REQUISITE VARIETY AND FIRM PERFORMANCE: AN EMPIRICAL EXPLORATION

Timothy J. Vogus[1]
Kathleen M. Sutcliffe
University of Michigan Business School

Abstract
The organizational demography, sensemaking, and high reliability literatures often assert that requisite variety enables organizations to notice more, develop a broader repertoire of responses, and be more adaptive over time. While this assertion remains intuitively appealing it has received little focused empirical attention. The empirical tests that have claimed to test requisite variety have focused on variety to the exclusion of requisite. We rectify this gap by testing the effects of requisite variety on risk detection (noticing), innovation (responding), and firm performance (adapting) on a sample of 174 IPO software firms.

[1] Please direct correspondence to: Timothy J. Vogus, University of Michigan Business School, 701 Tappan St., Ann Arbor MI 48109, Telephone: (734) 623-1179, Fax: (734) 623-1179, E-mail: tvogus@bus.umich.edu

1. INTRODUCTION

In hypercompetitive environments, where means-ends relationships are uncertain, organizational learning and adaptability take on central importance to firm performance and survival (D'Aveni, 1994). How are firms able to navigate such rugged landscapes? The top management demography (e.g., Milliken & Martins, 1996), high reliability (Roberts, 1990), and sensemaking (Weick, 1995) literatures have all argued that building and maintaining requisite variety is a key basis of learning, adaptability, and performance. Weick (1995) offers a representative quotation when he asserts, "…organizations with access to more varied images will engage in sensemaking that is more adaptive than will organizations with more limited vocabularies" (p. 4). Ashby (1956) first posited the law of requisite variety as, "variety within a system must be at least as great as the environmental variety against which it is attempting to regulate itself" (Buckley, 1968, p. 495). Therefore, at the team or organizational level, requisite variety entails a matching process between environmental demands and characteristics of the team and organization. While perfect requisite variety remains more a theoretical ideal than practical option due to the costs an organization incurs to maintain such breadth, organizations that are closer to this ideal are more likely to outperform their competitors. Weick echoes this call for maintaining high levels of diversity when he asserts "organizations have to be preoccupied with keeping sufficient diversity inside the organization to sense accurately the variety present in ecological changes outside it" (Weick, 1979, p. 188).

The sensemaking, organizational demography, and high reliability literatures each offer suggestive and testable answers. Bogner and Barr (2000) propose that greater requisite variety within teams allows more stimuli to be noticed, responded to, and consequently leads to greater adaptability in hypercompetitive environments. Morrison (1992) also claims that organizations that are internally as diverse as their customer base are more likely to meet their customers' needs and anticipate changes in their tastes. In this paper we draw upon the sensemaking, organizational demography, and high reliability literatures, to derive and propose a design for testing the three hypotheses suggested by Bogner and Barr (2000) and Weick (1995). First, do organizations with greater requisite variety notice more in their environment than their more homogenous counterparts? Second, does greater variety also lead to more effective short-term responses to environmental demands (e.g., innovation, lower costs, better quality, etc.)? Does this lead to greater long-term adaptability (performance and survival)?

In this paper we propose to examine one source of requisite variety of fundamental importance to the operation of a firm: the differences and variations in work experiences of the "dominant coalition" (Cyert & March, 1963) or the top management team (TMT). We operationalize these work experiences both at the individual and team levels based on the amount of time member of the TMT has spent in various functional areas (e.g., sales, operations, engineering, human resources, finance, etc.). Thus, functionally diverse teams should be comprised of managers with diverse work experiences. By focusing on work experiences, we attempt to recreate what Weick (1979) refers to as a "complicated individual embodies in one place the several sensors implied when there is one sensor applied to each variable … complicated observers take in more" (p. 193).

We test these hypotheses using a sample of initial public offering (IPO) software firms. We choose initial public offering (IPO) software firms because they clearly exist in a hypercompetitive environment that necessitates broad noticing skills, varied and rapid responses, and ongoing adaptability. That is, the software industry is characterized by equivocal information regarding current and potential competitors as well as the direction of technological innovation and consumer preferences. We also choose these firms because top managers play an especially key role in setting the firm's agenda (an even more prevalent role than in larger firms). Thus, requisite variety in the TMT can help to effectively reduce equivocality and improve performance. In the remainder of the paper we do the following: in the next section we link the requisite variety argument more directly to organizational information, then we derive hypotheses regarding noticing, responding, and adapting, lastly we offer a proposed design for testing my hypotheses.

1.2 Requisite Variety and Organizational Information

Information can be defined as a detectable pattern that conditions action. Requisite variety plays a crucial role in detection/registration, retention, and retain "conditioning" occurs because it (and its empirical analog in this study - functional background) serves as the template and the framework within which each of these processes occurs. Requisite variety affects detection/registration because it enhances awareness of a broader variety of inputs, provides a larger set of cause-effect expectations (Cyert & March, 1963), and to the extent that individuals also exhibit requisite variety (i.e., are generalists with varied experience) they are readily able to act as boundary spanners (Thompson, 1967). Weick (1979) also asserts that organizations with requisite variety are more adaptive because they "align their actions and beliefs retrospectively and achieve an unequivocal behavior orientation with regard to a greater proportion of the environment … No one is ever free to do something he can't think of" (p. 193). Requisite variety allows greater detection/registration and subsequently greater action. Firms with greater requisite variety are also capable of retaining more in the form of multiple accounts of prior action (or accounts of a greater array of prior action). Lastly, requisite variety allows for greater retention of action patterns (e.g., repertoires, routines) by building broader skill sets and interpretations that allow for the maintenance of a wider assortment of activities.

1.3 Costs

However, there are limits to the performance enhancing capabilities of requisite variety. There are two main costs of maintaining requisite variety. First, maintaining requisite variety may engender significant conflict. To the extent that the conflict is task related (i.e., multiple interpretations of a course of action), it may enhance decision quality and innovativeness. However, extensive conflict can slow the decision process and cripple an organization when competitors are moving quickly. In addition, the maintenance of requisite variety may necessitate the quasi-resolution of conflict through "acceptable decision rules" in order to maintain social cohesion (Cyert & March, 1963). In doing so, the value of maintaining divergent perspectives may be undermined. Furthermore, non task related conflict can harm both types of performance (speed and quality; Eisenhardt, Pelled, and Xin, 1999). Second, building requisite variety may require costly investment that emerging firms can ill afford or large firms are capable of generating. Most new firms achieve success being simpler than their environment as they generate one viable product to fill one specific niche. Thus, if young firms try to replicate their external environment internally they may jeopardize their viability because they over-invest in costly exploration at the expense of exploitation that could build the slack resources necessary for building variety.

2. RESEARCH MODEL AND HYPOTHESES

2.1 Requisite Variety, Selective Perception, and Risk Detection

By asking how requisite variety affects noticing and risk detection, we revisit Dearborn and Simon's (1958) classic study on selective perception. That is, requisite variety is believed to overcome the effects of selective perception that cause managers to rely on overlearned or functionally disciplined experiences when faced with an ambiguous task (i.e., executives with more complex experience bases are better able to maintain ambivalence in their beliefs and notice more). We explore the link between functional diversity and the risks listed by firms undertaking their initial public offering (IPO). This measure of risk has an established precedent in the literature (Beatty & Zajac, 1994). However, articulating a risk factor and the proposed strategies for mitigating the risk implies more than mere noticing it more closely approximates what Daft and Weick (1984) refer to as interpretation. They define interpretation as the "process of translating events and developing shared understanding and conceptual schemes among members of upper management" (Daft & Weick, 1984). Requisite variety should aid in developing more comprehensive and less biased interpretations because the team will have a more complex and varied series of images to draw from that will not likely result in functionally driven or myopic responses. For example, in our sample (IPO firms) financial concerns may loom especially large and therefore induce selective perception (or overperception relative to the composition of the team) of financial issues. Or, conversely, the ambiguous and unanalyzable information environment may necessitate that firms pursue an enacting strategy in which the organization constructs their own environments and gathers information by trying new behaviors and seeing what happens (Daft & Weick, 1984). In either case firms with greater requisite variety should be better able to engage in interpreting and enacting their environments. Given our review of the selective perception and requisite variety literatures we hypothesize

> *H_1: TMTs with greater requisite variety will interpret more risks and more varied risks in their environment.*

2.2 Requisite Variety and Innovation

Requisite variety is also a necessary antecedent of turning noticing into more and more varied responses to environmental uncertainty. Top management teams with greater requisite variety may notice more, but they are also better equipped to envision a number of strategies to cope with a more varied environment. For the purposes of this paper, we define innovation in a manner consistent with Van de Ven (1986) as a new idea which "may be a recombination of old ideas, a scheme that challenges the present order, a formula, or a unique approach which is perceived as new by the individuals involved" (591). This conception of innovation is also consistent with March's (1991) concept of exploration and notions of "search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation" (p. 71). Thus, requisite variety generates innovation because it encourages the divergent thinking consistent with exploration and new ideas. However, we also impose an additional criterion for innovation, above and beyond the perception of the individuals involved. That is, we require that a firm capitalize on the new idea. Capitalizing on an idea does not necessarily require the realization of financial gain (very few innovations would meet this criterion), but rather it signifies producing something tangible as a result of idea generation and exploration. This conceptualization is consistent with March's concept of exploitation (e.g., refinement, choice, production, efficiency, selection, implementation, and execution) as well as Kanter's (1988) definition of innovation as a collaborative activity that relies on an organizational structure and social arrangements as well as individual idea generation. Requisite variety fosters this social structure to the extent that each functional subunit is more sensitive to each other subunit. This sensitivity to and between subunits is likely to reduce "technological utopianism." That is, if engineers are more capable of a holistic interpretation of the social system of innovation (i.e., aware of other's capabilities and needs) they will be more likely to solicit and understand input from sales and marketing professionals and, subsequently, produce a more viable innovation (Stinchcombe, 1990).

Requisite variety is likely to enhance a firm's ability to innovate in four ways. First, requisite variety allows firms to have a broader agenda with more variables under consideration (Arrow, 1974). The broader agenda begets innovation because broader agendas are more likely to have more items earlier than competitor's agendas. Second, greater requisite variety fosters innovation through the management of competing perspectives or what Van de Ven (1986) refers to as understanding part-whole relationships or what Schumpeter (1934) refers to as seeing and creating novel recombinations. Third, greater requisite variety within the top management team should also affect innovation by foster greater absorptive capacity (Cohen & Levinthal, 1990) or an ability to assimilate knowledge related to existing capabilities. Absorptive capacity facilitates both spillovers and understanding of technological progress in the industry. Similarly, Stinchcombe asserts that greater requisite variety allows organizations to attend to more of their environments and to consequently more up-to-date on the relevant "news" (Stinchcombe, 1990). By analogy firms are more readily able to resemble CNN when they have broad capabilities whereas firms with less breadth are only capable of coping with immediate challenges and the informational equivalent of the local news. Lastly, while requisite variety is less extreme than a garbage can approach to resolving equivocality it elicits similar organizational responses (e.g., a more extensive search process that searches in new neighborhoods not previously considered) (Cohen, 1986). Searching more extensively in new neighborhoods in novel ways is likely to unearth the novelty that fuels innovation. Prior research in organizational demography has also empirically solidified the link between heterogeneity embedded in requisite variety and innovation (Bantel & Jackson, 1989; O'Reilly, Caldwell, & Barnett, 1989).

Although the definition of innovation we utilize is applicable across multiple types of innovation, we focus on one specific type of innovation, technological innovation. We choose this focus because in hypercompetitive environments, TMTs are likely to encourage technical innovation as a response to environmental pressures and the environment is likely to necessitate this type of innovation. Although it is unlikely that members of the TMT are producing technical innovations (although in the software industry this is not unheard of), they do play a critical role in creating a milieu that is supportive of innovation. Given my definition of innovation (idea generation and capitalizing on the idea) an innovation-fostering milieu plays a critical role. Furthermore, testing TMT heterogeneity on technological innovation also tests the boundary conditions of requisite variety. If TMT heterogeneity is found to predict technological innovation substantial proof exists that requisite variety is strongly related to innovation, if not TMT heterogeneity may be limited to generating administrative innovation (e.g., Bantel & Jackson, 1989; O'Reilly, Caldwell, & Barnett, 1989). Therefore, we hypothesize

H_2: TMTs with greater requisite variety will generate more innovations.

2.3 Requisite Variety and Firm Performance

Lastly, we hypothesize that the effect of requisite variety on firm performance (stock price and survival) will only be partially mediated by innovation. That is, requisite variety enables firms to adapt in myriad ways (e.g., new strategies, new and more effective organizational structures and practices) aside from more plentiful innovation. The modifier requisite implies that the teams are able to utilize the variety for greater idea generation and creativity in the areas needed while minimizing the costs of conflict that plagues studies exploring the relationship between maximal diversity and performance (Eisenhardt, Pelled, and Xin, 1999). Therefore,

H_3: TMTs with greater requisite variety will have greater stock price growth.

Hypotheses 2 and 3 are partially mediated by interpretation of risk and number of innovations, respectively. Figure 1 also illustrates untested feedback loops. We assert that feedback is a key component of this system because adaptation produces new data for interpretation and action.

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3. METHODS

3.1 Sample

The sample consists of software firms that conducted their IPO between 1993 and 1996 (269 firms). After accounting for firms that are no longer autonomous entities three years after IPO (either through merger/acquisition, bankruptcy, or delisting) or otherwise missing data, the sample size is reduced to 174. The sample is biased in that the surviving firms (i.e., those included in the study) tend to be larger and younger. The descriptive statistics for the sample are as follows: on average, the firms in the sample were on average 7 years old and had 204 employees. Each U.S. geographic area is represented in the sample with 9.3 percent of the firms headquartered in a foreign country and 28 percent are headquartered in Silicon Valley. The software firms in the sample include SIC codes 7371 (computer programming services) and 7372 (prepackaged software). We chose these two segments because they are a locus of innovation in the software industry as well as extremely competitive segments. Although these industry categorizations are fairly coarse grained, in that the firms in a four digit SIC code may never directly compete, a more fine-grained distinction would require a much larger sample (the Software Encyclopedia categorizes the software industry into thirty-seven segments and hundreds of sub categories). We also eschew a more fine-grained analysis of sectors because all the firms compete in one critical arena – the labor market. They all seek to attract and retain the top programmers and technical staff (and they so note repeatedly in their prospectuses).

There are several theoretical reasons why software is an appropriate sample for the study of requisite variety, noticing, responding, and adapting. The turbulence of the IPO software market closely resembles the hypercompetition described by D'Aveni (1994) and the ambiguous and overwhelming information environment created by Dearborn and Simon (1958) in their classic study. Also this sample provides an ideal test case for the effects of requisite variety because if requisite variety fails to yield interpretation, innovation, and performance gains in this industry it is highly unlikely that it will matter for firms in more stable industries where overlearned responses and well worn strategies may be more apropos. Furthermore, Hambrick and Abrahamson (1995) note that top management teams in the software industry (which they define as SIC code 7372) have greater discretion (defined as latitude of action) than their counterparts in other industries, thereby making them an especially appropriate group to study noticing, responding, and adapting. Lastly, the software industry is an increasingly important but understudied aspect of the economy.

3.2 Data Collection and Coding

The primary data source was the prospectus of each firm in the sample. The prospectus is the document filed with the Securities and Exchange Commission (SEC) prior to a firm's IPO. Strict guidelines govern the content and the format of a prospectus and firms are legally liable for any information that might mislead investors (O'Flaherty, 1984). The Securities Act of 1933 sets specific requirements for the prospectus and thereby insures its consistency. The typical prospectus writing process involves two investment banking firms, multiple lawyers, and a certified public accountant (Welbourne & Cyr, 1999). Each party has a vested interest and a legal obligation to provide an honest and accurate assessment of a company. The utility and validity of the prospectus as a data source has also been demonstrated in prior research (e.g., Welbourne & Cyr, 1999;

Welbourne & Andrews, 1996; Beatty & Zajac, 1994). The coding strategy is similar to that used by Welbourne and Andrews (1996). The authors content coded the prospectuses for the variables of interest in this study using a similar code sheet and coding handbook to that used by Welbourne and Andrews (1996). Every tenth prospectus was cross-coded by the second author. In addition to the prospectus additional financial and innovation data was obtained from the following sources 2) COMPUSTAT (financial data), 3) CRSP and Going Public: The IPO Reporter (stock price data), 4) Dialog's "U.S. Patents Fulltext" database and the U.S. Patent and Trademark Office database (patent data).

3.3 Variables

3.3.1 Dependent Variable: Noticing. In order to capture the varied aspects of risk detection and interpretation we created several measures of relevant risk factors. We derived the various risk factors from the risk factor section of each firm's prospectus. Each risk factor was coded as a dichotomous variable (1 if the risk factor exists, 0 otherwise) and then clustered for theoretical reasons (factor analysis was not a viable technique for clustering the data given all the variables are dichotomous). We also clustered the risk factors in a manner consistent with D'Aveni and MacMillan (1990). Figure 2 illustrates the two cluster approaches. In order to test my hypotheses on varied interpretation of risks and comprehensive interpretation of risk requires measuring interpretation in multiple ways. Following D'Aveni and MacMillan (1990) **we** measured ***absolute attention,*** which consists of the total number of risk factors and the total number of paragraphs in the risk section. These measures approach aggregate readings of noticing more and noticing more comprehensively. We also measured the ***focus of attention.*** This measure consists of the number of paragraphs in a given cluster or category as a portion of the total number of risk paragraphs. Lastly, we computed measures of relative ***emphasis*** this includes the ratio of external to internal factors (calculated as (Output + Input) – Internal) and the output input ratio.

3.3.2 Dependent Variable: Responding. We use patents (innovation) as the measure of responding and a dependent variable. We operationalize patents as a count variable (the number of patents three years after the IPO) to assess the rate of innovation and the relative intensity of responding. We use patents as the dependent variable for several reasons. First, it meets our theoretical definition of innovation. Patents are consistent with our definition of innovation as a new idea because they reflect a process of "exploration" (March, 1991) and idea generation. That is, in order to patent an innovation a firm must generate a novel and nonobvious idea and then execute an elaborate process to file the patent and get it approved. Second, capitalizing on and protecting innovation through patents is of utmost importance to these nascent firms. In the sample over 83.6 percent of the firms cited the risk of not gaining or losing a patent and 90.3 percent cited the risk of technological obsolescence as material risks to their continuing viability. The major advantage for software firms is that patents preclude others from making commercial use of a patented technique, even if it is developed with no knowledge of the patented work, as long as the patent is in force (Nichols, 1998). Another significant advantage is the twenty-year duration of the patent. This virtually ensures that all the economic benefit associated with a given invention will accrue to the holder of the patent, especially in an industry as dynamic as software. Third, patents have also become increasingly popular in the industry. Specifically, the number of software related patents have grown tremendously over the past decade from virtually zero in the 1970s and 1980s to 3,600 in 1993 and 8,100 in 1996 (Nichols, 1998) and 17,500 in 1998 (Erickson, 1999). These numbers are likely a conservative estimate of software patenting activity because they only refers to patents in categories 364 and 395, that are the primary categories of software patents. However, software patents can be found in a number of different categories. The data we collected is not restricted to these categories, but rather retrieved all the patents for firms in the sample. Patents are considered as a dependent variable as long as the firm applied for and was granted the patent after the date of their IPO. The window for the dependent variable is the first three years after IPO. Three years is a relevant window because it allows each firm to process at least one cohort of patents (the software patent process usually take between eighteen and thirty months, although the lag time has decreased slightly over time). Given that patents may be thought of as incremental innovations, we also compute a measure of the significance of the patent. To determine significance we computed a "hazard rate" for the patent being cited. That is, we calculated the number of times each firm's patent was cited, summed the number of citations across all the firm's patents then divided the sum by the total exposure time (number of days from the grant of the patent until the end of 1999).

3.3.3 Dependent Variable: Adaptation. Lastly, I compute the change in stock price using data from CRSP and Going Public: The IPO Reporter. Change in stock price is computed as follows:

Change in Stock Price = price 12/31/99 (adjusted for split) – offer price/offer price.

Maintaining a high stock price over time is the ultimate test of an organization's adaptability as failure to maintain an ever-growing stock price (or an ever-escalating rate of growth) strongly affects the ongoing viability of a firm.

3.3.4 Independent Variable: Requisite Variety. The central variable of interest is functional background heterogeneity (FBH). FBH is well established in the literature on TMT demography (e.g., Pelled, Eisenhardt, & Xin, 1999; Hambrick, Cho, & Chen, 1996; Bantel, 1993; Michel & Hambrick, 1992; Murray, 1989; Bantel & Jackson, 1989). FBH has also had effects on a range of dependent variables from innovation adoption (Bantel & Jackson, 1989), clearer strategies (Bantel, 1993), market share and profit growth (Hambrick, Cho, & Chen, 1996), and long-term performance (Murray, 1989). However, there is some disagreement over how to measure (see Bunderson & Sutcliffe, in press for a more detailed discussion of different conceptualizations of heterogeneity measures). Given that there is ambiguity in the literature regarding about which measure of FBH is most appropriate for the phenomena of interest, we utilize four different conceptualizations. The first is the Blau's (1977) heterogeneity index which bases the computation on an executives "dominant functional background":

$$FBH = 1 - \Sigma p_i^2$$

Where p_i equals the percentage of the group whose dominant functional background is in the i^{th} functional area. The score is normed so that the values range from zero (minimum possible diversity) to one (maximum possible diversity). One alternative conceptualization is intra-personal functional heterogeneity (Walsh, 1988) summed across the entire team and divided by the number of members as follows:

$$IFH = \Sigma(1-\Sigma p_{ij}^2)/n$$

Where p_{ij} equals the percentage of executive i's total years of experience spent in the j^{th} functional area. N equals the number of team members. As with FBH, the score is normed to range between zero and one. Another option is the generalist scale, computed as follows:

$$Generalists = (\Sigma g)/n$$

Where g equals the number of generalists and n equals the number of team members. A generalist is defined as an executive that has spent no more than two thirds of his or her career in any one functional area.

Lastly, we constructed interaction terms in what we (and the firms' prospectuses) claim to be the requisite areas of expertise needed to effectively compete. These areas include technology, sales and marketing, and general management. We computed these variables as follows:

$$Technology * Sales = (N_t/Team Size) * (N_s/Team Size)$$

$$Technology * GM = (N_t/Team Size) * (N_{gm}/Team Size)$$

Where $N_{t, s, or gm}$ equals the number of team members with a dominant background in any of these functional areas. The generalist, interaction, and intrapersonal measures best reflect requisite variety because firms with high values across these measures have greater variety to cope with the environment, but also the cohesion necessary (through ability to use a shared language based on shared experiences) to capitalize upon the variety. The variety is "requisite" in the sense that the team's diversity is directed toward key environmental contingencies. That is, team's high in variety across these measures have an understanding of what the environment demands in terms of finance, sales and marketing, research and development, and human resource management. The interaction terms are especially compelling in this sense because they measure team skills considered to be of primary importance to these young firms (innovation, sales, and managerial acumen) and also provide a more fine grained test of what is requisite (i.e., technology, sales, and/or general managerial skills).

Data were gathered from the Management section of each firm's prospectus. The prospectus provides detailed work histories for all the members of the TMT and the board of directors. The functional background categories utilized are provided in Appendix 1 (detailed coding rules are available from the author upon request).

3.4 Control Variables.

3.4.1 Demographic Controls. Based on a review of the relevant literatures and a consideration of this specific research context, several demographic and team variables were added to the model in order to establish the robustness of the hypothesized relationships. These control variables include team size, average years of work experience, age diversity, average age, average tenure, and tenure diversity.

Research on group behavior and performance has established quite clearly that group size has important implications for group processes and outcomes (Goodman, Ravlin, & Argote, 1986). In the present study, it is important to control for ***team size*** for at least three reasons. First, larger teams may have more diverse viewpoints and perspectives that could be associated with both increased risk detection and innovation. However, larger firms may have difficulty reaching consensus due to the sheer size of the team and this may decrease noticing capabilities as team members are unable to reach consensus Third, since larger teams are associated with larger firms, it is important to control for any possible relationship between size and firm performance (above and beyond firm size). Team size was computed simply as the number of managers on the top management team (CEO and his/her direct reports) and was obtained from the firm's prospectus.

Although the functional diversity variable included in the model as an independent variable gets at the mix of functional expertise on a management team, it does not indicate how many years of work experience team members have overall. Since competence and expertise are at least partially a function of time, it is therefore important to control for the ***average years of work experience*** of team members. The number of years of work experience was derived from the Management section of the prospectus where each member of the top management team and the board of directors provide a synopsis of their work history. These histories were summed for each team member and then averaged across the team in order to produce a measure of average years of work experience for each team.

Although functional diversity is the central focus of the present study, other forms of diversity have also been shown to relate significantly to management team process and performance. Although the findings for the effects ***age diversity*** does not appear to be related to performance outcomes, however (Williams & O'Reilly, 1998: 103-104). We therefore controlled for age diversity in the present model in order to account for any possible effects and to control for the conventional wisdom that only young entrepreneurs run innovative and high performing high technology firms. The implicit hypothesis being that less age diversity (as long as average age is low) results in less risk detection, more innovation and better performance. Age diversity was computed from ages at the time of IPO (as indicated in the Management section of the prospectus) using the coefficient of variation (standard deviation across team members divided by the mean for the team; Allison, 1978). Based on the previously mentioned assumption, we also controlled for ***average age***. Individual ages were averaged across team members to create an average tenure score for each team.

Unlike other measures of team composition such as age, race, gender, or education, tenure gets at the depth and content of actual work experiences in a manager's career (Pelled, 1996). Diversity in team member tenure has also been shown to affect group processes and outcomes. Consequently, the distribution of tenures across team members provides insight into the range of experiential resources available to the team and the extent to which team members "think alike" (which, in turn, has implications for social cohesion; see Michel & Hambrick, 1992). Past research has supported a relationship between unit performance and measures of tenure (Finkelstein & Hambrick, 1990; Keck, 1997). Although this research has been limited to reasonably stable contexts that do not characterize the software industry, longer-tenured teams that are relatively homogenous in terms of tenure tend to perform better. However, the performance benefits tend to come at the cost of risk detection and innovation as longer tenures beget homogeneity that reduces the amount of scanning and communication within the group (Katz, 1982). Studies examining the relationship between tenure diversity and performance have produced conflicting results (see Williams & O'Reilly, 1998: 96). Given these findings, we include a measure of ***organizational tenure diversity*** in the model to account for any possible effects. Organizational tenure diversity was measured using the Management section of the firm's prospectus which indicates the month and year an executive started working in the focal organization and then computing the coefficient of variation (Allison, 1978). We also computed ***average tenure***, based on the month and year that an executive began working in the focal organization. We focused on tenure in the organization (rather than team) in computing average tenure in order to capture the depth of shared, organization-specific experience represented on a team. Individual tenures were averaged across team members to create an average tenure score for each team.

3.4.2 Other Controls. In addition to the demographic control variables included in all the analyses we also include some specific control variables relevant to each analysis. For risk detection we control for ***underwriter***. Underwriter could be relevant to risks included in the risk section of the prospectus because some underwriters underwrite a number of IPOs (e.g., Goldman Sachs, Hambrecht & Quist, Piper Jaffray, etc.) and, consequently, may have pre-established risks listed for all their IPO clients in a given industry. IPOs may be especially susceptible to underwriter influence during prospectus writing because these firms likely wield the financial, legal, and accounting expertise that most IPO firms lack. Furthermore, we include several variables previously demonstrated to affect innovation and/or patenting as controls. Consistent with Sorensen and Stuart's (2000) finding that older firms are more prolific patenters, we control for ***age***. Age is measured as the natural log of the year of IPO minus the year of incorporation. Natural log is used to correct for skewness in the distribution of the variable. Year of incorporation is used instead of year of founding because many firms did not report the year of their founding and because the nature of the business may have substantively change between the year of founding and incorporation. Larger firms and firms that spend more on research and development (R&D) should also be more likely to innovate and patent. Therefore, we control for ***size*** by including a control for natural log of the number of employees at IPO as well as the amount of R&D spending. The ***R&D intensity*** control is calculated by dividing R&D spending during the IPO year by sales in that same year. Relatedly, we control for the ***number of patents prior to IPO***. Firms with patents prior to their IPO are more likely to patent again because they have invested in the intensive patenting process and likely have developed competence and routines for efficiently processing patents. We use a count of prior patents rather than a dichotomous variable because each additional patent filed and granted contributes to making patenting more appealing and the process more efficient. Therefore, all patenting firms are not equal and a firm with five patents at IPO should be more likely to patent after its IPO than a firm with only one. We controlled for location of firm headquarters because firms embedded in a regional nexus of innovating (and patenting) are more likely to innovate due to knowledge spillover effects and intraregional personnel movement. Firms in these regions are also more likely to patent because a legal infrastructure is also readily accessible. Saxenian (1994) has documented such activity in California's Silicon Valley. Therefore, a control is included for whether or not the firm is ***headquartered in Silicon Valley*** (1 if yes 0 otherwise). In order to control for the effects of prior firm performance, we control for ***market to book ratio.*** Prior firm performance should contribute to all the dependent variables. Market to book is a better indicator of prior performance for this sample than profits because at the time of IPO many firms may have negative or zero profits. Market to book ratio is calculated by dividing the firm's IPO offer price by book value (Davis, 1991). Lastly, in all the analyses we control for ***SIC code*** and ***IPO year***. Both of these variables consist of a series of dummy variables for each SIC code (7371 or 7372) and each cohort year (1993, 1994, 1995, 1996). These factors are controlled to ensure that there are no systematic differences resulting from SIC code or year of IPO.

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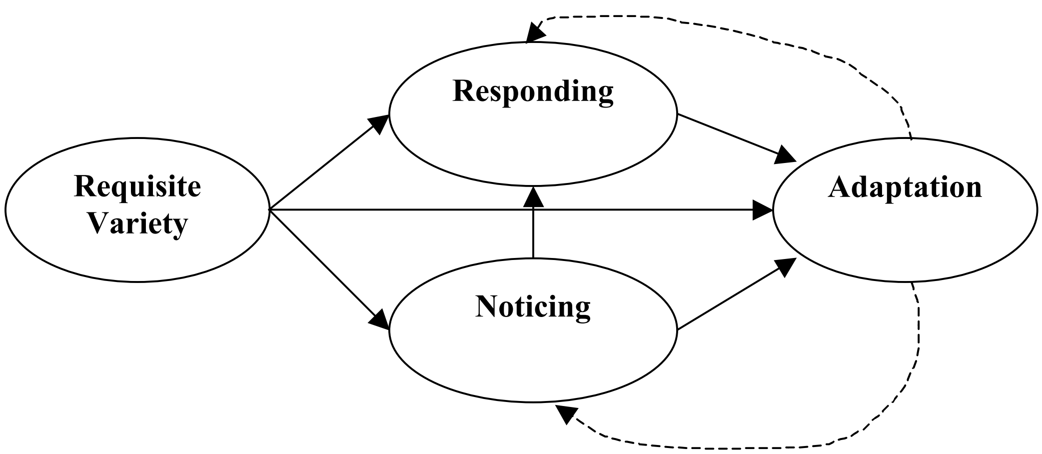
Figure 1 – Theoretical Model of Requisite Variety and Performance



* Dashed lines represent hypothesized but untested feedback effects.

Figure 2 – Two Approaches to Clustering the Risk Factors

THE CLUSTER APPROACH
The Finance Cluster
Legal Risk (a current legal proceeding against the firm)
Liability
Limited Underwriter Experience (uncommon)
Takeover Risk (and corresponding defenses)
Governmental Regulation

The Relational Cluster
Dependence on Customers
Dependence on Suppliers
Dependence on a Single Product
Dependence on the Government as a Customer

The Employee Cluster
Inexperienced Management
Competitive Labor Market
Dependence on Employees (Risk of Not Being Able to Attract Key Employees)
Limited Operating History (?)

The Environmental Cluster
Risk of a New Product (?)
Seasonality of the Business
Not Having or Losing a Patent
Competition
Technological Change and Obsolescence

THE D'AVENI AND MACMILLAN APPROACH (1990)

Internal Attention – In the original sentences referring to owners, employees, or top managers
Inexperienced Management
Competitive Labor Market
Dependence on Employees (Risk of Not Being Able to Attract Key Employees)
Limited Operating History (?)

Output Attention – General economic factors affecting demand (customers, business cycles, unemployment, interest rates, inflation)
Risk of a New Product (?)
Seasonality of the Business
Not Having or Losing a Patent
Competition

Technological Change and Obsolescence
Dependence on a Single Product
Dependence on the Government as a Customer
Dependence on Customers

Input Attention – Creditors and Suppliers
Legal Risk (a current legal proceeding against the firm)
Liability
Limited Underwriter Experience (uncommon)
Takeover Risk (and corresponding defenses)
Governmental Regulation
Dependence on Suppliers

Appendix 1 – Functional Background Categories

Marketing & Sales – Marketing, Sales, Customer Service, Customer Support
Finance & Accounting – Finance, Accounting, CFO, Big 6 Accounting Firm, Controller, Treasurer
General Manager - CEO, Head of Business Unit, Founder, COO, President, Business Development, Strategic Planning
Engineering - Hardware, Software, Technology, R&D, Product Development, Project Management, CTO, CIO
Operations - Production, Manufacturing, MIS
Professional - Lawyer, Consultant, VC, Professor, General Counsel
Human Resources - Employee Relations, Industrial Relations