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Michael Song
University of Washington

Hans van der Bij
Eindhoven University of Technology

Mathieu Weggeman
Eindhoven University of Technology

Correspondence address
Michael Song
Executive Director, Center for Technology Entrepreneurship
Michael L. & Myrna Darland Endowed Distinguished Chair in Entrepreneurship
Professor of Marketing and Innovation Management
309 Mackenzie Hall, Box 353200
University of Washington
Seattle, Washington 98195-3200
(206) 543-4587 Fax: (530) 706-5432
email: song@u.washington.edu

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Abstract

This study develops and tests a conceptual model that focuses on how managerial controllable variables influence the level of knowledge generation. Based on literature and "theory-in-use" field research in seven knowledge-intensive organizations, the authors developed research hypotheses and tested the hypotheses using data collected from 277 firms in high technology industries. The findings suggest that the R&D budget, job rotation, information technologies, individual commitment, and organizational crisis increase levels of knowledge generation.

Introduction

Globalization and other rapid changes in markets and technologies increasingly require companies to generate new knowledge in order to remain competitive. Many researchers have suggested that knowledge is the principle source of competitive advantage (e.g., Spender and Grant 1996). In order to innovate successfully, firms must generate knowledge faster than their rivals (Prahalad and Hamel 1990, Teece and Pisano 1994). Knowledge lies at the core of the firm, unlike traditional resources such as land, labor and capital. Therefore, factors influencing knowledge generation are crucially important to researchers and managers.

Growing recognition of its importance has spawned an explosion of research about the generation and management of knowledge, representing several distinct research traditions, including organizational learning, management of technology and managerial cognition (Grant 1996). However, much of this research has treated knowledge as an object and has focused on its definition (Audi 1995), on distinguishing it from other dimensions, whether explicit or tacit, individual or collective (e.g., Polanyi 1966, Faulkner 1994, Matusik and Hill 1998), or on distinguishing the object of knowledge from the object of information (e.g., Dretske 1981). Apart from the work of Nonaka (1994) and Coombs and Hull (1998), little research has been focused on the process by which knowledge in an organization is generated and the factors that can facilitate this generation. And most research has a normative perspective, relying heavily on case studies and anecdotes, or conceptual frameworks (e.g., Nonaka 1994, Coombs and Hull 1998). We are still far from a theory enabling the design of what one could call a knowledge-friendly organization. Furthermore, there is a lack of insight into the factors that enable the productivity of knowledge processes in these organizations. The relevance of such a theory is evident, given the increasing amount of knowledge-intensive organizations in the advanced economies (Drucker 1993).

In this study we concentrate on one of these processes by undertaking “theory-in-use” research to investigate what organizational factors positively influence the level of knowledge generation. We focus on knowledge generation in new product development, on the kind of knowledge that is most important in the success of product and process innovations. We deduced more than 20 potential facilitating factors from management literature, and based our final selection of these potential factors on in-depth case interviews with executives at IBM, Philips, Microsoft, Motorola, Sony, Intel, and Merck. The effects of the facilitating factors on knowledge generation were tested with data collected from 277 firms.

The remainder of this paper is organized as follows. After defining knowledge generation, and discussing our identification and selection of potential facilitating factors, we develop a conceptual framework and research hypotheses. Then we describe our research design and report our empirical findings. Finally, we discuss important implications, limitations and directions for future research.

Theoretical Framework and Research Hypotheses

Definition of Knowledge Generation

It has been widely accepted that knowledge is critical to firm success, particularly for firms operating in knowledge-intensive industries. The unique approach to knowledge management by high-profile Japanese companies, such as Honda, Canon, Matsushita, NEC, and Kao is generally acclaimed as the secret to their success over western competitors (Nonaka 1991, Nonaka and Takeuchi 1995).

But what is knowledge? This question has intrigued some of the world's greatest thinkers from Plato to Popper, but no clear consensus has emerged. In this study, we follow the epistemological tradition that defines knowledge as "justified true belief" (Audi 1995). Knowledge here is understood as information that has been validated by experience, that has entered human belief systems as rules for guiding actions, and, in the case of business, that has proved beneficial to firm performance. Because of our focus on high-technology firms, we are interested in technological knowledge, that is, knowledge generated in response to major technological shifts.

Knowledge alone, however, is static. To achieve lasting competitive advantage, practitioners should not simply use knowledge in an instrumental fashion; they must continuously create new knowledge (Nonaka and Takeuchi 1995). In this paper we focus on knowledge generation, the enlargement of the knowledge of individuals, and especially the organization-wide generation of new knowledge pertaining to current and future technology needs.

Identifying and Selecting Potential Facilitating Factors

Because our goal is to develop a knowledge-friendly treatment of the NPD process, we adopted a theory development orientation (Madhavan and Grover 1998). We conducted a review of the literature on knowledge management and related topics such as organizational learning, individual learning, innovation management, R&D management, technology management, information systems, human resource management and strategic management. Based on a review of articles published in 17 top management journals over the last 15 years, we identified over 20 potential facilitating factors for knowledge generation. These factors were a starting point for the development of our hypotheses.

Parallel with the development of the hypotheses from the theory base, we conducted 10 in-depth interviews with executives in seven knowledge-intensive organizations, including IBM, Philips, Microsoft, Motorola, Sony, Intel, and Merck (Madhavan and Grover 1998). The purpose of these interviews was threefold. First, we sought to get a firsthand feel for the relevance and face validity of our framework of potential facilitating factors. The interviews helped us confirm that our theory-based assertions were in line with managerial experience or "theory-in-use" practices and, thus, provided a sound basis for further theory development (Yin 1989). Second we sought input from the executives that could be used to guide the theory development process itself. We asked the executives to select those potential factors that in their perception were most important in influencing knowledge generation. Third, the executives were invited to describe cases about their firms' successes and failures in managing knowledge generation.

We followed the standard format of the structured open-response interview, which uses an interview schedule similar in format to the structured interview, with questions included in a set order, but includes open-ended questions, and allows variation in the order in which groups of questions are asked (King 1998: 16). In the end, we selected seven of the most interesting and important factors for their empirical testability, their ability to stimulate testable hypotheses for future research, and their acknowledged status as strong influencers of knowledge generation during our field research.

Conceptual Framework

The conceptual framework guiding this study is presented in Figure 1. The framework is a result of both literature review and the field research described above. Briefly, the model focuses on seven antecedents that positively influence knowledge generation. To reflect the potential influence of the external environment, we incorporated a set of control variables, for which we will not separately formulate hypotheses.

(Figure 1 about here)

Research hypotheses

In this section seven research hypotheses are developed regarding the seven antecedents that are expected to aid in knowledge generation. These antecedents are R&D budget, co-location of R&D personnel, lead user and supplier networks, job rotation, information technologies, individual commitment and organizational crisis. The antecedents will be defined and related to existing literature. Then they will be related to the qualitative data, if available. Finally, the research hypothesis will be developed.

R&D budget

The R&D budget is defined as the percentage of total revenues allocated to R&D expenditures in the Strategic Business Unit (SBU). The relationship between R&D expenditures and innovation success has been studied extensively in the management literature. Innovation success has been defined in several ways from patents or important patents to sales volume of new products. Kamien and Schwarz (1982) conclude that, on average, a direct positive relationship between innovational effort and innovational output exists. However, the transformation may depend on factors other than effort, and may not be linear, though still steadily increasing. Other studies found that patenting output decreases gradually with an increase of R&D expenses (e.g., Hausman, Hall and Griliches, 1984). According to Dodgson (1993), R&D departments also serve as a major source of learning. The size and focus of R&D budgets are likely to be a primary factor encouraging and directing learning.

No research explicitly explains how R&D budgets affect knowledge generation. However, it is difficult to generate patents without generating knowledge. Executives from Philips suggest that high investment in fundamental research at their firm is the key to its success as an innovation leader in medical systems. More than its competitors, Philips emphasizes fundamental research. In general, when the R&D budget increases, more resources are available to generate knowledge. Therefore we hypothesize:

> H1: An increase in R&D budget is positively related to a higher level of knowledge generation.

Co-location of R&D personnel

Co-location of R&D personnel is defined as the location of different departments and offices of R&D personnel in close proximity to each other (from: Pinto, Pinto and Prescott 1993). Many scholars have examined the influence of architecture on organizational communication (e.g., Allen 1988; Moenaert and Caeldries 1996). Allen (1988) concluded that the probability of communication decreases with distance, and at a startling rate: a mere swing-door or staircase between two departments can result in a huge difference. However, Moenaert and Caeldries (1996) found that while placing R&D professionals in closer proximity to one another does not increase technological learning, it increases market learning. Apparently, members of other R&D teams are more important as sources of market information than of technological information.

What does this mean for the level of knowledge generation? Co-location increases the probability of communication, and so of the circulation of up-to-date information about technologies and markets (see Moenaert and Caeldries 1996). This should generate more knowledge. However, communication, which takes up time, also has a social element; it will not be spent exclusively on the provision of up-to-date information. Moreover, the technological information communicated may already be available, and workers may spend time on the communication of redundant information that they might spend generating knowledge in their own directions. So there are arguments both for and against the positive influence of co-location on knowledge generation. Based on our field research, however, we hypothesize:

> H2: Co-location of R&D personnel is positively correlated to the level of knowledge generation.

Lead user and supplier networks

Lead user and supplier networks are defined as the pattern of relations among the organization's members and its lead users and suppliers, through which an organization member seeks advice from a lead user or supplier, or vice versa (from Athanassiou and Nigh 1999).

Past research has suggested that effective knowledge generation depends on information from external sources as well as internal sources. Gemünden, Heydebreck and Herden (1992) mention lead user networks; Nonaka (1994) emphasizes the value of information from customers and suppliers; and Dodgson (1993) states that learning from customers and users is particularly important for innovation.

However, as in the case of co-location, communication with lead users and suppliers takes time, its efficiency may be impaired by its social element, and it may result in redundant information. Thus, we find arguments both for and against the positive influence of lead user and supplier networks.

As a way to increase knowledge generation, several companies in our field research often invite their current and potential suppliers and lead users to participate in retreat conferences to discuss their current technological and new product development problems. The suppliers and customers make notes, ask questions and talk with each other at the conference. Many participants come back with proposals for solving the problems within days or weeks after the conference. The companies then start to co-develop with those participants whose proposals look most promising. We follow the main line in the literature and the results of the field research and hypothesize:

> H3: The use of lead user and supplier networks is positively correlated to the level of knowledge generation.

Job rotation

Job rotation is defined as the planned shift of workers back and forth among different tasks and different departments (Bobbitt et al. 1978). In a special issue of the *Journal of Organizational Behavior*, the careers of people are considered repositories of knowledge (Bird 1994), and organizational learning is considered an engine for career transitions (Miner and Robinson 1994). Bird (1994) states that employees add value to their organization by generating information and knowledge through their work experiences, and that job rotation is one way this process can be shaped to serve the organization's information needs. Miner and Robinson (1994) argue that managers must facilitate career transitions. Coombs and Hull (1998) conclude that six months of job rotation between the staff of R&D Labs and of Product Divisions will promote an exchange of knowledge between different knowledge domains and help in the identification of new areas for R&D.

We conjecture that job rotation will have a positive influence on the level of knowledge generation. Through job rotation, both the rotated individual and his or her new colleagues will gain new and more varied knowledge (Miner and Robinson 1994). Furthermore, job rotation may also reveal new ways of handling and solving technological problems or dealing with market needs. We hypothesize:

H4: Job rotation is positively correlated to the level of knowledge generation.

Information Technologies

Information Technologies refer to the availability, level of investment in and usage of state-of-the-art computer-assisted communication technologies and decision-aid information technologies (Huber 1990; Kendall 1997; Sethi and King 1994). Computer-assisted communication technologies, particularly inter-organizational technologies such as Electronic Data Interchange (EDI) and technologies designed particularly for linking the firm with consumers and industrial resources, provide the firm with information about markets, industries and suppliers. With the increased storage and acquisition of external information and the development of computer-enhanced organizational memories, 'organizational intelligence is likely to be more accurate, comprehensive, timely, and available' (Huber 1990). Decision-aid information technologies are designed to facilitate such tasks as decision making, planning, idea generation, conflict resolution and negotiation (Williams and Wilson 1997). Therefore, decision-aid information technologies provide decision-makers with additional capacities to extend their bounds of rationality (Todd and Benbasat 1999). By structuring the decision process, such technologies direct attention to key decision issues, while encouraging the use of objective data and criteria (Kraemer and King 1988). They allow for better exploration of real problems and fuller generation of alternatives, activities often neglected because of a lack of time (Huber 1982). Finally, the anonymity associated with general decision-aid information technologies allows users to participate freely in discussion without considering status and personality, thus alleviating common problems such as conformity of thought. The increased diversity of opinion often leads to generation of new knowledge (Robbins 1997). Therefore, Information Technologies can increase knowledge about markets, industries and suppliers. We hypothesize:

> H5: Information Technologies are positively correlated to the level of knowledge generation.

Individual commitment

Individual commitment is defined as the employer's identification with and involvement in a particular organization (Mowday, Steers and Porter 1979). Nonaka (1994) found that individual commitment is one of the most important requirements for promoting the formation of new knowledge within an organization. According to Nonaka (1994), individual commitment is based on three factors: intention, autonomy and environmental fluctuation. Intention regards the way individuals approach their environment and try to make sense of it. Autonomy leads to greater flexibility in acquiring, relating and interpreting information. Environmental fluctuations generate new pattern of interaction between people and their environment (Nonaka 1994). March and Olson (1975) claim that a certain amount of fluctuation is required for individual and organizational learning. Winograd and Flores (1986) emphasize the role of periodic breakdowns in human perception. When these occur, people question the value of habits and routines, and realign their commitments. Thus, following Nonaka (1994), we hypothesize:

> H6: Commitment of the members of an organization is positively correlated to the level of knowledge generation.

Organizational crisis

Organizational crisis refers to perceived discontinuities in technologies, markets or other environmental conditions (from Tushman and Anderson 1986, Kim 1998).

Breakdowns in human perception are generated naturally when an organization faces a real crisis, such as a rapid decline of performance. But a sense of crisis can also be generated intentionally by the leaders of an organization either in response to or in the absence of an external crisis (Nonaka 1994). Kim (1998) argues that discontinuous or nonlinear learning normally takes place when a firm perceives a crisis and deploys a strategy to resolve the critical situation. Drazin, Glynn and Kazanjian (1999) found that at the occurrence of disruptive events a frame may be broken and what once made sense no longer does; the individual experiences disruptive disorganization. If, because of new information, enough individuals experience interpretative disorganization, then an entire intersubjective frame may shift. This allows a new set of frames to emerge, at least temporarily. An organizational behavior study by Greve (1998) uses learning theory to examine how performance feedback affects the probability of risky organizational changes that affect an organization's performance. Empirical research shows that change decisions are guided by performance relative to social and historical aspiration. The probability of change declines as the performance relative to social or historical aspiration increases. However, performance shortfall is not the only antecedent; the opportunity and ability to change are important as well.

In general, the feeling of failure, caused by either a real or a constructed organizational crisis, increases the probability of change by initiating search activities (Cyert and March 1963). These search activities probably will lead to new knowledge, thus increasing the level of knowledge generation. Therefore, we hypothesize:

H7: The creation of an organizational crisis has a positive influence on the level of knowledge generation.

Methodology

Research Instrument Development Procedure

We used existing scales wherever possible and undertook the following six steps to develop the new scales. First, we conducted a literature review and identified a pool of items for each of the constructs from the existing literature. We tried to generate items that tap the domain of each construct as closely as possible (Churchill 1979).

Second, in addition to the "theory-in-use" field research described earlier, we also conducted in-depth interviews in seven knowledge-intensive organizations (IBM, Philips, Microsoft, Motorola, Sony, Intel, and Merck) to build an understanding of the knowledge management process, and to develop appropriate measurement items. A total number of 32 senior executives, IT officers, and R&D experts were interviewed during this research stage. The interviews followed a standard protocol and they consisted of three parts. The first part of the interviews was designed to elicit salient constructs and definitions of those constructs. Participants were first asked their opinions regarding important issues in the knowledge creation process. The second part of the interviews focused on eliciting team member evaluations of the theoretical model to describe their own experiences. The third part of the interviews addressed perceptions of the relevance and completeness of scale items drawn from our literature review and earlier case studies.

Third, we carried out desk research by examining company documents regarding their knowledge generation process and reviewing the relevant literature. We then performed a content analysis using the procedure recommended by Kassarjian (1977). The aim was to standardize the outcomes of the different interviews from the different companies. All measurement items generated from the above two steps were given a unique code. Five researchers with adequate knowledge in the field of knowledge management independently verified for all issues how they could be positioned in the developed research instrument. Four researchers compared their outcomes and discussed any differences. In cases where consensus could not be reached, the fifth researcher served as a referee and determined the final positioning. The referee had to intervene in only one of the measurement items.

Fourth, using the measurement items generated, we developed the first draft of our research instrument. We discussed this first draft with a representative panel of experienced IT officers and R&D managers from the companies. This helped us to refine a number of the items included in the first draft of our research instrument. We then followed the recommendations of Churchill (1979) and identified subsets of items that were unique and possessed "different shades of meaning" to informants. We submitted a list of constructs and corresponding measurement items to a panel of academic “experts” for critical evaluation and suggestions. We constructed a questionnaire based on those items judged to have high consistency and face validity.

Fifth, we pretested the survey for clarity and appropriateness using the participants of the case studies. The participants were asked to indicate any ambiguity or difficulties they experienced in responding to the items. Based on the feedbacks from the participants, we eliminated some items and modified other items which managers either had difficulties with or found them to be ambiguous.

Sixth, the final research instruments were subjected to additional pretests involving personal interviews with six executives in Motorola, Microsoft, and IBM. We ask these executives to complete the survey as they applied to their business unit. At this stage, this pretest resulted only minor refinements on two measurement items.

Measures

Dependent variable. Since a scale for the *knowledge generation* was not available in the literature, we developed the scale using the research instrument development procedure discussed in the earlier section. *Knowledge generation* was defined as the organization-wide generation of new knowledge pertaining to current and future technology needs. The 6-items scale measures: to what extent does the firm conduct in-house knowledge generation? how much intelligence on the competitors' technological development is generated independently by several departments in the organization? what level does the company constantly monitor technology changes in the industry? and how often does the firm meet with customers to find out what products or technologies they will need in the future?

Independent variables. *R&D budget* was measured by the percentage of the R&D expenditures to the total revenues. *Co-location of R&D personnel* was measured by the approximate percentage of R&D personnel that were conveniently co-located, the physical distance between the different departments of R&D, the extent to which offices of R&D personnel were located in close proximity to each other, and the ease with which R&D personnel might travel to meet. These items were developed by Pinto, Pinto and Prescott (1993).

Lead user and supplier networks were measured by the strength of the network of suppliers of the company relative to the main competitors, and by the strength of the lead user network relative to the main competitors. The measures were adopted from Athanassiou and Nigh (1999).

Job rotation was measured by the extent job rotation was routinely used to develop the capabilities of the employees, by the emphasis that was put on planned job rotation as a device for developing manager's capabilities, and by the rotation of chairmanships of new product development among R&D, manufacturing and marketing personnel. These measures were adopted from Song, Xie and Dyer (2000).

Information Technologies were measured by the level of investment relative to the industry standard, the IT systems' ease of use, the IT systems' level of use, and the quality of the service for the systems (adopted from Sethi and King 1994).

Individual commitment was measured by the extent to which people defended the company when others criticize it, employees' loyalty to the company, their commitment to the company, their expectation to work with the company for some time, and the extent to which they looked for work with other companies (adopted from Anderson and Weitz 1992).

Organizational crisis was measured by the extent to which top management intentionally created organizational crises, the frequency of organizational crises in the organization, and the extent to which organizational crises were characteristic of the firm. This measure was based on the field research.

To control for possible industry and firm effects, we included eight variables: buyer power (BPOW) measures the extent to which the customers of the firm are able to negotiate lower prices from it; supplier power (SPOW) measures the extent to which the firm is able to negotiate lower prices from its suppliers; seller concentration (CONC) measures the percentage of total sales accounted for by the four competitors with the largest sales; ease of entry (ENTRY) measures the likelihood of a new competitor being able to earn satisfactory profits in the firm's principal served market segment within three years after entry; market growth (MGRO) measures the average annual growth rate of total sales in an SBU's principal served market segment over the past three years; technological change (TCHG) measures the extent to which production/service technology in an SBU's principal served market segments has changed over the past three years; relative size (RSIZE) measures the size of an SBU's sales revenues in its principal served market segment in relation to those of its largest competitor; and relative cost (RCOST) measures the SBU's average total operating costs (administrative, production, marketing/sales, etc.) in relation to those of its largest competitor in its principal served market segment. These control variables were adopted from Narver and Slater (1990).

Data Collection

The data were collected using mail surveys. The sampling frame consisted of the companies listed in the *High-Technology Industries Directory*, all of which were sent a mailing. After initial contacts to identify appropriate informants, we narrowed the original list to 686 firms that had valid contact information for the final survey. Phone calls were made to verify the contact information. In administering each of the mail surveys, we followed the total design method for survey research (Dillman 1978). The first mailing packet included a personalized letter, an express postage-paid envelope with individually typed return-address label, and the questionnaires. We sent out three follow-up letters. We re-sent the questionnaire, together with a reminder letter, to each firm that did not respond after three weeks. To increase the response rate, we supplemented our extensive personal contacts and networking efforts with numerous incentives. From the 686 firms, we collected complete data from 277 firms (a 40% response rate). These companies are operating in the following businesses: telecommunications equipment; semiconductors and computer related products; software related products; Internet related services and equipments; instruments and related products; electronic and electrical equipment; pharmaceutical, drugs, & medicines; industrial machinery & equipment.

To test for possible non-response bias, we compared early (first wave of mailing) with late responses on the level of knowledge generation of the firm. The results indicated no significant differences at a 95% confidence interval. We also collected additional financial data from secondary sources such as CompuStat and company annual reports to compare respondent with non-respondent firms on annual sales and number of employees. The results indicated that there were no significant differences between the responding and non-responding firms at a 95% confidence interval. Thus, we conclude that there is no non-response bias and that the results may be generalized to the firms that did not respond.

Analyses

We performed a factor analysis using Varimax rotation. The factor loadings are reported in Table 1. For the seven factors, all the corresponding measures have acceptable loadings, ranging from 0.55 to 0.88. These loadings suggest a high level of validity for all the seven constructs. The total variance explained by the seven factors is 71%.

(insert Table 1 about here)

For hypothesis testing purposes, the measure on each multiple-item scale was obtained by simple addition of the individual scale items and division by the number of items in the scale. In Table 2, we present construct reliabilities on the diagonal, and correlations on the off-diagonal.

The reliabilities of all measures but one were found to surpass the 0.70 threshold recommended by Nunnally (1978), hence implying a satisfactory level of scale reliability.

(insert Table 2 about here)

Results

Ordinary least squares technique was employed for estimating model parameters. Results for the regression are presented in Table 3. F-statistic was 13.73 ($p<.0001$), R-square and adjusted R-square were respectively 0.44 and 0.41. Overall, the findings provide support for five of the seven hypotheses. R&D budget (H1), job rotation (H4), Information Technologies (H5), individual commitment (H6), and organizational crisis (H7) positively influence the level of knowledge generation at an alpha level of 0.05, or 0.01. So these can be considered facilitating factors for knowledge generation. Lead user and supplier networks (H3) appear to have a negative influence on the level of knowledge generation at an alpha level of 0.01. The only insignificant factor is co-location of R&D personnel (H2). Two control variables (technological change and relative size) were also found to be significant at an alpha level of 0.05.

(insert Table 3 about here)

The result regarding lead user and supplier networks (H3) is counter-intuitive. The findings suggest that the use of such networks is negatively related to the level of knowledge generation. The non-significant result of co-location is also interesting.

Discussion

We have developed hypotheses and found some interesting results regarding the importance of seven factors in improving level of knowledge generation. Although the results do not allow us to develop a new theory on knowledge-friendly organizations, they have several theoretical and strategic implications. First, the empirical findings suggest that information technologies have the greatest impact in increasing the level of knowledge generation. Past research suggests that companies made tremendous investments in IT. In the USA alone, IT investments in 1995 were estimated at about $505 billion, while steadily increasing worldwide at an average of 10% between 1996 and 2000 (Strassmann 1997, Willcocks and Lester 1999). Whether IT's promised value will materialize, however, remains to be an open question. Researchers have extensively studied the link between IT and performance. Despite the widely presumed value of IT, the discordant findings on the IT-performance relationship, known as the "IT-productivity paradox", have somewhat confused scholars and practitioners (see Brynjolfsson 1993 for a review). However, in this study we found a clear, positive impact of Information Technologies on the level of knowledge generation, thus offering valuable insights in IT design. Past research in IT design largely focused on technical issues, like speed, accuracy and capacity. This study highlights the importance of designing IT explicitly to improve the level of knowledge generation.

Second, creation of organizational crisis has the second highest effect on the level of knowledge generation. Kim (1998) found that an intentionally constructed proactive crisis, particularly at the suborganizational level, increased expeditious learning at the catching-up process of Hyundai. A constructed crisis will intensify efforts to learn and solve problems and together with a minimal level of prior knowledge and hence increase the level of knowledge generation. But how can a crisis be constructed? According to Kim (1998), top management can create organizational crisis and present a clear gap between the current performance and the performance needed in the future. Given unambiguous, focused, and challenging goals to close the performance gap, mandates for change, and determination of the management coalition, constructed crises will also prompt members to accept organizational goals and increase personnel loyalty to the organization. Pitt (1990) also argues that managers can intentionally create organizational crises to isolate or preempt opposition to change. The management of constructed crises include (1) cognitive construction and articulation of a state of crisis around specific technical issues and circumstances, (2) postulation and evaluation of viable post-crisis states, (3) postulation and evaluation of potential technical transformations between pre- and post-crisis states in the light of known organizational competences and resources, and (4) selection (albeit intuitively) of an appropriate moment to trigger the transformation process.

Third, our empirical results also reveal several counter-intuitive findings: the significantly negative influence of lead user and supplier networks and the insignificantly negative effect of co-location of R&D personnel. In the literature, both network and co-location have been positively associated with learning, knowledge creation, or innovation success. Dodgson (1993) suggests that learning from customers and users is particularly important for innovation. Nonaka (1994) contends that extensive use of knowledge from customers and suppliers is critical in increasing the level of knowledge creation. Gemünden et al (1992) hypothesize and find empirical supports for the importance of lead users in the knowledge creation. These prior studies use broader concepts like knowledge creation (including knowledge generation, dissemination, and application), learning and innovation success.

A plausible explanation for our counter-intuitive findings (i.e., the negative influence of lead user and supplier networks) may be that isolation is good for knowledge generation. Information about markets, industries, technologies and suppliers may be useful, but a "lean" medium such as IT is preferred for the information gathering during the knowledge generation process. Lead user and supplier networks may be important for the dissemination or application of knowledge. This explanation may also be applied to the (non-significant) negative influence of the co-location of R&D personnel on knowledge generation. Prior research has not been explicitly focused on knowledge generation (Allen 1988, Coombs and Hull 1998, Madhavan and

Grover 1998) and some studies have already showed some counter-intuitive findings (e.g., Moenaert and Caeldries 1996). Thus, our study shows that knowledge creation and learning are concept that are too broad to obtain consistent insight for the complex knowledge processes. Empirical research on a more detailed ontological level by investigating each process separately is expected to result in more consistent outcomes.

This study has several limitations. First, we studied the generation of technological knowledge in new product development. We validated our model using data collected from high-technology US industries. Future research may include knowledge of markets and industries, and stable and low technology industries, as well as other countries and other knowledge processes such as knowledge dissemination and knowledge application (Coombs and Hull 1998).

Second, our theoretical framework did not include all possible antecedents. We focused only on those that managers in our field research regarded as important. For instance, we did not study feedback mechanisms, including post-project evaluations, or the use of self-organizing teams, or the use of organizational redundancy, although these are named in past research (Matusik and Hill 1998; Coombs and Hull 1998; Busby 1999; Nonaka 1994). Future research may include these antecedents, as well as a more thorough analysis of our counter-intuitive results.

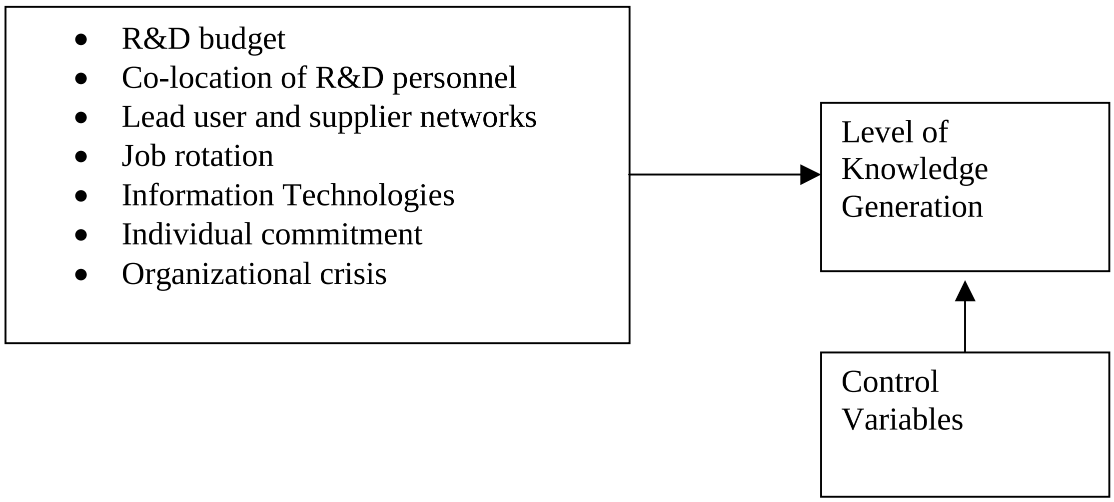

Figure 1.

A conceptual framework for studying the influence of facilitating factors on the level of knowledge generation

Table 1.

Factor Loadings from Factor Analysis

Items	F1	F2	F3	F4	F5	F6	F7
KG2	**0.84**	0.16	0.29	-0.01	0.07	-0.10	-0.07
KG1	**0.83**	0.18	0.25	-0.03	0.00	-0.12	-0.06
KG5	**0.79**	0.10	0.02	0.17	0.24	0.26	-0.04
KG6	**0.79**	0.10	0.08	0.16	0.18	0.26	-0.03
KG4	**0.70**	0.04	0.53	0.15	0.19	-0.13	-0.07
KG3	**0.67**	0.03	0.51	0.15	0.12	-0.19	-0.06
COMMIT1	0.17	**0.88**	0.06	0.03	0.03	-0.05	-0.04
COMMIT3	0.08	**0.85**	0.04	0.10	-0.01	-0.17	-0.02
COMMIT4	0.07	**0.84**	0.07	0.08	0.08	-0.02	0.09
COMMIT5	0.02	**0.78**	0.03	0.34	-0.09	-0.04	0.03
COMMIT2	0.14	**0.69**	0.07	0.05	0.22	0.01	-0.08
UIT5	0.10	0.08	**0.82**	-0.01	-0.07	0.06	-0.02
UIT1	0.21	0.04	**0.74**	0.07	0.19	-0.02	0.19
UIT3	0.25	0.16	**0.71**	0.09	0.13	0.01	0.12
UIT4	0.09	-0.02	**0.55**	0.18	0.24	-0.33	0.01
CL4	0.01	0.24	0.13	**0.84**	0.12	0.05	-0.05
CL2	0.05	0.13	0.25	**0.82**	0.17	0.05	-0.02
CL1	0.12	0.05	0.10	**0.72**	0.24	0.19	0.03
CL3	0.18	0.12	-0.13	**0.71**	-0.00	-0.21	0.09
ORGC1	0.08	0.05	0.01	0.14	**0.79**	0.13	0.08
ORGC4	0.29	0.15	0.18	0.22	**0.72**	-0.12	0.05
ORGC3	0.23	0.05	0.38	0.18	**0.68**	-0.18	-0.06
JOBR4	0.03	-0.03	0.16	-0.01	-0.14	**0.70**	0.15
JOBR3	0.02	-0.07	-0.17	-0.06	-0.03	**0.67**	-0.16
JOBR1	-0.01	-0.16	-0.13	0.20	0.19	**0.62**	-0.18
NETW1	-0.11	0.02	-0.02	-0.01	0.04	-0.01	**0.88**
NETW2	-0.07	-0.04	0.19	0.05	0.03	-0.14	**0.84**

*Item identified as seven factors: F1=knowledge generation; F2=individual commitment; F3=information technologies; F4=co-location; F5=organizational crisis; F6=job rotation; F7=led user and supplier networks. Descriptions for the item abbreviations can be found in appendix A.

Note: black numbers indicate items that load highly for each of the seven factors.

Table 2.

Descriptive Statistics

	Mean	S.D.	KG	R&D	COMM	UIT	CL	ORGC	JOBR	NETW	BPOW	SPOW	CONC	ENTRY	MGRO	TCHG	RSIZE	RCOST
Knowledge generation	6.28	2.17	*0.91*															
R&D budget	5.98	2.74	0.29	*NA*														
Individual commitment	5.94	2.24	0.27	0.15	*0.89*													
Information Technologies	6.05	1.96	0.49	0.14	0.19	*0.78*												
Co-location	5.72	2.17	0.29	0.57	0.32	0.26	*0.83*											
Organizational crisis	5.37	2.52	0.46	0.30	0.22	0.41	0.42	*0.77*										
Job rotation	5.33	2.24	0.00	0.03	-0.16	-0.18	0.04	-0.04	*0.52*									
Lead user and supplier networks	2.82	2.47	-0.11	0.03	-0.01	0.17	0.04	0.07	-0.15	*0.72*								
Buyer power	4.68	3.39	0.16	0.01	0.18	0.12	0.03	0.07	-0.29	0.17	*NA*							
Supplier power	4.84	2.71	0.23	0.26	0.42	0.27	0.45	0.33	0.02	0.02	-0.06	*NA*						
Seller concentration	3.46	2.63	-0.11	-0.20	-0.06	0.01	-0.08	-0.05	-0.01	-0.00	-0.06	0.03	*NA*					
Ease of entry	4.77	3.75	-0.24	-0.20	-0.25	-0.27	-0.28	-0.11	0.20	-0.05	-0.35	-0.13	0.12	*NA*				
Market growth	5.79	3.68	-0.04	-0.05	-0.03	0.07	-0.05	-0.12	-0.25	0.02	0.14	-0.06	-0.02	-0.16	*NA*			
Technological change	4.58	3.50	0.13	-0.02	-0.08	0.15	-0.05	0.07	-0.07	0.11	0.17	-0.06	0.04	-0.11	0.08	*NA*		
Relative size	6.57	2.10	0.42	0.34	0.32	0.48	0.28	0.36	-0.06	0.04	0.12	0.38	-0.07	-0.09	-0.05	0.05	*NA*	
Relative costs	5.92	2.77	0.42	0.37	0.06	0.39	0.34	0.63	-0.01	-0.02	0.11	0.27	-0.09	-0.13	-0.13	0.05	0.46	*NA*

*Note: The Cronbach Coefficient Alpha for each measure is on the diagonal in italics; the intercorrelations among the measures are on the off-diagonal.

Table 3.

Regression Analysis: Level of Knowledge Generation as Dependent Variable

	Coefficient Estimate	Standard Error	t-value	Standardized Coefficients
Intercept	1.21 ns	0.73	1.66	0 ns
R&D budget	0.09 *	0.05	1.87	0.11 *
Co-location	-0.04 ns	0.07	-0.66	-0.04 ns
Lead user and supplier networks	-0.17 **	0.04	-4.07	-0.20 **
Job rotation	0.10 *	0.05	1.97	0.10 *
Information Technologies	0.35 **	0.07	5.33	0.32 **
Individual commitment	0.12 *	0.04	2.18	0.12 *
Organizational crisis	0.19 **	0.06	3.41	0.22 **
Buyer power	0.06 ns	0.03	1.63	0.09 ns
Supplier power	-0.03 ns	0.05	-0.71	-0.04 ns
Seller concentration	-0.04 ns	0.04	-1.08	-0.05 ns
Ease of entry	-0.04 ns	0.03	-1.26	-0.07 ns
Market growth	-0.02 ns	0.03	-0.56	-0.03 ns
Technological change	0.05 *	0.03	1.76	0.09 *
Relative size	0.11 *	0.06	1.71	0.11 *
Relative costs	0.04 ns	0.05	0.78	0.05 ns
F-value	13.73			
R^2	0.44			
Adjusted R^2	0.41			

Notes:
*p<0.05; ** p<.01; ns indicates that the coefficient is not significant at 95% confidence level using one tail t-test.

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Appendix A
Constructs, Measurement Items, and Construct Reliabilities

<u>Dependent Variable:</u>

Knowledge Generation (Construct reliability: 0.91) (new scale)
(Anchor: 0=strongly disagree; 10=strongly agree)

We do a lot of in-house knowledge generation

We often poll end users at least once a year to assess the quality of our current technologies

We periodically collect industry information through informal means (e.g., lunch with industry friends, talks with trade partners)

Intelligence on our competitors' technological development is generated independently by several departments

We are slow to detect fundamental technological shifts in our industry (R)

We periodically review the likely effect of changes in our business environment (e.g., regulation) on the direction of our technology development

<u>Independent Variables:</u>

R&D Budget (%)

Percentage of the R&D/Sales (in %)

Co-location (Construct reliability: 0.83) (from Pinto, Pinto, and Prescott 1993)

What is approximate percentage of the R&D personnel who are conveniently co-located?

The physical distance between the different department of the R&D is: (0=none; 10=very far)

The offices of R&D personnel are located in close proximity to each other *(Anchor: 0=strongly disagree; 10=strongly agree)* (R)

It is easy for the R&D personnel to travel to meet. (Anchor: 0=strongly disagree; 10=strongly agree) (R)

Lead user and supplier networks (Construct reliability: 0.72) (from Athanassiou and Nigh 1999) (Anchor: 0=strongly disagree; 10=strongly agree)

Relative to our major competitors, our company has a stronger network of suppliers

Relative to our major competitors, our company has a stronger network of lead users

Job Rotation (Construct reliability: 0.52) (from Song, Xie and Dyer 2000)
(Anchor: 0=strongly disagree; 10=strongly agree)

Job rotation is routinely used in this organization to develop the capabilities of our employees

Planned job rotation of managers is emphasized as a device for developing their capabilities

We rotate chairmanships of new product development among R&D, manufacturing, and marketing personnel

Information Technologies (IT) (Construct reliability: 0.78) (from Sethi and King 1994)

Relative to the industry norm/standard, the level of the investment in information technologies in this organization is (Anchor: 0=much lower than the industry norm/standard; 5=the same as the industry norm/standard; 10= much higher than the industry norm/standard)

Our information technologies systems are <u>easy</u> to use. (Anchor: 0=very easy to use; 10=very difficult to use)

The availability of the information technologies systems to our employees (Anchor: 0=none; 10=everyone)

The level of usage of our information technologies systems in this organization (Anchor: 0=very low; 10=very high)

Individual Commitment (Construct reliability: 0.89) (from Anderson and Weitz 1992)
(Anchor: 0=strongly disagree; 10=strongly agree)

People defend our company when others criticize the company

Generally speaking, there isn't much personal loyalty to this organization (R)

People are not very committed to this company (R)

People expected to work with the company for some time

Many people are continually on the lookout for the opportunity to work with the other companies (R)

Organizational Crisis (Construct reliability: 0.77) (new scale)
(Anchor: 0=strongly disagree; 10=strongly agree)

Our top management sometimes intentionally creates organizational crisis

We tend to have frequent organizational crisis in this organization

Organizational crisis is a characteristic of our firm

Control Variables (Narver and Slater 1990)

Buyer power (BPOW)
The extent to which the customers of the firm are able to negotiate lower prices from it (0-10 scale)

Supplier power (SPOW)
The extent to which the firm is able to negotiate lower prices from its suppliers (0-10 scale)

Seller concentration (CONC)
In an SBU's principal served market segment, the percentage of total sales accounted for by the four competitors with the largest sales (including the SBU if appropriate) (0-10 scale)

Ease of entry (ENTRY)
The likelihood of a new competitor being able to earn satisfactory profits in the firm's principal served market segment within three years after entry (0-10 scale)

Market growth (MGRO)
Over the past three years, the average annual growth rate of total sales in an SBU's principal served market segment (0-10 scale)

Technological change (TCHG)
The extent to which production/service technology in an SBU's principal served market segments has changed over the past three years (0-10 scale)

Relative size (RSIZE)
The size of an SBU's sales revenues in its principal served market segment in relation to those of its largest competitor (0-10 scale)

Relative costs (RCOST)
An SBU's average total operating costs (administrative, production, marketing/sales, etc.) in relation to those of its largest competitor in its principal served market segment (0-10 scale)

Note: (R) indicates that the item was reversed coded.