

A FRESH LOOK AT INCREMENTAL AND RADICAL
INNOVATION IN THE ENTREPRENEURIAL FIRM

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ABSTRACT

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Highly innovative and entrepreneurial firms, those generating ideas aimed at new and enhanced products, manufacturing processes and services, require entrepreneurial leaders who successfully manage the innovation process to discover or create, and then exploit opportunities (Oster, 1994; Venkataraman & Shane, 1998). This paper investigates whether innovations, categorized into incremental and radical, could be arranged in a progressive hierarchy of ascending order according to scope and scale. We examined environmental characteristics (dynamism); organizational characteristics (age, size and intrafirm linkages); organizational processes (improvisation, experimentation and transitioning); and managerial characteristics. Our findings suggest that a different mix of environmental and organizational characteristics and processes explain incremental and radical innovation.

Highly innovative and entrepreneurial firms, those generating ideas aimed at new and enhanced products, manufacturing processes, and services, require entrepreneurial leaders who successfully manage the innovation process to discover or create, and then exploit opportunities (Oster, 1994: 302; Venkataraman & Shane, 1998). The innovation processes of those highly innovative and entrepreneurial firms is influenced by a number of environmental, organizational, and managerial forces, although researchers rarely investigate whether such forces, rather than operating in isolation, comprise a set of factors that in combination, influence the ability of firms to innovate. Moreover, studies that distinguish between types of innovations are rare (Damanpour, 1992; Drazin & Schoonhoven, 1996; Klein & Sorra, 1996), although different types of innovations range from the minor or incremental to the major or radical.

We investigated whether, innovations categorized into incremental and radical, could be arranged in a progressive hierarchy of ascending order according to scope and scale. We examine the influence of the following factors for incremental and radical innovation: environmental characteristics (dynamism); organizational characteristics (age and size of the firm); structural characteristics (intrafirm cross linkages); organizational processes (improvisation, experimentation, and transitioning or sequenced steps); and managerial characteristics (education, age, tenure in the position, and tenure with the company). We chose to examine these relationships in two different industries: aerospace, and electronics/telecommunications. We chose these two industries because they are highly dependent on entrepreneurial managers for developing innovation for competitive advantage and survival.

Incremental and Radical Innovation

Differentiating between incremental and radical innovation is somewhat a matter of degree. According to a punctuated equilibrium or metamorphosis model of convergence and reorientation (Gersick, 1988), organizations evolve through relatively long periods of stability in their basic patterns of activity that are punctuated by “relatively short bursts of fundamental change” (Romanelli & Tushman, 1994). Tushman, Newman, and Romanelli (1986) examined four major organizations and found that technology evolves through relatively long periods of incremental change punctuated by relatively rare innovations that radically improve the state of the art. Most innovations simply build on what is already there, requiring modifications to existing functions and practices, but some innovations change the entire order of things, making obsolete the old ways (Van de Ven, Polley, Garud & Venkataramen 1999: 171).

Herbig (1994) describes higher order innovations as those that serve to create new industries, products, or markets (for example, lasers). Lower order innovations, by contrast, involve three types of innovation: (1) continuous innovation, the introduction of a modified product (for example, product line extensions), (2) modified innovation, slightly more disruptive innovation such as the introduction of a technology that performs the same basic functions (for example, electric pencil sharpener), and (3) process innovation or improvements in the way existing products are being produced (for example, TQM and CAD). In accordance with the work of Herbig (1994), we define incremental (first or lower order) innovation as low in cost and breadth of impact that here refers to the following broad categories of innovation: procedural (management-determined innovations in rules and procedures.); personnel-related (innovations in

selection and training policies, and in human resource management practices); process (new methods of production or manufacturing); and structural (innovative modifications to equipment and facilities and new ways in which work units are structured). We define radical (higher or second-order) innovation as major in scope, breadth, and cost that here refers to strategic innovations or the creation of new products or services offered or markets served.

Although not formally tested as a hypothesis, incremental and radical innovations require different degrees of change that may be explained by a different mix of environmental, organizational, structural, and managerial forces, and therefore may need to be managed differently (Rogers, 1995; Van de Ven et al., 1999). Angle (1989) in his work with the Minnesota Innovation Research Program (MIRP) found that different cultural characteristics (individualism versus collectivism) affect incremental and radical innovations differently. Herbig (1994) found that the conditions that favored high-order or radical innovations (for example--computers) differed from those favorable to incremental innovation (for example—new and improved products). Van de Ven and colleagues (1999) argue that some organizations may be better suited to one type of innovation but not the other, and different degrees of novelty need to be managed differently. For example, structural variables that increase the degree of incremental innovation may simultaneously decrease the degree of radical innovation.

Complexity theory argues that organizations are characterized by a continuous pattern of large and small changes, and that larger systems change occurs exponentially less frequently than small ones do (Anderson, 1999).

Accordingly, we expect that

Hypothesis 1: Entrepreneurial managers will report incremental innovation with significantly greater frequency than radical innovation.

Relating Environmental Characteristics to Innovation

Complexity theory argues that environmental pressures that continually shift drive internal organizational change. The more dynamic the external environment perceived by entrepreneurial managers, the greater the perception of an environment favorable to innovators. Firms in high velocity environments with short product cycles must engage in rapid and continuous innovative change in order to survive (Brown & Eisenhardt, 1997). An uncertain and rapidly changing environment serves to reduce structural rigidity and organizational inertial, thereby opening up opportunities to innovate. Accordingly,

Hypothesis 2: Entrepreneurial managers will positively relate perceived environmental dynamism to incremental and radical innovation.

Relating Organizational Characteristics to Innovation

“The older, larger, and more successful organizations become, the more likely they are to have a large repertoire of structures and systems which discourage innovation” (Van de Ven, 1986: 596). “While resources are necessary to innovate on a consistent basis, there do not appear to be substantial economies to scale in the discovery of new ideas. Thus small firms may well innovate where larger firms often fail” (Oster, 1994: 302). With increasing size and age comes “bureaucratic procedures. . . that often constrain innovation unless special systems are put in place to motivate and enable innovative behavior” (Van de Ven et al., 1999: 201). Herbig (1994) states “large

industrial research laboratories are a relatively minor source of radical inventions, but a main source of process or evolutionary inventions”.

Hypothesis 3: Entrepreneurial managers will negatively relate age and size of the firm to incremental and radical innovation.

Relating Structural Characteristics to Innovation

Complexity theory highlights the fact that the work of organizations is carried out by agents who are “partially connected to one another, so that the behavior of a particular agent depends on the behavior (or state) or some subset of all the agents in the system” (Anderson, 1999: 219). The innovation process is a product of a networking building effort (Van de Ven, 1986), and lateral relationships inside an organization that create an environment favorable to innovation (Brown & Eisenhardt, 1997; Legnick-Hall, 1992; Spender & Kessler, 1995). To bring a product to market requires that organizations “form linkages, upstream and downstream, lateral and horizontal” (Kessler & Charkrabarti, 1996: 1166, 1171). Kolodny, Liu, Stymne, and Denis (1996) studied the introduction of innovative flexible technologies in twelve companies in Sweden, France, and Canada, and found successful companies transitioned to flatter organizational structures with more horizontal communication. Thus we predict:

Hypothesis 4: The greater the number of intrafirm structural linkages, the greater the incremental and radical innovation of the firm.

Relating Process to Innovation

Improvisation and experimentation. From a complexity theory perspective, innovation cannot be planned but must evolve, and requires emergent and dynamic processes such as openness and improvisation (Lewin, 1999: 215). Brown and

Eisenhardt (1998) in their study of groundbreaking study of firms in the computer industry found, among other things, that successful innovators were able to improvise, experiment, and choreograph transitions from one project or product to the next. An entrepreneurial manager who is able to *improvise* balances “the structure that is vital to meet budgets and schedules with flexibility that ensures the creation of innovative products and services that meet the needs of changing markets” (1998: 28). Clearly some coordination is required and crucial to innovation. The question is not whether coordination is required, but rather how too much or tight coordination impedes an organization’s capacity for innovation, given how uncertain and technically complex innovative work is.

An entrepreneurial manager who is able to *experiment* has “insight into the future that may unfold without losing the flexibility to react to the future that does unfold” (1998: 131). The key issue for managers is the focus on reacting to new opportunities (strategic responsiveness) versus proactively pursuing new opportunities. In the ideal, managers gather information necessary for an informed vision while simultaneously maintaining an ability to see opportunities early and to move quickly and shift strategies in response to unexpected market, competitive, technological, and regulatory changes. “If managers focus their attention too much on the present, they end up chaotically reacting to the moves that others make. If their focus is too much on the future, then they tend to lock into a particular future, lose flexibility, and end up in the rigidity of a planned future” (1998: 131). From the above we expect that:

Hypothesis 5: Entrepreneurial managers will positively relate improvisation and experimentation to incremental and radical innovation.

Transitioning (sequenced steps). Stumbling blocks to innovation are created by an absence of well-established routines for leaving old businesses and by no or little coordination across projects. Rather than “leaving transitions to chance or rigidly avoiding transitioning at all, managers of successful product portfolios . . . create an almost seamless switch from one project to the next” (Brown & Eisenhardt, 1997: 21). Smooth transitions from one project to another are created by introducing products or services at predictable intervals, following explicit procedures for developing projects, and synchronizing projects with the needs of key customers and suppliers. In successful firms, “managers had created processes in which projects were planned out with work broken down into small tasks and then passed through a structured sequence of steps from concept specification to pre-prototype and so on. As each step was completed, the project was passed to the next step. The whole process was governed by specifications, procedures, and checkpoints” (1997: 14). We predict:

Hypothesis 6: Entrepreneurial managers will positively relate transitioning across projects (sequenced steps) to incremental and radical innovation.

Relating Managerial Characteristics to Innovation

By virtue of their personal characteristics, entrepreneurial managers will vary in the degree to which they develop and promote different types of innovation. Upper echelon research holds that cognitive biases, values, and

perceptions measured by such proxies as tenure and age influence what choices managers make. Research shows, for example, that long tenure of a manager is associated with performance conformity and strategic persistence (Finkelstein & Hambrick, 1990), while short tenure which may be a means by which an organization overcomes inertia is associated with strategic change (Wiersema & Bantel, 1992). As for the age of the entrepreneurial managers, “it is expected that in high-discretion situations, chief executives will tend to be relatively young” (Hambrick & Finkelstein, 1987). CEO age has been linked to risky strategies since younger managers typically have less commitment to the status quo and have more favorable attitudes toward risk taking (Bantel & Jackson, 1989). Accordingly we expect that:

Hypothesis 7a: The lower the age and the shorter the tenure of the entrepreneurial manager in the position and with the company, the greater the incremental and radical innovation of the firm.

Hypothesis 7b: The greater the level of the education of the entrepreneurial manager, the greater the incremental and radical innovation of the firm.

Methods

Organizations and Executives. The sample frame for this study was selected from the 1998 and 2000 editions of Ward’s Business Directory of U.S. Private and Public Companies. The Ward’s Directory contains a complete list of public companies and is also a leading source of information about companies that are not publicly traded or are subsidiaries of larger companies. The directory contains information on over 132,500

companies (90% of which are private), which lists CEO names, addresses, sales information, employee figures, and five and six digit Standard Industry Classification (SIC) codes. A two-step approach was used to select the sample from the Ward's directory. Because innovation can differ across industries, we selected three industry strata: (1) aerospace (SIC 336411 through 336415, and 336419); (2) electronic components and superconductors (SIC 334415 through 334419); and (3) telecommunications (SIC 513321, 513322, and 51331 through 51333). We selected random samples of 300, 350, and 250 from each of the three industry strata for a total of 900 firms. Although these industries vary in technical development and batch processing, all are highly dependent on innovation for competitive advantage and survival.

Aerospace. While sales of planes, jets, missiles and other space vehicles have declined since 1991, space and defense spending has recently increased (“Aerospace: Prognosis 1999,” Business Week, January 11, 1999, p. 114), and military exports and the civilian side of the business offer promise for growth and innovation in this industry. Menes (1998) summarizes the aerospace (along with the high technology) industry as follows: “The ten fastest growing manufacturing industries are heavily dominated by high tech industries. At the top is computer equipment, followed by the six aerospace industries. This is a dramatic turnaround for these industries since, with the exception of aircraft engines, they all ranked near the bottom in growth for 1995 and 1996 (1998: xxxiii)”.

Electronics/telecommunications. The electronic and telecommunications industries have seen multiple product innovations, rapid technological progress, and

unpredictable change. In the microprocessor industry, R&D can amount to 25-30 percent of firm sales (Oster, 1994). The deregulation by the Telecommunications Act of 1996 has opened up competition and made possible new kinds of service for new classes of customers in this industry.

In accordance with the Total Design Method (TDM) described by Dillman (1978), we mailed questionnaires, accompanied by postpaid return envelopes and cover letters, to the chief executive officers (chairman, CEO, and president) of the 900 firms in the sample frame. The cover letters served to identify the sponsor of the study and to explain its purpose and importance. We assured executives of confidentiality and promised them a report of the aggregated findings once the study was completed. A reminder letter with a replacement survey questionnaire was mailed three weeks after the initial mailing.

Some researchers question the validity of studies that rely on a single informant's perceptions (Lant, Milliken, & Batra, 1992). However, there is little convincing research that supports or contradicts the generally accepted belief that CEOs and top administrators can provide reliable information about their basic environmental and organizational characteristics of their organizations. Our approach of collecting data using one informant per organization has been supported when survey instruments were well designed and executed (Huber & Powers, 1985; Jennings & Lumpkin, 1992; Russell & Russell, 1992; Starbuck & Mezias, 1996).

The response rate for mail surveys sent to top level managers typically is lower than other mail surveys because top managers have relatively less discretionary time to devote to completing questionnaires sent to them by academic researchers. We obtained

response rates of 24.3%, 23.7%, and 14.8%, respectively, for the aerospace, electronic components, and telecommunications industries; response rates that are consistent with Stimpert (1992) who cites response rates ranging from 14% to 34% in studies using CEOs as addressees. Nonresponse bias is always a concern when response is voluntary; nonresponding firms, however, did not differ significantly from responding firms in annual sales or geographic area. However, a disproportionate number of nonresponding firms were from the telecommunications industry. This industry is experiencing a complete overhaul and shakeout, with many small wireless operators going out of business because of a decline in the price of wireless minutes, and an increased competition for capital (“Industry Outlook,” Business Week, January 12, 1998, p. 93; “Telecommunications,” Business Week, January 10, 2000, p. 96). Because a large number of firms from the telecommunications industry failed to respond, we combined the telecommunication and electronics firms for purposes of data analysis.

In terms of characteristics of the executives who responded, they included 182 males and 10 females, and had a mean age of 41 to 50 years. They had been in their present position a mean of 6 to 10 years or more, and had been with the company of a mean of 11 to 15 years or more. A large number of respondents held a college (N=73) or advanced degree (N=84); the others held an associate degree (N=19) or had a high school education (N= 16).

Approximately twenty-four percent (N=46) of the responding firms employed fewer than 100 workers; with nineteen percent (N=37) employing over 500 workers. The majority of firms (N= 109) employed between 100 and 500 employees. The mean age of the companies sampled was 34.36 years. A small number of firms, approximately thirteen

percent (N=25), reported declining sales over the last three years. About eighteen percent of the firms (N=34) reported a stable growth rate; twenty-four percent (N=46) reported a growth rate of less than 10%. A larger percentage of firms, approximately thirty-three percent (N=64), reported a growth rate between 10% and 25% annually, and a smaller number of firms, approximately twelve percent (N=23), reported an annual growth rate over 25%.

We also conducted, multiple, semi-structured follow-up interviews of a total of twenty-five executives who volunteered to be interviewed. We conducted interviews to help generate descriptive indicators of multiple innovations, to avoid misinterpretation of the results, and to help strengthen the results. The interviews were conducted on the telephone and lasted 30 to 40 minutes.

Measures

We employed scales that had been had been standardized and validated by other researchers (e.g., Brown & Eisenhardt, 1997, 1998; Duncan, 1972). We developed other scales specifically for this study based on a literature review and interviews with executives from each of the two industries.

Environmental dynamism. Dynamism, reflecting the extent to which strategists perceive unpredictable change in the external environment, is considered a perceptual phenomena, inasmuch as uncertainty resides “in the perceptions and minds of managers in terms of their ability to predict future environmental states” (Bluedorn, 1993: 166). We measured perceived environmental dynamism using ten items developed by Duncan (1972). Using a scale anchored from 1=very frequent change to 5=very rare change (reverse scored), we asked executives to rate the frequency of change in their firm’s

external environment sectors, including distributors, users, suppliers, competitors, public political attitude and development of new or improved production methods and new or improved products and services. To test the dimensionality of the scale (alpha coefficient of .70), the ten items were factor analyzed using principal components analysis with varimax rotation, yielding one identifiable factor (eigen value of 2.81) and loadings ranging from .42 to .74.

Intrafirm structural linkages. We measured intrafirm structural linkages, defined as cross-functional and coordination mechanisms designed with the aim of increasing integration, by eight 5-point Likert items. The eight items were based on the works of Brown and Eisenhardt (1998) and Muffatto and Panizzolo 1996. Executives rate the accuracy (1=very accurate to 5=very inaccurate) (reverse scored) of each of eight statements. We obtained an alpha coefficient of .76, and one identifiable factor (eigen value of 3.14), with loadings ranging from .42 to .69, was produced.

Improvisation and experimentation. We employed a group of paired statements adopted from Brown and Eisenhardt (1998) to measure improvisation and experimentation. The statements were developed based on their in-depth study of firms in the computer industry in Asia, Europe, and North America. We asked executives to rate the extent to which the paired statements, separated by a 5-point Likert scale, best approximated or described their firm. *Improvisation*, defined as too much versus too little structure, consisted of the following five paired statements: (1) change is expected (versus problematic); (2) priorities are clear (versus ambiguous); (3) priorities drive resources always (versus never); (4) communication is constant (versus infrequent); and (5) communication is channeled (versus chaotic). We obtained an alpha coefficient of

.73 and one identifiable factor with an eigen value of 2.48 and loadings ranging from .27 to .67.

Experimentation, defined as being able to focus on both the present and future without losing the flexibility required to react to the future and unexpected events (1998: 131), consisted of six paired statements: (1) The collective vision of our business is clear (versus ambiguous); (2) Our future is based on careful planning (versus reacting to future development); (3) Our attention to the future is constant (versus rare); (4) We have several (versus no) meaningful experimental products and future-oriented strategic alliances; (5) We extensively (versus never) use experimentation; and (6) Our business is considered to be a leader (versus follower). We obtained an alpha coefficient of .80, and one identifiable factor with an eigen value of 3.05 and loadings of .51, .45, .66, .63, .34, and .45. The factor analysis indicated to us that the items for measuring improvisation and experimentation were on the whole relevant and able to capture aspects of the processes that were considered theoretically and practically meaningful by Brown and Eisenhardt (1998).

Transitioning (sequenced steps). We measured transitioning, defined as transitioning or sequencing from one project to another, by three items developed by Brown and Eisenhardt (1997: 21). Executives rated (using a 5-point Likert scale anchored from 1=never to 5=frequently) the frequency with which: (1) new product or service performance is measured with well-defined metrics; (2) well-established routines are used for leaving old business areas; and (3) the firm has explicit procedures existing for development projects. One identifiable factor (eigen value of 2.29) was produced with factor loadings of .54, .65, and .59. We obtained a reliability coefficient of .75.

Size and age of firm. We measured size of the firm in terms of the number of total employees. A logarithm of the number of employees was computed to represent size since a logarithmic transformation provides the most generally useful procedure for effecting linearity. The age of the firm was determined by the firm's founding date.

Incremental and radical innovation. We asked executives to indicate how often during the last three years their firm made an organizational innovation in each of two categories. We told executives that organizational innovations refer to a broad range of innovations, either internally developed or externally acquired, that firms use to meet customer demand to maintain or improve firm performance. **Incremental** innovation included four categories: (1) *procedural* (innovations in rules, work procedures, work schedules, etc.); (1) *personnel* (innovations in human resource management; creative changes in selection and training policies, etc.); (2) *process* (new methods of production or manufacturing processes or significant technology enhancements in the organization's operations that are used to produce a product or render a service); and (4) *structural* (new innovations or creative modifications to equipment and facilities; innovative redesign of departments, divisions, and/or projects, etc). **Radical** innovation included one category, *strategic* (innovations in basic product or service programs offered or market served; creation of new major product/service programs leading to expansion of current markets). We computed a single composite overall measure of incremental innovation (alpha coefficient of .73) by averaging the unweighted score on each of the four incremental variables. The items were factor analyzed, producing one significant eigen value of 2.25 and individual loadings of .49, .63, .62, and .52.

We acknowledge that field studies using self-report, cross-sectional data are

particularly susceptible to errors resulting from consistency, priming, and problems associated with common method variance (Podsakoff & Organ, 1986). Factual data of which the respondent possesses direct knowledge pose less serious problems, since such data are in principle verifiable. Some of the data collected in the present study (such as change in number of employees over the last 3 years, age and size of the firm) were of this type. Also, Spector (1987) proposed that method variance might well be more of a problem with single items or poorly designed scales and less of a problem with multi-item and well-designed scales. Problems of common method variance should therefore be somewhat attenuated.

Analysis of Results and Research Findings

Data on the distributional characteristics of the scaled variables, along with the bivariate relationships (correlations) among the variables without controlling for the effects of other variables, are given in Table 1. Predictably, the two innovation variables (incremental and radical), and the process variables, experimentation, improvisation, and transitioning (sequenced steps) were positively related to each other.

In other analysis (not shown in the table), the results of an analysis of variance and a comparison of industry means using Scheffe post-hoc tests showed that improvisation was significantly greater for electronics/telecommunications (Mean=2.22) than for aerospace firms (Mean 2.02) ($F=6.81$, $p=.001$, $df=1,189$). Also, age was significantly greater for aerospace (Mean=40.14 years) than for electronics/telecommunications firms (Mean=30.71) ($F=9.73$, $df=1,189$, $p=.01$).

TABLE 1**MEANS, STANDARD DEVIATIONS, AND ZERO ORDER
CORRELATIONS AMONG THE STUDY VARIABLES**

			Zero-Order						
	Means	S.D.	1	2	3	4	5	6	7
1. Environmental dynamism ^a	2.55	.49	-						
2. Age of the firm	34.36	20.81	-.01	-					
3. Size of firm	2186.76	113.72	.18	.37**	-				
4. Intrafirm structural linkages ^a	3.54	.62	.01	.01	.17*	-			
5. Improvisation ^a	3.59	.55	-.04	.07	.06	.32**	-		
6. Experimentation ^a	3.46	.69	.08	-.06	.09	.43**	.56**	-	
7. Transitioning	2.79	.77	.05	-.01	.11*	.46**	.23**	.31**	-
8. CEO Age ^b	3.64	.59	-.14	-.06	-.13	.04	-.03	.04	.05
9. Tenure in position	4.40	1.8	-.03	-.05	-.28**	-.03	-.11	.001	-.03
10. Tenure with the company ^c	5.55	1.64	-.04	.17*	.05	-.06	-.02	-.02	.05
11. Education ^a	3.26	1.03	-.04	.05	.20**	.06	.04	.08	.03
12. Incremental Innovation ^a	3.14	.75	.22**	.24**	.34**	.27**	.06	.11	.20
13. Radical Innovation ^a	2.98	.91	.28**	-.06	.11*	.25**	.10	.24**	.26

a=5-point scale; b=4 point scale; c=7 point scale; * p=.05; ** p=.01.

Results: Research Hypotheses

A correlated (paired sample) t-test showed that incremental innovations occurred with significantly greater frequency than did than radical innovations ($t=2.37$, $df=191$, $p=.02$). This finding supports Hypothesis 1.

We used hierarchical regression, an efficient analysis alternative that allows blocking on variables, to test the research hypotheses that the environmental, organizational, structural, process, and managerial variables will be related to incremental and radical innovation (see table 2). Hierarchical regression allows sets of independent variables, rather than single IVs to be entered cumulatively in a hierarchical order, and upon the addition of each new set, an adjusted R-square and the changed in the adjusted R-square can be computed.

TABLE 2

RESULTS OF HIERARCHICAL REGRESSION OF
INCREMENTAL AND RADICAL INNOVATION

INDEPENDENT VARIABLES	INNOVATION VARIABLES (Standardized Regression Coefficients)	
	Incremental	Radical
Environment		
Environmental dynamism	.22**	.27**
Organization		
Age of the firm	.16*	-.08
Size of the firm	.21**	.06
Intrafirm structural linkages	.22**	.21**
Change in Adj R-Square	.16**	.05**
Process		
Improvisation	-.03	-.04
Experimentation	-.01	.15
Transitioning	.09	.16*
Change in Adj R-Square	.01	.04*
Managerial		
CEO age	-.15*	-.04
Education	.03	.04
Tenure in position	-.09	-.16
Tenure with company	-.06	.13
Change in Adj R-Square	.03	.02
180, p=.001	F=5.22, df=11, 180, p=.001	F=3.69, df=11,
R ² =.18	Multiple R=.49, R ² =.25	Multiple R=.43,
*p=.05; **p=.01		

Hypothesis 2 related perceived environmental dynamism to incremental and radical innovation. Perceived environmental dynamism was a significant positive predictor of both incremental and radical innovation. Hypothesis 3 related age and size of the firm to innovation. Size and age of the firm predicted incremental but not radical innovation and not in the direction predicted. Hypothesis 4 related intrafirm structural linkages to innovation. Intrafirm linkages were a positive predictor of both types of innovation. Hypotheses 5 and 6 related the process variables (improvisation, experimentation, and transitioning) to innovation. Experimentation and transitioning were positive predictors of radical innovation. Last, Hypothesis 7 related managerial characteristics to innovation. CEO age was a significant negative predictor of incremental (but not radical) innovation. In summary, there is support for hypotheses 1, 2, and 4, partial support for hypotheses 5, 6 and 7, and no support for hypothesis 3.

To determine the unique contribution of the environmental, organizational, process, and managerial variables to innovation, we examined the change in the adjusted R-square. Table 2 reveals that environmental and organizational variables were a significant predictor of incremental and radical innovation. The process variables were a significant predictor of radical innovation, and the managerial variables were a significant predictor of incremental innovation.

Discussion and Conclusions

Our findings from a group of aerospace and electronic/telecommunication industries suggest that over a three-year period entrepreneurial managers reported incremental innovations most frequently, and radical innovations reported least frequently. Our results also suggest that a different mix of environmental, organizational,

structural, process, and managerial variables explain incremental and radical innovation. Our findings are consistent with Ettlie, Bridges, and O’Keefe who studied 192 firms in the meat, canning, and fish industries, and found that “strategy-structure causal sequence for radical innovation is markedly different from the strategy-structure sequence for incremental innovation” (1984: 692). Our results indicate that the following variables predicted incremental innovation among a sample of aerospace and electronics/telecommunications firms: perceived environmental dynamism, age and size of the firm (although not in the expected direction), intrafirm structural linkages, and the age of the CEO. The following variables predicted radical innovation: environmental dynamism, intrafirm structural linkages, experimentation, and transitioning or sequencing from project or product to another.

Our results imply that changing environments are significantly related to both incremental and radical innovations. Among the environmental changes and uncertainties described by executives in both the aerospace and electronics/telecommunications industries were global economic fluctuations and uncertainty, cyclical demand, the Asian crisis, increased partnering across industries, double-digit growth, and “the broadband revolution.” Our finding that radical (along with incremental) innovation increased as environmental dynamism increased lends support to Tushman and Romanelli’s suggestion that “effective organizations in environments with substantial technological and/or legal/social uncertainty” will tend to undertake reorientations or quantum (radical) changes (1985: 207).

Contrary to our expectations, incremental innovation increased as age and size of the firm increased. Our results reinforce the idea suggested by Herbig (1994) that older

and larger firms are more likely to produce incremental innovations. However, Herbig also expected younger and smaller firms to produce more radical innovation and our results failed to support that idea.

Our findings suggest that both incremental and radical innovation increase as the number of intrafirm structural linkages increased. These intrafirm linkages, which include such things as cross-project meetings and communications as well as a mixing of old and new team members to form new teams, are significantly related to both types of innovation. These results lend empirical support to the conceptual work by Kessler & Charkrabarti (1996) that suggests “to bring a product to market requires that organizations form linkages, upstream and downstream, lateral and horizontal”.

“The innovation journey entails many of the same core processes, irrespective of organizational settings” (Van de Ven, Polley, Garud, & Venkataraman, (1999: 17). Our findings suggest that radical innovation had a positive association with the processes, experimentation and transitioning or sequencing steps whereas incremental innovation did not. That is, core processes may not be the same in all organizational settings. Those firms that produce radical innovations may be more likely to engage in improvisation, experimentation and transitioning processes.

We expected to find that higher educated, younger managers with a shorter tenure in the company would be positively related to incremental and radical innovation of the firm. We found CEO age to be a significant negative predictor of incremental innovation. That is, lower CEO age was significantly related to incremental innovation, but we were unable to show the same to be true for radical innovation (although it was in the same direction, just not significant). Neither education nor tenure were significant

predictors of radical or incremental innovation.

Our findings are limited by the inherent difficulties in performing a cross-sectional study, drawing generalizations from two industries, and disentangling cause and effect. For example, we need to consider the extent to which perceived environmental dynamism contributes to innovation, and the reverse possibility that incremental and radical innovation contribute to perceptions of environmental change. Also, although we quantified the degree to which entrepreneurial managers undertake incremental and radical innovation, we failed to measure the intervening variable of choice, and we did not examine the relationship between innovation and firm performance. Despite its importance to scholars and practitioners alike, performance was difficult to measure because the majority of firms in our sample are not publicly traded and reliable performance data are difficult or impossible to obtain. Future research is needed to investigate other environmental and organizational antecedents of incremental and radical innovation such as environmental scanning, interorganizational linkages, and organizational norms.

Our findings have implications for entrepreneurial managers who seek to innovate in fast-paced and highly competitive environments. Those leaders must successfully manage the innovation process if they want to discover, create and exploit opportunities. This study has suggested that age and size of the firm as well as a dynamic external environment will increase innovation potential. But these are variables that are generally outside the scope of the entrepreneurial manager's duties. Even so, this study has also suggested that there are steps that the entrepreneurial manager can take to increase innovation potential and these steps include the use of intrafirm linkages.

Entrepreneurial managers must find ways, whether it be through networking, cross-project communications, the mixing of old and new team members or other creative ideas, to increase intrafirm structural linkages.

Additionally, the use of improvisation and experimentation are organizational processes that entrepreneurial managers should consider. Those managers who are able to balance on the edge between structure and flexibility (improvisation) and those who attempt to gain insight into the future that may yet unfold (experimentation) are more likely to be able to discover, create and exploit opportunities. In a world that at times appears to be moving at the speed of sound, it is imperative that entrepreneurial managers seek out and use those tools which will propel them successfully into the future.

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