terms of participation and in championing front-end efforts. A. G. Lafley, CEO of Procter & Gamble, and Apple's Steve Jobs are generally acknowledged as exemplars of the kind of support that drives innovation success. Lafley puts customer-centric innovation at the heart of his management process, making one of P&G's core strengths "consumer and shopping research, with a particular focus on immersive research" (Lafley and Charan 2008, 13) and continually evaluated the "changing landscape in [P&G's] industry" (Lafley and Charan 2008, 15). Similarly, Steve Jobs played an integral role in the design of all of Apple's products, as a *Wall Street Journal* profile described: "When it comes to product design, Mr. Jobs functions like an exacting editor, challenging hardware engineers and industrial designers to trim unnecessary features that don't add value to a product, says one former Apple executive" (Wingfield 2007). Another compelling set of examples comes from Lynn, Morone, and Paulson (1996), who attribute the huge success of Corning's optical fiber, GE's computerized axial tomography scanners, and

TABLE 3. Variables accounted for in the NCD model

NCD Element	Variable	Explanatory Power of Model
Engine	Organizational attributes	53%
Engine	Teams and Collaboration	24%
Activity elements associated with incremental projects		27%
Activity elements associated with radical projects		30%

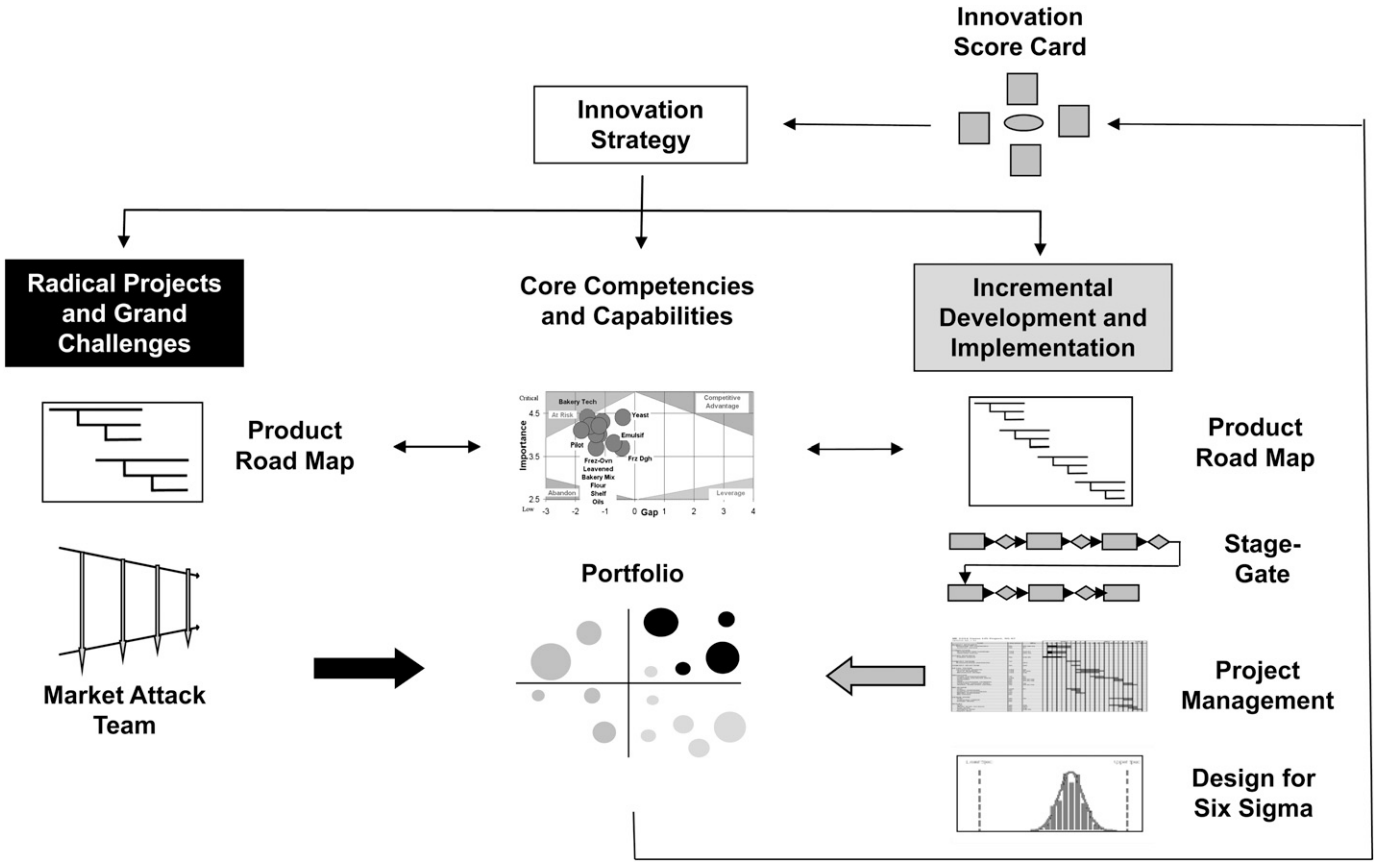

FIGURE 3. High-performer product innovation strategy (adapted from Koen 2005; used with permission)

The company with superior front-end performance is proficient in all five organizational attributes.

Motorola's cellular phone—all of which had long gestational periods—to the persistence of senior management.

Vision is a broad guide, providing a core ideology that gives employees a context for imagining entirely new products and services. Having a vision for markets, technology, and front-end projects before product strategies are even formed is essential to harness the boundary-spanning activities of employees, helping them understand what is within the scope of a company's overall strategy and what is not. Collins and Porras (1994) stress the importance of a core ideology—or vision—that is consistent with both the corporate and product strategies. That vision opens avenues to the future and enforces constraints, suggesting where the company *could* go and where it will not. Apple's vision encompasses hardware and software in an integrated, easy-to-use design. In the context of that vision, one could imagine the company creating customer-inspired televisions, but would not expect it to develop separate software or a hardware that could not be integrated.

Strategy provides a detailed roadmap for future products. The most effective organizations have a front-end strategy for both new markets and disruptive businesses. In highly innovative companies, there is a distinct strategy for incremental and radical projects, both mediated by the portfolio (Figure 3).

Resources are essential to support front-end activities. Companies that are successful in the front end dedicate sufficient resources to support such key activities as exploration, idea generation and identification, and development and definition. Although results are sometimes difficult to see, or may take some time to emerge, resourcing these activities is essential to a successful front-end process.

Culture is the set of attitudes, beliefs, and feelings that drive—or stifle—innovative behaviors. The behaviors captured in our five-item construct are key indicators of a culture that fosters successful front-end innovation. The importance of culture is a recurring theme in the innovation literature. Daniel Pink (2011) provides convincing evidence that a culture for innovative thinking requires an environment that supports autonomy (allowing people control over their work), mastery (giving people opportunities to get better at what they do), and purpose (cultivating a sense that people are part of something bigger). In a similar vein, Hill and colleagues (2010) found that great innovation leaders create cultures in which employees feel empowered to be creative. Or, as Nelson Mandela (1995) described it, "A leader . . . is like a shepherd. He stays behind the flock, letting the most nimble go on ahead, whereupon the others follow, not realizing that all along they are being directed from behind" (22).

Conclusion

The objective of this three-year project was to identify the most effective practices in the front end of the innovation process; the NCD model provided the lens through which to identify constructs and structure instruments. Our data show that the engine of the NCD model, or more specifically the organizational attributes, is the most important part of the front end, explaining 53 percent of front-end performance, compared to an explanatory potential of less than 32 percent for the other parts of the model. This important conclusion supports the recent focus in popular business books on the importance of vision and culture in fostering innovation. It also runs counter to much of the existing front-end research, which, with the exception of Khurana and Rosenthal (1998), focuses on the activity elements of the front end.

The importance of these factors may not be surprising to the many practicing innovation professionals who would cite them as critical. But the degree of their importance—our analysis found that organizational attributes were twice as important as any other factors—may be unexpected. Our results suggest that initiatives to create more innovation should start with a focus on the organizational attributes rather than on the activity elements such as team formation, opportunity identification, ideation or business planning. In addition, our study indicates that the company with superior front-end performance is proficient in all five organizational attributes. Succeeding in the front end, first and foremost, requires a holistic and integrative perspective from senior management with a focus on commitment, resources, vision, strategy, and culture rather than on specific project initiatives.

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