Journal of Technology Management & Innovation

Received May 25, 2007 / Accepted August 15, 2007

MANAGING THE INNOVATORS FOR EXPLORATION AND EXPLOITATION[1]

C. Annique UN
University of South Carolina, Moore School of Business
Sonoco International Business Department, 555
1705 College Street, Columbia, SC 29208, USA

Tel.: 1-803-777-0315, Fax: 1-803-777-3609,
annique_un@moore.sc.edu

Abstract

I analyze how to manage employees to achieve a balance between exploration and exploitation in large established firms. Previous studies suggest that, although firms need to undertake both exploration and exploitation simultaneously, this is difficult either because of the scarcity of resources or because of the incompatibility of these two processes. Proposed solutions have been ambidexterity, punctuated equilibrium or specialization. I suggest another method: managing employees. Specifically, I argue that using the so-called "innovative" system of human resource management practices, consisting of team-based incentive system, team-based job design, and job rotation, enables the firm to undertake exploration and exploitation simultaneously because it provides the psychological safety for people to explore new knowledge to make novel products and develops employees to have the perspective-taking capability that enables the integration of knowledge cross-functionally for efficiency. Using the so-called "traditional" system of human resource management practices, consisting of individual-based incentive system, individual-based job design, and no job rotation, has limited impact on either exploration or exploitation because it does not create the psychological safety for people to explore new knowledge and does not develop the perspective-taking capability needed for exploitation. Moreover, mixing practices from both systems is better than only using the traditional system in achieving exploration or exploitation, but less effective than only using the innovative system as the mix of practices can create inconsistent expectations on employees.

Key words: Exploration; exploitation; human resource management practices

[1] I would like to thank Alvaro Cuervo-Cazurra for working with me on previous drafts of this paper. The paper is an extension of my thesis at the Massachusetts Institute of Technology's Sloan School of Management, which received the INFORMS Best Dissertation Award. I received useful suggestions on previous versions of the paper from Eleanor Westney, Michael Beer, John Carroll, Don Lessard, Andrew Pettigrew, Jacky Swan, participants at the European Conference on Organizational Knowledge, Learning, and Capabilities annual meeting, the Strategic Management Society annual meeting, the Academy of Management Review Theory Development Workshop at the Academy of Management annual meeting, the Massachusetts Institute of Technology Proseminar, and anonymous reviewers. I thank the MIT-Japan Program Starr Foundation, the CS Holding Fellowship in International Business, and the Massachusetts Institute of Technology Doctoral Fellowship for their generous funding. I also thank the Center for International Business Research and Education and the Riegel & Emory Human Resource Research Center at the University of South Carolina for financial support. All errors are mine.

INTRODUCTION

How do large established firms achieve a balance between exploration and exploitation? Achieving a balance between these two activities has become an important question in the organizational learning literature (Smith, Gupta, and Shalley 2006 provide a recent review of the literature on the topic). Researchers refer to exploration as learning and innovation (e.g., the pursuit and acquisition of new knowledge; Smith et al. 2006), where innovation is commercialized new knowledge in the form of products (Roberts 1988). Exploitation refers to the use of knowledge for efficiency, particularly the amount of resources used to generate the innovation (Adler, Goldoftas, and Levine 1999; Liker and Sobek 1996; Womack, Jones, and Roos 1989).

Researchers generally agree that firms need to do both exploration and exploitation simultaneously in order to prosper in the long term (e.g., Benner and Tushman 2002; Eisenhardt and Martin 2000; March 1991, 1996, 2006). However, how to achieve this is less clear. March (1991, 1996, 2006) argues that firms need to choose one over the other, either because of scarcity of resources or due to the incompatibility of the two processes. Therefore, despite the agreement that both activities are important, firms still face the exploration and exploitation conundrum (Smith et al. 1996).

Three possible solutions have been proposed to achieve a balance: ambidexterity, punctuated equilibrium and specialization. Ambidexterity refers to the synchronous pursuit of both exploration and exploitation via loosely coupled and differentiated subunits or individuals, each of which specializes in either exploration or exploitation (e.g., Tushman and O'Reilly 1996; Benner and Tushman 2002, 2003). Punctuated equilibrium refers to temporal rather than organizational differentiation and suggests cycling through periods of exploration and exploitation as a more viable approach than the simultaneous pursuit of the two (e.g., Burgelman 1991, 2002; Holmqvist 2004; McNamara and Baden-Fuller 1999). Specialization suggests that firms can specialize in one or the other activity in relationships with other firms (e.g., Siggelkow and Rivkin 2006). However, the existing literature is silent on the question of whether these approaches are equally viable, so that an organization can choose one or the other, and whether other factors should drive the choice between these avenues (Smith et al. 2006).

I build on this line of research and present another way to achieve a balance: managing employees in such a way that they *simultaneously* explore new knowledge to make novel products and exploit knowledge to achieve efficiency. Specifically, I argue that firms can manage employees to undertake both exploration and exploitation simultaneously using the "innovative" system of human resource management practices, which until now has been used only to explain productivity gain of production workers (e.g., Ichniowski et al. 1997; MacDuffie 1995; Osterman 2006). This system of practices includes team-based job design, a team-based incentive system, and job rotation of individuals within the same function (e.g., production). I argue that when these practices are applied to all employees of the firm cross-functionally, they enable the achievement of exploration. They do so because they reinforce each other to provide the psychological safety for people to explore new knowledge to make novel products. The practices also provide individuals with the ability to adopt the viewpoints of people working in other functions, which is difficult to do. This perspective-taking capability facilitates cross-functional knowledge integration, which helps achieve efficiency.

In contrast, I argue that the "traditional" system of human resource management practices (Ichniowski et al. 1997; Osterman 2006), which include individual-based incentive system, individual-based job design, and no job rotation, limits both exploration and exploitation. This system of practices does not generate the psychological safety for people to explore new knowledge to create novel products, nor does it develop employees to have the ability to adopt the perspective of the people of other functions that would facilitate integration to achieve efficiency.

Finally, I discuss how the use of practices from both systems can create inconsistent expectations on the employees. This inconsistency reduces the psychological safety required for experimentation and diminishes the perspective-taking capability required for efficient knowledge integration. These result in lower exploration and exploitation than using only the innovative system of practices.

The present paper contributes to the discussion on achieving a balance between exploration and exploitation in the organizational learning literature by showing how firms can manage people to achieve both simultaneously. It also contributes to the literature on human resource management by suggesting that the innovative system of human resource management practices when applied not only to employees in the same function, but across functions to all employees of the firm enables firms to achieve simultaneously exploration and exploitation. It helps support the mediating conditions of psychological safety and perspective-taking capability needed for exploration and exploitation respectively.

The remainder of the paper comprises three sections. In the following section, I explain the need to achieve a balance between exploration and exploitation and

discuss the three models to achieve it that have been proposed in the literature. I then present my own model of employee management to achieve balance, discussing systems of human resources management practices and how these can affect exploration and exploitation. In the final section I provide my conclusions and directions for future research.

BALANCING EXPLORATION AND EXPLOITATION

In his seminal work, March (1991) argues that firms need to undertake both exploration and exploitation simultaneously if they are to achieve persistent success. Exploration includes things captured by terms such as search, variation, risk taking, experimentation, play, flexibility, discovery, and innovation. Exploitation includes such things as refinement, choice, production, efficiency, selection, implementation, and execution (p. 71). Although both exploration and exploitation are important, he argues that these activities are incompatible in a given firm; therefore, firms face the dilemma of choosing one over the other. March (1996, 2006) maintains this claim and provides several arguments for it. First, he argues that exploration and exploitation compete for scarce organizational resources. Thus, more resources devoted to one imply fewer left over for the other. Second, the mindsets and organizational routines needed for exploration are markedly different from those needed for exploitation, making the simultaneous pursuit of both unfeasible. Third, both types of activities are iteratively self-reinforcing. Because of the range of possible outcomes, exploration often leads to failure, which in turn promotes the search for even newer ideas and thus more exploration, thereby creating a "failure trap." Exploitation often results in early success, which in turn reinforces more exploitation along the same trajectory, resulting in a "success trap." As such, firms face a dilemma of choosing one over the other.

However, recent studies question the above assumptions and argue that a balance between exploration and exploitation can be achieved simultaneously. For example, Katila and Ahuja (2002) question the first argument that exploration and exploitation compete for scarce resources. They argue that not all resources are scarce, especially publicly available resources such as patents. They use patent data from the robotic industry to show that the interaction between exploration of new knowledge (measured by the propensity to cite different patents) and exploitation (viewed as search depth or the propensity to cite certain patents repeatedly) predict new product development. Danneels (2002) questions the second argument that the simultaneous pursuit of exploration and exploitation is unfeasible because of the differences in mindsets. In a study of five established high-tech firms, he found that product innovation generates path dependencies as a result of its effect on firm competences, which in turn influences the new products that the firm is likely to develop and with which it is likely to find success. The availability of competences relating to other technologies or customers promotes product innovations on the basis of those competences, whereas the lack of competence relating to other technologies or customers leads to the neglect of other innovation possibilities. McNamara and Baden-Fuller (1999) question the third argument that exploration and exploitation are iteratively self-reinforcing. In their examination of the Celltech case, they show that renewal based on exploration is possible even in a firm where exploitation has come to dominate. Similarly, basing himself on an analysis of a Scandanivian software firm, Holmqvist (2004) argues that the generation of competence in the form of either exploration or exploitation does not necessarily generate "traps" of learning and is thus not contrary to organizational change. Stable exploitative behavior can be a cause of exploration and vice versa. In their study of Singaporean firms, He and Wong (2004) also found that firms that pursue both exploration and exploitation simultaneously achieve higher sales performance.

Despite an increased interest in achieving a balance between exploration and exploitation, few studies have examined how firms can achieve a balance between the two. Table 1 summarizes key articles and explains how the exploration and exploitation concepts have been used. It also presents the various ways in which firms might achieve balance. It specifies the context in which these studies have been conducted, levels and unit of analyses, and the conclusions reached by these studies. I now discuss the approaches that have been proposed to achieve a balance (ambidexterity, punctuated equilibrium and specialization), describe their limitations and present an alternative model.

Table 1. Summary of main articles on managing exploration and exploitation

Article	Theoretical/ empirical	Context	Definitions of exploration/exploitation	Level and unit of analysis	Achieving balance	Conclusions
March (1991)	Theoretical	Acontextual	Exploration: search, variation, risk taking, experimentation, play, flexibility, discovery, innovation Exploitation: refinement, choice, production, efficiency	Organization, individual	Unknown	Adaptive systems tend to prefer exploitation orientation over exploration. Firm must devote enough resources to exploitation to ensure present viability and enough resources to exploration to ensure future viability.
Levinthal and March (1993)	Theoretical	Acontextual	Exploration: developing new knowledge Exploitation: exploiting current competencies	Organization, individual	Unknown	The cognitive limits that constrain rationality also constrain learning, which is crucial to exploration. Both simplification and specialization support learning. There is a tendency to prefer exploitation. This tendency can be managed if temporal, spatial, and failure myopias are also managed.
March (1996)	Theoretical	Acontextual	As March 1991	Intellectual field of organization theory	Unknown	Both exploration and exploitation have tendency to be self-reinforcing. Intellectual adaptation is a balance between exploration and exploitation.
McNamara and Baden-Fuller (1999)	Empirical/ case study	Biotech	Exploration: new drug discovery, movement to Phase I trial, collaboration. Exploitation: Phase II, III trials; "use and development of things already owned."	Organization	Punctuated equilibrium	Renewal of exploration in mature organizations stuck in exploitation (inertia, decline) is possible. Requires applying tested managerial techniques: new CEO, new staff, new team structures, new processes.
Katila and Ahuja (2002)	Empirical	Robotic industry	Exploration: search scope((how widely a firm searches for new knowledge) Exploitation: search depth (how deeply a firm uses existing knowledge for products)	Organization	Unknown	Search depth and scope are not mutually exclusive, have positive interactive effects leading to more innovation.
Benner and Tushman (2002)	Empirical	Paint and Photography industry	Exploration: innovation based on new knowledge Exploitation: innovation based on existing knowledge	Organization	Ambidexterity	Process management practices (TQM, Six Sigma,etc.) strengthen exploitative innovations to the detriment of exploration innovations.
Danneels (2002)	Empirical/ case study	High-tech	Exploration: developing a product that draws on new competencies. Exploitation: developing a product that draws on existing competencies	Organization	Unknown	The renewal of the firm depends on building new competencies. One of the sources of new competencies is new product innovation, which depends on both technology competence and customer competence.
Benner and Tushman (2003)	Theoretical	Acontextual	Exploration: new knowledge innovation Exploitation: incremental innovation based on present knowledge	Organization	Ambidexterity; specialization can have benefits	Process management activities (TQM, etc.) preference incremental innovation and are detrimental to new (exploratory) innovation.
Holmqvist (2004)	Empirical/ case study	Scandinavian software producer	Exploration: creating variety in experience, and thrives on experimentation and free association Exploitation: creating reliability in experience, and thrives on productivity and refinement	Organization	Punctuated equilibrium	The generation of competence in the form of either exploitation or exploration does not necessary generate "traps" of learning; not contrary to organizational change. Stable exploitative behaviors can be a cause of exploration and vice versa.
He and Wong (2004)	Empirical	Manufacturing firms	Exploration: technological innovation activities aimed at entering new product-market domains Exploitation: technological innovation activities aimed at improving existing product-market positions	Organization	Ambidexterity	The interaction between explorative and exploitative innovation strategies is positively related to sales growth rate, and the relative imbalance between explorative and exploitative innovation strategies is negatively related to sales growth rate.
March (2006)	Theoretical	Acontextual	As March 1991	Organization	Unknown	Rationality sustains standard procedures (strategic planning and action) this can be sub optimal in complex and changing environments. Feedback based systems are better. Adaptation requires both exploration and exploitation to be successful.

Ambidexterity, Punctuated Equilibrium and Specialization

The ambidexterity model (e.g., Tushman and O'Reilly 1996) suggests that one way to achieve this balance is to differentiate the subpart of the firm that pursues exploration from the subpart that undertakes exploitation. An ambidextrous organization is decentralized, consisting of small autonomous subunits that focus on exploration while the rest of organization focuses on exploitation. For example, in their study of firms in the photography and paint industries, Benner and Tushman (2002) found that exploitation crowds out exploration. Therefore, if a firm is to achieve balance, it must locate the two activities in different parts of the firm. Specifically, they state that ambidextrous organization designs are composed of highly differentiated but weakly integrated subunits. While exploratory units are small and decentralized, with loose cultures and processes, the exploitation units are larger and more centralized, with tight cultures and processes (Benner and Tushman 2003: 252). Taylor and Greve (2006) show that multimember teams and teams with experience working together produced innovations with greater variation in value. However, individuals are better than teams at integrating diverse knowledge. The implication here is that teams are better at exploration and individuals are more effective at exploitation; therefore, the two activities should be separated as they have different determinants. This implies that within the subpart of the firm that undertakes exploration, individuals should be organized into teams to perform their tasks. In contrast, within the subpart of the firm that focuses on exploitation, individuals should be organized individually to fulfill their responsibilities. Hence, one of the limitations of the ambidexterity model is that product innovation requires the integration of new and existing knowledge that cannot be separated (e.g., Carlile 2004; Dougherty and Hardy 1996; Henderson and Clark 1990).

The punctuated equilibrium model argues for temporal rather than organizational differentiation and suggests that cycling through periods of exploration and exploitation is a more viable approach than simultaneous pursuit of the two. For example, Burgelman (1991) argues that consistently successful firms are characterized by top management's expending effort on building induced and autonomous strategic processes (exploration) and successful reorientations (exploitation) in organizations. In his analysis of Intel Corporation, he found that this company experienced success in exploration at a given point in time, and in exploitation at another point in time. In their analysis of Celltech, McNamara and Baden-Fuller (1999) also found that it was successful at exploration in one period and exploitation in another. In a follow-up study of Intel, Burgelman (2002) found that top managers were able to undertake temporal differentiation of exploration and exploitation. Therefore, one of the limitations of the punctuated equilibrium model is that firms cannot undertake both exploration and exploitation simultaneously, possibly compromising their future advantages (He and Wong 2004; Levinthal and March 1993; March 1991, 1996, 2006).

The main argument behind specialization is that since firms are in a relationship with other firms, they can specialize in one activity or the other, and let the social system deal with the balance (Siggelkow and Rivkin 2006; Smith et al. 2006). It is argued that a given firm can specialize in exploration, such as creating new product designs, and another can focus on manufacturing them. A limitation of the specialization approach is that hold-up problems can occur, especially for established manufacturing firms. For example, such problems may arise when one firm specializes in designing the product and another in manufacturing it (e.g., Smirnov and Wait 2004). The manufacturer could refuse to make the product as expected by its designer or refuse to do so efficiently; likewise, the designer firm could refuse to play its part.

I propose another way to achieve a balance between exploration and exploitation: managing people using the innovative system of human resource management practices (e.g., Gant et al. 2002; Ichniowski et al. 1997; Osterman 2006). Studies have indicated that exploration and exploitation are typically undertaken by individual employees, either at the individual or the team level (e.g., Miller et al. 2006; Taylor and Greve 2006); therefore, analyzing how firms manage people to achieve this balance is important.

MANAGING THE INNOVATORS FOR EXPLORATION AND EXPLOITATION

Product innovation requires the integration of new and existing knowledge which is dispersed in the firm (Tsoukas, 1996)[1]. As such, all employees of the firm are

[1] There is also knowledge outside the firm that can be useful for innovation. This includes knowledge from customers (Danneels 2002; Griffin and Hauser 1993; Un and Cuervo-Cazurra 2007; Verona, Prandelli, Sawhney 2006), lead users (Von Hippel 1988), suppliers (Dyer and Nobeoka 2000; Takeishi 2002), competitors (Afuah 2000), or professional organizations (Holmqvist 2003; Swan and Newell 1995, 1999), among others. The management of knowledge integration with people outside

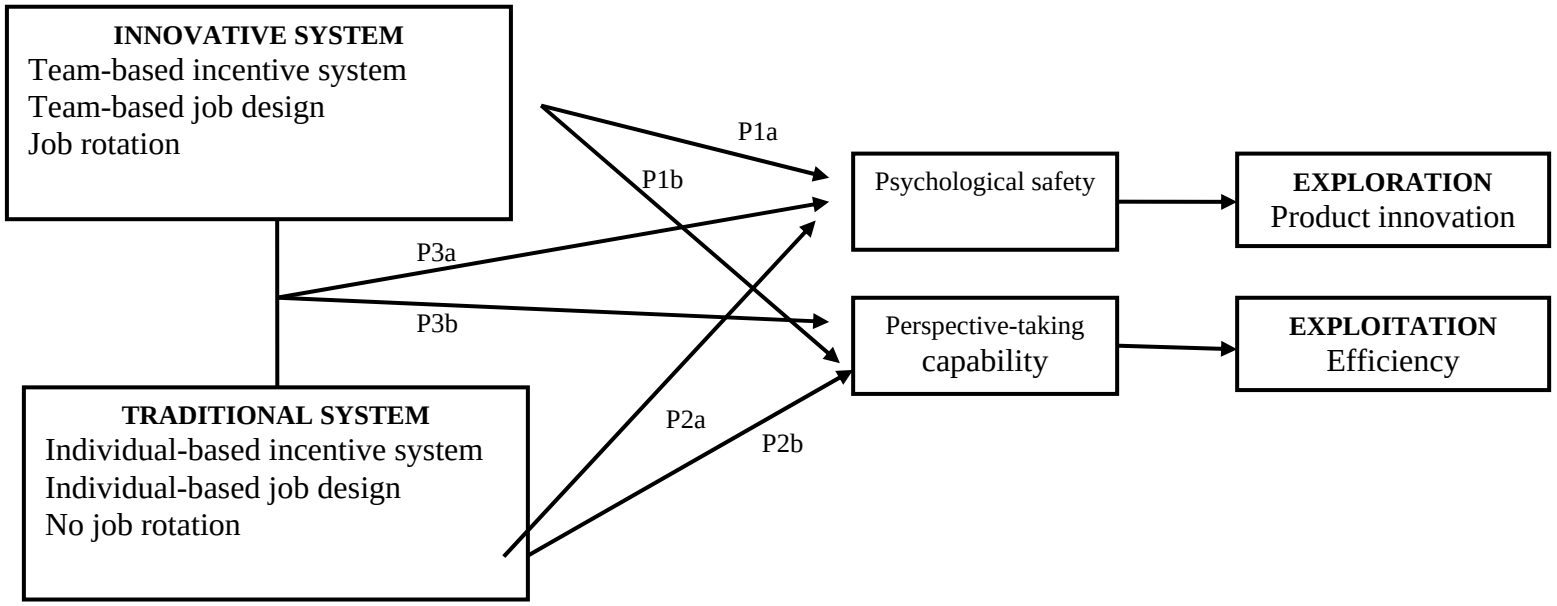
potential innovators (Kogut and Zander 1992). Therefore, the integration of knowledge among employees from different functions such as R&D, marketing, sales, and production is crucial for the creation of new knowledge (Carlile 2004; Dougherty 1992; Lawrence and Lorsch 1967; Leonard-Barton 1995; Nonaka and Takeuchi 1995). This new knowledge can not only take the form of innovations and new products but also can take the form of improvements and increased efficiency.

However, to achieve their innovative and efficiency potential, employees need to be managed. Leadership scholars (e.g., Bass 1985; Bass and Steidlmeier 1998; Burns 1978; Kets de Vries 1994; Schein 1992) have discussed how leaders create the conditions conducive for accomplishing various tasks. As Schein's (1992) suggests, leadership is important in building an organizational culture that is safe for people to explore. He also states that other practices, especially, how people are managed such as how they are rewarded help maintain this type of culture (p. 74). He argues that it is important for leaders to provide signals about the importance of certain behaviors over others. This is consistent with arguments made by other leadership scholars (e.g., Bass 1985; Burns 1978) who suggest that it is important for leaders to provide signals about which behaviors are valuable and which ones are not so that the former are reinforced. In addition, Schein's work also acknowledges that there are differences in perspectives of people belonging to different subcultures such as the production and engineering cultures (Schein 1996). Schein (1992) argues that when companies are still new and relatively small, leaders can interpret the different perspectives and integrate them to accomplish certain tasks; however, this is difficult when companies become large and established as the ones I analyzed. Un and Cuervo-Cazurra (2005) discuss how top managers play a key role in product improvement by evaluating product market performance, selecting products for improvement, initiating the innovation process through delegation to middle managers of the responsibility to organize bottom-level employees to take actions toward product improvement, and monitoring of progress to ensure improvement. These findings are consistent with Selden and MacMillan (2006) who suggest that top managers play critical roles in managing employees to innovate customer-oriented products. In other words, firms that deliberately invest in building strategic routines, skills and mindsets of their employees are more likely to have dynamic or learning capabilities that supports change and innovation (e.g., Kogut and Zander 1992, 1996; Pisano 1994; Teece, Pisano and Shuen 1997; Winter 1987; Un and Cuervo-Cazurra, 2004; Zollo and Winter 2002). Thus, the management of employees leads to innovation, but in a mediated manner.

I build on this line of thinking and discuss two systems of human resource management practices – innovative and traditional– which, until now, have been used primarily to understand productivity of assembly line workers (e.g., Ichniowski et al. 1997; Osterman 2006). I propose that both exploration and exploitation are better achieved using the innovative system, whereas the traditional system will have a limited influence on exploration or exploitation. The reason is that the innovative system supports the development of the psychological safety and perspective taking capability needed for exploration and exploitation respectively. I also argue that combining practices from both systems can create inconsistent expectations on the individuals reducing psychological safety and perspective-taking capability, leading to lower exploration and exploitation than firms that use only the innovative practices, although still better than firms that use the traditional practices only. Figure 1 illustrates the proposed model.

the firm differs (Un and Cuervo-Cazurra 2007) and is beyond the scope of this paper.

Figure 1. Relationships between innovative and traditional systems of practices and exploration and exploitation



Innovative System

The innovative system of human resource management practices includes problem-solving teams, incentive pay plans, careful recruitment and selection, extensive labor-management communication, flexible job assignment, and employment security (Gant et al. 2002). They are considered innovative because they are new to the U.S. firms (Gant et al. 2002), and have been applied primarily to production workers (e.g., Ichniowski and Shaw 2003; MacDuffie 1995). Productivity effects of the innovative system of practices have now been well documented in various studies (e.g., Becker and Gerhart 1996; Huselid and Becker 1996; Ichniowski et al. 1997; MacDuffie 1995); however, its use with all employees in the firm has yet to be thoroughly explored.

Researchers vary in the practices they consider as forming part of the innovative system (for reviews, see Bartel et al. 2004 and Osterman 2006). However, several practices cut across studies: team-based job design, team-based incentive pay, and job rotation. In my model team-based job design is cross-functional team-based job design formed for performing tasks whose accomplishment requires the involvement of employees from different functions. Team-based incentive system is cross-functional team-based compensation, meaning that individuals are rewarded based on cross-functional team performance. For example, Adler et al (1999) found that the NUMMI plant was more effective in their model changeovers than their competitors, in part, due to their team-based incentive practices. Cross-functional job rotation is a practice that allows employees the opportunity to work in other functional areas. Nonaka and Takeuchi (1995), for example, indicate that in large established firms such as Honda and Nissan, employees are given the opportunity to work in different functional areas such as marketing, production, and R&D (p. 77). The idea behind this practice is that prior to joining the firm, individuals tend to have deep expertise in a particular area such as engineering. This knowledge is primarily acquired through formal education (Postrel 2002). The purpose of cross-functional job rotation is to provide individuals with some knowledge of other functional areas while maintaining their deep expertise in a particular area (Nonaka and Takeuchi, 1995). Based on her study of large established U.S. firms, Leonard-Barton (1995) suggests that individuals with "T-shaped" knowledge tend to be more effective and efficient at knowledge integration. The stalk of the T represents deep disciplinary knowledge, or knowledge in a particular functional area; the bar represents the breadth of knowledge of other areas often acquired through work experience in the company.

The above practices produce the psychological safety that supports exploration of new ideas useful for product innovation. Psychological safety refers to a shared belief that the individual is safe to take risk (Edmondson 1999; Schein 1992). The term is meant to suggest neither a careless sense of permissiveness, nor an unrelentingly positive affect, but rather a sense of confidence that the individuals will not be embarrassed, rejected, or punished by someone else for speaking up (Edmondson 1999). This confidence stems from mutual respect and trust among organizational members. It also goes beyond trust, describing an atmosphere characterized by mutual respect in which people are comfortable being themselves. Psychological safety has been found to encourage individuals to explore and experiment with new ideas (Edmondson 2002; Lee et al. 2004; Tjosvold et al. 2006). For example, Edmondson (2002) found that in organizational teams that perceive psychological safety tend to experiment more with novel solutions to task-related problems. Lee et al. (2004) also found that individuals working in organizations where there are fewer evaluative pressures experiment more with different types of knowledge in comparison to individuals under higher evaluative pressures. This is consistent with Tjosvold et al. (2006), who found that when people are not punished or blamed for making mistakes they are more likely to take a problem-solving approach in performing their tasks, which requires exploration and experimentation with different ideas.

The practices used within the innovative system help achieve this psychological safety. Having cross-functional team-based job design and reward based on such team performance reduces evaluative pressure. The pressures are diffused across the team rather than being concentrated on a single individual. If they are under less pressure, individuals are more likely to experiment with novel ideas for new products. Additionally, cross-functional job rotation helps create the psychological safety needed for individuals to experiment with new knowledge that could be useful for creating distinct products. It allows individuals to gain some shared knowledge with others in other departments, which builds trust (Madhaven and Grover 1998), a critical ingredient for building psychological safety (Edmondson 1999; Schein, 1992; Tjosvold et al 2006). In their analysis of large established firms such as Nissan and Canon, which use innovative human resource management practices, Nonaka and Takeuchi (1995) found that employees are more likely to experiment with different ideas because they feel safe to do so. In the development of the Nissan Primera, for example, employees were encouraged to experiment with driving in Germany to get a better sense of how to make a product for

the European market. In addition, employees often met to explore and experiment with different ideas for new products without feeling that they are being judged individually for the quality of their thoughts. This observation is consistent with other studies (e.g., Liker and Sobek 1996; Womack et al. 1989), which found that large established firms, such as Toyota and Honda, that use innovative human resource management practices tend to generate products that customers considered more innovative than those produced by their U.S. competitors. In her analysis of the Chaparral Steel mini-mill, for example, Leonard-Barton (1992) found that this company is more innovative than its competitors partly as a result of its human resource management practices, such as team-based incentive system and team-based job design.

Based on the arguments put forward here, I propose that:

Proposition 1a. The innovative system of human resource management practices provides employees the psychological safety that supports exploration.

The innovative system of human resource management practices also facilitates exploitation. It provides employees with the ability to adopt the perspective of people from other departments, which is difficult to do (Bechky 2003; Boland and Tenkasi 1995; Carlile 2004; Dougherty 1992; Leonard-Barton 1995; Nonaka and Takeuchi 1995). Dougherty (1992), for example, found that departments have their own ways of thinking, or "thought worlds", that separate them. What is viewed as an important issue by one department may be considered unimportant, and, thereby rejected, by other departments. Bechky (2003) found that the differences in language, the locus of practice, and conceptualization of the product contribute to difficulty in integrating knowledge. These findings are consistent with those of Schein (1992) who found that people in different departments (e.g., engineering and marketing) use a different language to communicate and think differently about the same thing (p. 74). Therefore, the inability of the departments to take each other's perspectives in order to integrate knowledge can influence the amount of resources used, resulting in lower efficiency (Adler et al. 1999; Roth and Kleiner 1996).

Researchers have offered various solutions to the interdepartmental knowledge integration problem. For example, Boland and Tenkasi (1995) proposed the use of electronic communication systems. They argued that electronic communication systems facilitate perspective-taking by enabling individuals involved in knowledge integration to learn about each other's perspectives. Carlile (2004) recommends the use of boundary objectives, since they facilitate representing, learning about, and transforming knowledge to resolve the consequences that exist at a given boundary. Other researchers argue that firms need to invest in developing the necessary knowledge and skills of their employees (e.g., Kogut and Zander 1992; Leonard-Barton 1995; Nonaka and Takeuchi 1995).

Building on these ideas, I argue that another way to solve the knowledge integration problem is to manage employees to have cross-functional perspective-taking capability. Perspective-taking has been suggested to facilitate knowledge integration (Boland and Tenkasi 1995). Without an understanding of what others' viewpoints entail and an appreciation for their differences, perspective-taking is not possible (Hogan 1969; Hollin 1994; Smith 2006).

The innovative system of practices helps employees achieve the perspective-taking capability needed for efficiency. The ability of individuals to take the viewpoints of others can be acquired through direct experience in job rotation. Norhia and Ghoshal (1997), for example, suggests that in large established multinational companies managers who have been rotated to different subsidiaries as part of their career development gained knowledge about the perspectives of other subsidiaries facilitating knowledge integration across them. Parker and Axtell (2001) also found that perspective-taking capability between the internal suppliers and the internal customers is enhanced when the internal customers have experienced doing the work of the internal suppliers. By mandating that individuals work in other functions as part of the job rotation, they acquire knowledge about the perspectives of the people working in other functions, enabling perspective-taking. When individuals from a certain function have performed the work of people in other functions, they are more likely to be able to take the perspectives of those individuals and integrate knowledge efficiently, since cooperation is enhanced and miscommunication is reduced (Boland and Tenkasi 1995; Parker and Axtell 2001). In their study of knowledge creation for product innovation in large established firms such as Nissan and Kao, Nonaka and Takeuchi (1995) found that individuals who have experience working in other functional areas were able to take the viewpoints of others in integrating knowledge. As a result, innovation projects in these firms were usually completed efficiently using a reduced amount of resources. This finding is consistent with those of Womack et al (1989), who found that established Japanese auto firms use fewer engineering hours than U.S. firms to make comparable products. The use of cross-functional team-based job design, as found in the NUMMI plant (Adler et al, 1999) also supports efficiency. Employees become accustomed to working in teams that include employees with different perspectives. Such routines help integrate knowledge efficiently (e.g.,

Kogut and Zander 1992; Teece et al 1997; Zollo and Winter 2002). When individuals have prior experience working together their work proceeds more smoothly, since they are familiar with each others' perspectives. The ability to adopt the viewpoints of those with whom they must integrate knowledge eases knowledge integration, thereby enabling them to complete the project using a reduced amount of resources. Cross-functional team-based compensation reinforces perspective-taking, since employees need to learn about each others' perspectives in order to accomplish the task and be rewarded for it.

Therefore, building on these ideas I propose that:

Proposition 1b. The innovative system of human resource management practices helps employees develop the perspective-taking capability that facilitates exploitation.

Traditional System

In contrast to the innovative system, the traditional system includes an individual-based incentive system, individual-based job design, and no job rotation. An individual-based incentive system refers to individuals being rewarded based on their individual performance. Individual-based job design refers to tasks that are specifically designed for employees to perform individually. No job rotation exists when individuals are expected to perform the same narrowly defined tasks repeatedly within the same function. This system is referred to as traditional because it has been used since the 1960s by many U.S. firms (see Ichniowski and Shaw 2003 and Osterman 2006 for reviews).

The traditional system of practices limits exploration by not creating the psychological safety needed for individuals to explore and experiment with new ideas, which is necessary for making novel products. When employees feel threatened they become risk averse. The more risk averse they are, the less likely they are to experiment with different ideas (Amabile et al 1996; Schein 1992). Schein (1992) argues that, in organizations where individuals feel fearful of speaking up because they are afraid of being punished, embarrassed or rejected, employees are less likely to extend themselves beyond expectations. Lee et al. (2004) also found that individuals that are under higher evaluative pressure tend to be more risk averse, and individual-based incentive system creates this type of pressure. Individual-based job design, when reinforced by individual-based reward, makes individuals bear all the risk and they are therefore less likely to explore and experiment with new ideas. Womack et al. (1989) also found that in established U.S. auto firms where employees tend to be evaluated and rewarded for individual performance, individuals tend to focus primarily on how they are being evaluated individually and the type of reward they will receive for their individual performance. In such firms, individuals may be punished if new ideas fail; therefore, they will not experiment (Schein 1992). Individuals tend to behave consistently with the rewards they receive (e.g., Kerr, 1975; Osterman, 2006; Vroom, 1964); thus, if they are not rewarded for exploring they will not be accustomed to doing so and will not do so, since it does not constitute part of their work routines. Therefore, when experimentation with new knowledge is necessary, as in the case of making distinct products, employees will not be able to do so effectively. For example, in their analyses of established firms in various industries, Dougherty and Hardy (1996) found that when individuals are not accustomed to seeking out new knowledge and integrating it with existing knowledge in other functional areas for product innovation, the innovation often fails. Dougherty and Heller (1994) also found that established firms that were less successful at innovation were ones where employees had difficulty integrating knowledge and struggled to make changes to their work routines to support innovation. These tend to be firms where employees are not managed to have cross-functional knowledge and their incentive practices do not support innovation. The lack of cross-functional job rotation also restricts employees' acquisition of knowledge about other functional areas, limiting trust between them. Without trust there is no psychological safety (Edmonson, 1999).

In sum, I propose that:

Proposition 2a. The traditional system of human resource management practices limits the development of psychological safety and thus restricts exploration.

The traditional system of practices also limits exploitation, since it does not provide employees with the ability to take the perspective of the people working in other functions. By not providing cross-functional job rotation, people are not managed to have the necessary knowledge and skills about the viewpoint of people in other functions, which is the basis for the ability to take the perspectives of employees in other functions. Without this ability, cross-functional knowledge integration is difficult to achieve, since miscommunication and misunderstanding will occur (Boland and Tenkasi 1995). The resultant difficulty in knowledge integration leads firms to delay the launching of new products. In the process, they use more resources than necessary to complete their projects (Adler et al. 1999; Liker and Sobek 1996; Roth and Kleiner 1996). For example, in their analysis of established automobile firms, Liker and Sobek (1996) showed that, not only are established U.S. auto firms less competitive in product design, but they are also inefficient in terms of the quantity of resources used to generate their products. Without

perspective-taking capability conflicts occur, and people are required to have more meetings and to use more resources. For example, they may need other individuals (e.g., high-level managers or external experts) to intervene to assist them in adopting each others' viewpoints in order to complete the tasks (Roth and Kleiner 1996). The use of individual-based job design to perform daily tasks also limits exploitation, since individuals are not accustomed to working together to integrate knowledge. Therefore, when integrating knowledge for product innovation they cannot immediately do so efficiently. They must first learn about each others' viewpoints and agree on how to accomplish the task together. Due to their taking the time to learn about each others' perspectives, task completion is delayed (Roth and Kleiner, 1996). Individual-based incentive system also reinforces individual work as individuals tend to undertake behaviors that are rewarded (Katz and Allen 1985) rather than making the effort to learn about the perspectives of others and integrate knowledge. Womack et al (1989) found that established U.S. auto firms that tend to use the individual-based incentive system and individual-based job design, and that provide no cross-functional job rotation to employees spend more engineering hours to make a product comparable to those of their Japanese and European competitors. Without perspective-taking capability, knowledge integration for product innovation will occur inefficiently, meaning that the firm will use more resources than necessary to perform these tasks.

Therefore, these ideas support the proposition that: *Proposition 2b. The traditional system of human resource management practices restricts the development of perspective-taking capability, thereby limiting exploitation.*

Using Both Systems

Ichniowski et al (1997) and Osterman (2006) found that some firms use a mix of innovative and traditional practices. Among those firms that use a mix of practices, some use only certain practices from each system, which I will refer to as a *partial mix* of practices. Other firms use all of the practices from both systems, which I will call a *complete mix* of practices.

The result is a ranking of practices in their expected impact on exploration and exploitation. First, I propose that firms that use only the innovative system of practices will achieve the highest exploration and exploitation as the employees will have the necessary psychological safety and perspective-taking capability. Second, firms that use the complete mix of practices will achieve lower exploration and lower exploitation that the firms that only use the innovative system. Practices within each system reinforce each other to provide the psychological safety and perspective-taking capability. However, the two systems of practices can come into conflict with each other[2]. They can create inconsistent expectations on the individuals reducing the psychological safety and perspective-taking capability thereby reducing exploration and exploitation. Third, firms that use the partial mix of practices will likely achieve even lower exploration and exploitation than firms that use only the innovative system of practices or the complete mix. With fewer innovative practices reinforcing each other to develop the psychological safety and perspective-taking capability, these factors are reduced. In addition, there is potential conflict between the innovative and traditional practices creating inconsistent expectations on the individuals. Fourth, firms that only use the traditional practices will achieve the lowest exploration and exploitation as employees will lack both the psychology safety and perspective-taking capability. Before I explained how using innovative and traditional systems lead to high and low exploration and exploitation respectively. I now discuss how the mixed system leads to relatively different exploration and exploitation.

Inconsistent expectations on the individuals can reduce psychological safety and minimize experimentation (Lee et al. 2004: 313). Inconsistent policies make the rules ambiguous and unpredictable. The uncertainty about whether one will be punished individually creates the feeling of fear. Confronting the need to simultaneously serve contradictory expectations by the firm itself may create anxiety, lowering psychological safety. Inconsistent messages put people in a dilemma (Schein 1992) because they communicate two incompatible goals. Facing this tension, people feel afraid and anxious, making action and inaction equally unpleasant alternatives (Schein 1992). Inconsistency has been shown to create cognitive and emotional responses such as suspicion, mistrust and confusion, leading to "threat rigidity", a tendency towards risk aversion, behavior inhibition, avoidance, lack of openness, and an inability to try novel ideas (e.g., Lee et al. 2004; Staw et al. 1981).

Using both systems simultaneously can create inconsistencies that limit exploration. Team-based job design, which helps provide psychological safety, is inconsistent with individual-based reward because this

[2] Not all practices in the innovative and traditional systems will generate inconsistencies. For example, cross functional rotation of the innovative system will not generate inconsistencies with its counterpart in the traditional system because the traditional system does not call for any kind of rotation. However, the individual and team-based reward and the individual and team-based job designs will create inconsistencies as each places emphasis on opposite behaviors.

reward system expects individuals to act individually, in a manner that is inconsistent with team-work. These inconsistent expectations, team-work and individual performance, create ambiguity for people, affecting their willingness to explore and experiment with new ideas. Even if reward is based on individual and team performance, the inconsistency arises when the former is given higher importance or larger than the latter. Individuals will focus on individual rather than team performance, thereby making team-based incentive practice less attractive from the viewpoint of the employees; however, they still feel that they should pay attention to team-work. Given that the individual-based incentive is higher than the team-based, individuals will focus on that and will perceive higher evaluative pressure; they will therefore be reluctant to explore and experiment with new knowledge. Similarly, if job design is based on both individual and team concepts, depending on which one has a higher payoff, individuals will focus on one over the other and this will affect their level of perceived risk and exploration. The more risk averse the individual is, the less likely that he/she will experiment with new ideas useful for making novel products. However, at the same time, the individual feels it necessary to pay attention to team-work (Schein 1992). Even if the payoffs from both individual and team-based rewards are similar, employees will face a dilemma about which action to choose because they have limited resources, particularly in terms of time and effort (Lee et al. 2004). If job rotation is used this would be inconsistent with individual-based reward and individual-based job design. These practices reinforce each other to limit the development of psychological safety while job rotation helps create it. This tension creates stress on the individuals, reducing psychological safety and thereby rendering them less likely to explore and experiment with different ideas.

For the above reasons, firms that use only the innovative system of practices are likely to achieve the highest exploration. This is followed by firms that use both systems of practices simultaneously. They achieve exploration, because the practices within the innovative system can reinforce each other to develop the necessary psychological safety. However, these practices will come into conflict with practices in the traditional system creating inconsistent expectations on the individuals. The inconsistency partially limits psychological safety thereby reducing exploration. Moreover, firms that use the partial mix of practices will perform even less well in exploration than firms that use only the innovative system of practices and those that use a complete mix of the two systems. By using fewer innovative practices reinforcement between practices to develop the psychological safety is more limited. In addition, practices from the two systems can further come into conflict creating incompatible expectations on the individuals thereby reducing psychological safety. However, these firms will still achieve higher exploration than firms that use only the traditional system of practices as such firms will have the least psychological safety and therefore lowest exploitation.

Therefore, summarizing these arguments I propose the following ranking:

Proposition 3a. Firms that use only the innovative system of practices will achieve higher exploration than firms using a complete mix of practices. Firms that use the complete mix of practices will achieve higher exploration than firms that use a partial mix of practices. Firms that use a partial mix of practices will achieve higher exploration than firms that use only the traditional system of practices.

Combining practices from both systems can also result in lower exploitation than using only the innovative system, because the mix of practices can put inconsistent demands on employees. The innovative practices in the model reinforce each other to enhance perspective-taking capability to integrate knowledge efficiently. For example, job rotation that enables perspective-taking capability is inconsistent with traditional reward, where individuals are induced to focus mainly on individual performance and are under evaluative pressure to maximize their performance. Similarly, team-based reward places inconsistent expectations on individuals when individual-based reward is also used. Team-based reward, which encourages individuals to cooperate and learn about each others' viewpoints in performing tasks, is undermined by individual-based reward, which encourages employees to focus primarily on their own performance. Depending on the difference between the two types of reward, individuals will work hard to accomplish one over the other (Andreoni, Harbaugh, and Vestterlund 2003; Kerr 1975). Dougherty and Hardy (1996), for example, show how in the process of product innovation, when individuals were organized in to teams to work together to develop new products, in firms where reward is based on individual performance, it was difficult to get team members to work on the projects. At the same time, it was difficult to get support from various departments to complete the projects, since they also had no incentive to give such support. The inconsistency here is that, on the one hand, the formation of teams to work on the projects is intended to encourage individuals to learn about each others' perspectives and integrate knowledge to complete them. On the other hand, individual-based reward does not encourage that. As a result, many of the innovations they studied failed. In the process, these projects use more resources than expected. Similarly, in

their study Roth and Kleiner (1996) found that, because individuals were rewarded for their individual performance when working in a team to develop a new product, instead of learning about each others' perspectives and try to integrate knowledge, individual members had an agenda that was inconsistent with the agenda of the team. The inconsistency led to conflicts. As a result, the project was delayed and external experts had to be hired to help team members understand each other's perspectives in order to integrate knowledge to complete the project.

For the above reasons, firms will differ in how well they achieve exploitation. Firms that only use the innovative system of practices are likely to achieve the highest exploitation as their employees will have the highest perspective-taking capability. Firms that use a complete mix of practices will also achieve relative high exploitation as the practices within the innovative system will reinforce each other to develop the perspective-taking capability. However, by using both systems of practices simultaneously, there could be conflict between practices across the two systems generating incompatible demands on employees. This inconsistency can result in reduced perspective-taking capability. Firms that use the partial mix of practices are likely to achieve lower exploitation than firms that use only the innovative system of practices and lower than firms that use both systems of practices. When using partial mix, reinforcement between innovative practices is lower as there are fewer practices to reinforce each other for the development of perspective-taking capability. In addition, there is also potential conflict between the innovative and traditional practices reducing perspective-taking capability further. Finally, firms that use only the traditional system of practices are likely to achieve the lowest exploitation. Employees in these firms will lack perspective-taking capability, as I discussed before.

Therefore, based on these ideas I argue for the following ranking:

Proposition 3b. Firms that use only the innovative system of practices will achieve higher exploitation than firms using a complete mix of practices. Firms that use the complete mix of practices will achieve higher exploitation than firms that use a partial mix of practices. Firms that use a partial mix of practices will achieve higher exploitation than firms that use only the traditional system of practices.

CONCLUSIONS

Researchers have generally agreed that firms need to pursue both exploration and exploitation; however, how firms accomplish this is not well understood (Smith et al. 2006). I present a framework for managing employees to achieve exploration and exploitation simultaneously. Specifically, I argue that the innovative system of human resource management practices enables the firm to achieve exploration and exploitation simultaneously. The practices in the system reinforce each other to provide both the psychological safety needed for exploration and the perspective-taking capability needed for exploitation. The traditional system of human resource management practices has limited effectiveness in exploration or exploitation. It does not provide the psychological safety for people to explore new knowledge, nor does it aid in perspective-taking that supports efficiency. Firms that combine practices from both systems are less innovative and efficient than firms that use the innovative system, since these practices put inconsistent expectations on the individuals, reducing psychological safety and limiting perspective-taking capability. However, firms that use a mix of practices are still more innovative and efficient than firms using the traditional system, as some elements that support innovation and efficiency are provided.

This paper sets the base for future research, which can build on the ideas discussed here. First, the paper focused on large established firms, which tend to have more difficulty achieving exploration and exploitation, but which need to obtain both. Future research can explore how the processes that enable the achievement of both differ in small firms. Second, I discussed the use of the innovative system on all employees of the firm, under the view that knowledge is dispersed across individuals. Future research can explore whether this assumption can be relaxed and the practices applied only to certain employees in the firm. Third, the paper provided a theoretical framework. This can be empirically tested and extended in future research through the specification of additional boundary conditions. Fourth, I focused on benefits of the various human resource management systems in terms of exploration and exploitation. Future research can extend the discussion to analyze the costs of implementing each human resource management system, especially the cost of changing from one system to another.

The current paper makes several important contributions to the literature. First, to the organizational learning literature and the stream that discusses exploration and exploitation (e.g., Benner and Tushman 2003; Burgelman 2002; Danneels 2002; He and Wong 2004; Holmqvist 2004; March 1991, 1996, 2006; Smith et al. 2006), I provide a framework for how firms can manage employees to achieve exploration and exploitation simultaneously. I take a different route than that proposed in ambidexterity, punctuated equilibrium, or specialization, and instead focus on employee management within the firm. I discuss the practices that can support exploration

and exploitation by enabling the mediating mechanisms of psychological safety and perspective-taking capability. Second, the paper contributes to the literature on human resource management (e.g., Gant et al. 2002; Ichniowski 1997; MacDuffie 1995; Osterman 2006) by discussing how the innovative system of human resource management practices can be applied to all employees of the firm cross-functionally, rather than only to production workers, in order to enable firms to achieve efficiency and innovation simultaneously.

The framework presented has implications for practice. Managers of established firms competing on innovation and price need to have their firms undertake both exploration and exploitation. I explain how using the innovative system of practices may help the firm achieve both simultaneously. I discussed the mediating mechanisms that connect human resource management practices to the exploration and exploitation outcomes desired by managers of large established firms. I also explained how mixing practices from the two systems may not be appropriate because of the inconsistencies created.

REFERENCES

Adler, Paul S., Barbara Goldoftas and David I. Levine. (1999). Flexibility versus efficiency? A case study of model changeovers in the Toyota production system. *Organization Science* 10: 43-68.

Afuah, Allan. (2000). How much do your co-opetitors' capabilities matter in the face of technological change? *Strategic Management Journal* 21: 387-405.

Amabile, Teresa M., Regina Conti, Heather Coon, Jeffrey Lazenby, and Michael Herron. (1996). Assessing the work environment for creativity. *Academy of Management Journal* 39: 1154-85.

Andreoni, James, William Harbaugh, and Lise Vestterlund. (2003). The carrot or the stick: Rewards, punishments, and cooperation. *American Economic Review* 93: 893-1003.

Bartel, Ann, Casey Ichniowski, and Kathryn Shaw. (2004). Using "Insider Econometrics" to Study Productivity. *American Economic Review* 94: 217-223.

Bass, Bernard M. (1985). *Leadership and performance beyond expectations*. New York: Free Press.

Bass, Bernard M., and Paul Steidlmeier. (1998). Ethics, moral character and authentic transformational leadership. http://cls.binghamton.edu/BassSteid.html.

Becker, Brian, and Barry Gerhart. (1996). The impact of human resource management on organizational performance: Progress and prospects. *Academy of Management Journal* 39: 779-802.

Bechky, Beth A. (2003). Sharing Meaning Across Occupational Communities: The Transformation of Understanding on a Production Floor. *Organization Science* 14:312-330.

Benner, Mary J., and Michael L. Tushman. (2002). Process management and technological innovation: A longitudinal study of the photography and paint industries. *Administrative Science Quarterly* 47: 676-706.

Benner Mary J., and Michael L. Tushman. (2003). Exploitation, exploration, and process management: The productivity dilemma revisited. *Academy of Management Review* 28: 238-256.

Boland, Richard J., and Ramkrishnan V. Tenkasi. (1995). Perspective-making and perspective-taking in communities of knowing. *Organization Science* 6: 350-373.

Burgelman, Robert. (1991). Interorganizational ecology of strategy makign and organizational adaptation : Theory and field research. *Organization Science* 2: 239-263.

Burgelman, Robert. (2002). Strategy as vector and the inertia of coevolutionary lock-in. *Administrative Science Quarterly* 47:325-358.

Burns, James M. (1978). *Leadership*. New York: Harper & Row.

Carlile, Paul R. (2004). Transferring, translating, and transforming: An integrative framework for managing knowledge across boundaries. *Organization Science* 15: 555-568.

Daneels, Erwin. (2002). The dynamics of product innovation and firm competences. *Strategic Management Journal* 23: 1095-1122.

Dougherty, Deborah. (1992). Interpretative barriers to successful product innovation in established firms. *Organization Science* 3: 179-202.

Dougherty, Deborah, and Cynthia Hardy. (1996). Sustained product innovation in large, mature organizations: Overcoming innovation-to-organization problems. *Academy of Management Journal* 39: 1120-1152.

Dougherty, Deborah, and Trudy Heller. (1994). The illegitimacy of successful product innovation in established firms. *Organization Science* 5: 200-218.

Dyer, Jeffrey H., and Kentaro Nobeoka. (2000). Creating and managing a high-performance knowledge-sharing network: The Toyota case. *Strategic Management Journal* 21: 345-368.

Edmondson, Amy C. (1999). Psychological Safety and Learning Behavior in Work Teams. *Administrative Science Quarterly* 44: 350-383.

Edmondson, Amy C. (2002). The Local and Variegated Nature of Learning in Organizations: A Group-Level Perspective. *Organization Science* 13: 128-146.

Eisenhardt, Kathleen M. and Jeffrey A. Martin. (2000). Dynamic capabilities: What are they? *Strategic Management Journal* 21:1105-1122.

Eisenhardt, Kathleen M. and Behnam Tabrizi. (1995). Accelerating adaptive processes: Product innovation in the global computer industry. *Administrative Science Quarterly* 40: 84-110.

Gant, Jon, Casey Ichniowski, and Kathryn Shaw. (2002). Social capital and organizational change in high-involvement and traditional work organizations. *Journal of Economics & Management Strategy* 11: 289-328.

Griffin, Abbie and John R. Hauser. (1993). The voice of the customer. *Marketing Science* 12: 1-27.

Henderson, Rebecca M. and Kim B. Clark. (1990). Architectural Innovation: The Reconfiguration of Existing Product Technologies and the Failure of Established Firms. *Administrative Science Quarterly* 35: 9-30.

He, Zi-Lin, and Poh-Kam Wong. (2004). Exploration vs. exploitation: An empirical test of the ambidexterity hypothesis. *Organization Science* 15: 481-494.

Hogan, R. (1969). Development of an empathy scale. *Journal of Counseling and Clinical Psychology* 33: 307-316.

Hollin, C. (1994). Forensic (criminological) psychology. In A. Colman (Ed.), Companion encyclopedia of psychology (pp. 1231-1253). London: Routledge.

Holmqvist, Mikael. (2003). A dynamic model of intra-and-interorganizational learning. *Organization Studies* 24:95-123.

Holmqvist, Mikael. (2004). Experiential learning processes of exploitation and exploration within and between organizations: An empirical study of product development. *Organization Science* 15: 70-81.

Huselid, Mark A., and Brian E. Becker. (1996). Methodological issues in cross-sectional and panel estimates of the human resource-firm performance. *Industrial Relations* 35: 400-423.

Ichniowski, Casey, and Katherine Shaw. (2003). Beyond incentive pay: Insiders' estimates of the value of complementary human resource management practices. *Journal of Economic Perspectives* 17: 155-180.

Ichniowski, Casey, Katherine Shaw, and Giovanna Prennushi. (1997). The effects of human resource management practices on productivity: A study of steel finishing lines. *American Economic Review* 87: 291-313.

Katila, Riitta and Gautam Ahuja. (2002). Something old, something new: A longitudinal study of search behavior and new product introduction. *Academy of Management Journal* 45:1183-1194.

Katz, Ralph and Thomas Allen. (1985). Project performance and the locus of influence in the R&D matrix. *Academy of Management Journal* 28: 67-87.

Kerr, Steven. (1975). On the folly of rewarding A, while hoping for B. *Academy of Management Journal* 18: 769-783.

Kogut, Bruce, and Udo Zander. (1992). Knowledge of the firm, combinative capabilities, and the replication of technology. *Organization Science* 3: 383-397.

Kogut, Bruce, and Udo Zander. (1996). What firms do? Coordination, identity, and learning. *Organization Science* 7: 502-518.

Lawrence, Paul R. and Jay W. Lorsch. (1967). *Organization and Environment: Managing Differentiation and Integration*. Boston: Harvard University.

Lee, Fiona, Amy C. Edmondson, Stefan Thomke, and Monica Worline. (2004). The Mixed Effects of Inconsistency on Experimentation in Organizations. *Organization Science* 15: 310-326.

Leonard-Barton, Dorothy. (1992). The factory as a learning laboratory. *Sloan Management Review* 34: 23-38.

Leonard-Barton, Dorothy. (1995). *Wellsprings of Knowledge*. Boston: Harvard Business School Press.

Levinthal, Daniel and James G. March. (1993). The dynamic myopia of learning. *Strategic Management Journal* 14: 95-112.

Liker, Jeffrey K. and Durward Sobek. (1996). Involving suppliers in product development in the United States and Japan. *IEEE Transactions on Engineering Management* 43:165-179.

MacDuffie, Jean Paul. (1995). Human resource bundles and manufacturing performance: Organizational logic and flexible production systems in the world auto industry. *Industrial and Labor Relations Review* 48: 197-221.

Madhaven, Ravindranath, and Rajiv Grover. (1998). From embedded knowledge to embodied knowledge: New product development as knowledge management. *Journal of Marketing* 62: 1-12.

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

March, James G. (1996). Continuity and change in theories of organizational action. *Administrative Science Quarterly* 41: 278-287.

March, James G. (2006). Rationality, foolishness, and adaptive intelligence. *Strategic Management Journal* 27: 201-214.

McNamara, Peter, and Charles Baden-Fuller. (1999). Lessons from the Celltech case: Balancing knowledge exploration and exploitation in organizational renewal. *British Journal of Management* 10: 291-307.

Miller, Kent D., Meng Zhao, and Roger J. Calantone. (2006). Additional interpersonal learning and tacit knowledge to March's exploration-exploitation model. *Academy of Management Journal* 4:709-722.

Nonaka, Ikujiro, and Hirotaka Takeuchi. (1995). *The Knowledge-Creating Company: How Japanese Create the Dynamics of Innovation.* Oxford: Oxford University Press.

Osterman, Paul. (2006). The wage effects of high performance work organization in manufacturing. *Industrial and Labor Relations Review* 59: 187-204.

Parker, Sharon K., and Carolyn M. Axtell. (2001). Seeing another viewpoint: Antecedents and outcomes of employee perspective taking. *Academy of Management Journal* 44: 1085-1100.

Pisano, Gary P. (1994). Knowledge, integration, and the locus of learning: An empirical analysis of process development. *Strategic Management Journal* 15: 85-100.

Postrel, Steven. (2002). Islands of shared knowledge: Specialization and mutual understanding in problem-solving teams. *Organization Science* 13: 303-320.

Roberts, Edward. (1988). Managing invention and innovation: What we've learned. *Research-Technology Management* 31: 11-29.

Roth, George and Art Kleiner. (1996). The Learning initiative at the Auto Company Epsilon Program. Working paper 18.005, Organizational Learning Center, Massachusetts Institute of Technology, Cambridge, MA.

Schein, Edgar H. (1992). *Organizational culture and leadership*. San Francisco: Jossey-Bass.

Schein, Edgar H. (1996). Three cultures of management: The key to organizational learning. *Sloan Management Review* 38: 9-20.

Selden, Larry and Ian MacMillan. (2006). Manage customer-centric innovation--systematically. *Harvard Business Review* 84: 108-116.

Siggelkow, Nicolaj and Jan W. Rivkin. (2006). When exploration backfires: Unintended consequences of multilevel organizational search. *Academy of Management Journal* 49:779-795.

Smirnov, Vladimir and Andrew Wait. (2004). Hold-up and sequential specific investments. *RAND Journal of Economics* 35: 386-400.

Smith, Adam. (2006). Cognitive empathy and emotional empathy in human behavior and evolution. *Psychological Record* 56: 3-21.

Smith, Ken G., Anil K. Gupta, and Christina Shalley. (2006). The interplay between exploration and exploitation. *Academy of Management Journal* 49: 693-706.

Staw, Barry M., Lance E. Sandelands, and Jane E. Dutton. (1981). Threat-rigidity effects in organizational behavior: A multilevel analysis. *Administrative Science Quarterly* 26: 501-24.

Swan, Jacky A. and Sue Newell. (1995). The role of professional associations in technology diffusion. *Organization Studies* 16: 847-75.

Swan, Jacky A. and Sue Newell. (1999). Central agencies in the diffusion and design of technology: A comparison of the UK and Sweden. *Organization Studies* 20: 905-931.

Takeishi, Akira. (2002). Knowledge partitioning in the interfirm division of labor: The case of automotive product development. *Organization Science* 3: 321-338.

Taylor, Alva and Henrich R. Greve. (2006). Superman or the fantastic four? Knowledge combination and experience in innovative teams. *Academy of Management Journal* 4: 723-740.

Teece, David J., Gary Pisano, and Amy Shuen. (1997). Dynamic capabilities and strategic management. *Strategic Management Journal* 18: 509-533.

Tjosvold, Dean, Zi-you Yu, and Chun Hui. (2004). Team Learning from Mistakes: The Contribution of Cooperative Goals and Problem-Solving. *Journal of Management Studies* 41: 1223-1245.

Tsoukas, Haridimous. (1996). The firm as a distributed knowledge system: A constructionist approach. *Strategic Management Journal* 17: 11-25.

Tushman, Michael L., and Charles A. O'Reilly. (1996). Ambidextrous organizations: Managing evolutionary and revolutionary change. *California Management Review* 38: 8-31.

Un, C. Annique, and Alvaro Cuervo-Cazurra. 2004. Strategies for knowledge creation in firms. *British Journal of Management*, 15 (March): 27-41.

Un, C. Annique, and Alvaro Cuervo-Cazurra. 2005. Top managers and the product improvement process. *Advances in Strategic Management*, 22: 319-348.

Un, C. Annique, and Alvaro Cuervo-Cazurra. 2007. Interactions with customers for innovation. In Laura A. Costanzo and R. Bradley MacKay (eds.) *Handbook of Research on Foresight and Strategy*. Northampton, MA: Edward Elgar. (Forthcoming)

Verona, Gianmario, Emanuela, Prandelli, and Mohanbir Sawhney. (2006). Innovation and virtual environments: Towards virtual knowledge brokers. *Organization Studies* 27: 755-788.

Von Hippel, Eric. (1988). *The Sources of Innovation*. Cambridge, MA: MIT Press.

Vroom, Victor H. (1964). *Work and Motivation*. New York: John Wiley.

Womack, James P., Daniel T. Jones, and Daniel Roos. (1990). *The machine that changed the world: The story of lean production*. New York: NY, Harper Perenial.

Winter, Sidney G. (1987). Knowledge and competence as strategic assets, in *The Competitive challenge -- Strategies for industrial innovation and renewal*, edited by David J. Teece. Cambridge, Mass.: Ballinger Publishing Co.

Zollo, Maurizio, and Sidney G. Winter. (2002). Deliberate learning and the evolution of dynamic capabilities. *Organization Science* 13: 339-351.