

Working Paper SERIES

December 02, 2007

Wp# 0027MGT-199-2007

KNOWLEDGE RESOURCES, EXPLORATION, AND EXPLOITATION: A NEW PERSPECTIVE ON THE INTERPLAY BETWEEN INNOVATION AND APPLICATION

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An earlier version of this paper was presented at the National Academy of Management meetings, August 2005, Honolulu, HI

The first author would like to acknowledge summer research support from the College of Business, University of Texas at San Antonio during the preparation of this manuscript.

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Abstract

Knowledge resources are the fundamental ingredients used in exploration and exploitation and an overlooked source of distinction and tension between these two processes. In this paper we use a strategic lens to differentiate evidence-based knowledge resources from tinkerable knowledge resources. This conceptualization provides the basis for a bridge between the literature on the resource-based view of the firm and research into exploration and exploitation. We suggest that an examination of knowledge resources offers a new perspective for understanding exploration and exploitation, and suggests new opportunities for achieving organizational ambidexterity. A proposed model indicates the application consequences of match and mismatch across knowledge resources and knowledge flow activities in terms of exploration and exploitation. An agenda for future research is proposed along with steps that managers can take to develop exploration and exploitation capabilities in their firms by managing their knowledge resources more precisely and effectively.

Key Words: knowledge resources, exploration, exploitation, knowledge management

JEL Code: M190

A firm's capacity for exploitation (application of established competencies to problems characterized by productivity, efficiency, refinement, and other variation-reducing processes) and exploration (creation of novel, often unconventional ideas characterized by discovery, experimentation, innovation, search, risk taking and other variation-increasing processes) has been tied to organizational adaptability (O'Reilly & Tushman, 2004; Szulanski & Jensen, 2006; Tushman & O'Reilly, 1996), organizational learning (March, 1991), sustained strategic success (Beinhocker, 1999) and a number of other crucial measures of organizational performance (He & Wong, 2004; Tunisini & Zanfei, 1998; Winter & Szulanski, 2001). Tension between exploration and exploitation and subsequent organizational choices to emphasize one over the other has been explained in terms of organizational aspirations and targets for performance (Kahneman & Tversky, 1979; March, 1991; Simon, 1991), pressures toward inertia versus change (Hannan & Freeman, 1984), contradictory competencies and functional requirements (Burns & Stalker, 1961), levels of organizational turnover (March, 1991), rates at which individuals and organizations learn (Herriott, Levinthal, & March, 1985), degrees of environmental turbulence (March, 1991), and the nature of competition (March, 1991). There is, however, wide-spread agreement both processes are necessary for a firm to thrive in the long term (D'Aveni, 1994; Gupta, Smith, & Shalley, 2006; Levinthal & March, 1993; March, 1991).

One way to achieve both outcomes is through a punctuated equilibrium cycle that trades off one process against the other over time (Burgelman, 2002; Gersick, 1991; Romanelli & Tushman, 1994; Siggelkow & Rivkin, 2006). However, recent studies have argued that organizational ambidexterity, in which both exploration and exploitation receive simultaneous attention and investment, is a more successful balancing strategy (Benner & Tushman, 2003; He & Wong, 2004; Knott, 2002; Levinthal & March, 1993; Tushman & O'Reilly, 1996). An

ambidextrous approach is argued to facilitate innovation, absorptive capacity, and the development of dynamic capabilities (Ancona, Goodman, Lawrence, & Tushman, 2001; Eisenhardt & Martin, 2000; He & Wong, 2004; Katila & Ahuja, 2002). Knowledge resources are the basic ingredients that exploitation and exploration activities rely upon, transform, and apply. We contend that a better understanding of how a firm defines and acts upon its knowledge resources is a useful step toward achieving a desirable blend of exploration and exploitation and may be an important antecedent of organizational ambidexterity.

Knowledge resources are an overlooked source of distinction and tension between exploration and exploitation. The conceptualization presented in this paper departs from familiar approaches to categorizing knowledge; therefore we begin with a discussion of knowledge as a strategic resource and distinguish between evidence-based knowledge resources and tinkerable knowledge resources. We believe an important contribution of this paper is a way to differentiate distinct types of knowledge that contribute to specific strategic purposes from a resource-based perspective. This conceptualization is the basis for a new bridge between the literature on the resource-based view of the firm and research into exploration and exploitation processes.

Our discussion of knowledge as a strategic resource is followed by an examination of different mechanisms for transferring knowledge resources among individuals, groups and organizations. Existing literature is unclear about particular actions that move knowledge effectively to achieve specific outcomes (Lengnick-Hall & Griffith, 2005). This section of the paper relies on exploration and exploitation to provide a basis for sorting through inconsistent, and often conflicting, prescriptions for knowledge flow. An approach that ties knowledge resource differences to knowledge flow activities is proposed.

Third, we build upon the connections between knowledge resource types and knowledge flow alternatives to explain why different performance outcomes can be expected. This section of the paper provides additional support for the view that simultaneous exploration and exploitation, rather than punctuated equilibrium, is most likely to result in sustained superior performance.

The final section of the paper discusses the implications of this perspective for further research and practice. We explain how a knowledge resource based view provides new answers to prevailing questions regarding the ambidexterity hypothesis and suggest actions that managers might take to enhance their firm's knowledge management and their exploration and exploitation processes.

DEFINING KNOWLEDGE AS A STRATEGIC RESOURCE

An explosion of research publications, books, consulting services, and articles in the business press demonstrate the importance of knowledge as a pivotal organizational resource. However, possessing knowledge is not enough. In order to be strategically useful any crucial resource must be managed and must be effectively bundled and leveraged with other resources (Barney & Arikan, 2001). British Petroleum (BP), for example, one of the world's largest oil and gas companies, traces the source of its success not to the knowledge it possesses but to how it manages that knowledge (Collison & Parcell, 2001). A firm's ability to acquire, create, transmit, and use knowledge effectively is recognized as a key factor determining organization success or failure (Alavi & Leidner, 2001; Davenport & Prusak, 1998; Grant, 1996; Nonaka, 1994).

A number of related research streams contribute to our understanding of what knowledge is and how it can be nurtured and used within organizations. Some of the earliest research examined the basic nature of knowledge in an effort to identify and define various forms of

knowledge (Kogut & Zander, 1992, 1995, 1996; Nonaka, 1994; Polanyi, 1967; Schank & Abelson, 1977; Teece, 1981). Another body of work examines how knowledge is acquired and created (Nonaka, 1994; Nonaka & Takeuchi, 1995). This literature blends ideas from diverse fields to increase our understanding of knowledge generation and related organizational capabilities such as absorptive capacity (Cohen & Levinthal, 1990), intellectual capital formation (Winter, 1987), and creativity (Amabile, 1988). The strategy field has elaborated on the resource based view of the firm (Barney, 1991) to propose a knowledge-based perspective that sees knowledge management as an essential part of creating competitive advantage (Grant, 1996; Gupta & Govindarajan, 1991; Gupta et al., 2006; Szulanski, 1996). Research on learning organizations, decision making, cognitive processes, social capital, and many other arenas contribute to our understanding of how knowledge is obtained and used by organizations (Crossan, Lane, & White, 1999; Garvin, 1993; Tsai & Ghoshal, 1998; Van den Bosch, Volberda, & de Boer, 1999; Winter, 1987; Winter & Szulanski, 2001; Zander & Kogut, 1995).

A common thread throughout much of this literature is an examination of knowledge through philosophical (Polanyi, 1967) or epistemological (Nonaka & Takeuchi, 1995) lenses. In other words, the conceptual anchor for most of the existing research is a ‘tacit versus explicit’ or a ‘codified versus non-codified’ perspective on what knowledge is. Therefore knowledge is classified according to whether it is personal, context-specific, and rooted in actions and routines or whether it is easily formalized, efficiently transmitted, well-documented, communicated, or expressed in writing. While these perspectives certainly have merit, if one desires to approach knowledge from a strategic, resource-based view (RBV), the conceptualization should proceed with an anchor that reflects a clear resource-based orientation. Such an orientation involves the nature of knowledge as a resource designed to accomplish a particular strategic purpose. In other

words, a resource-based view of knowledge begins with an understanding of knowledge as a particular kind of asset and with a clear expectation of the strategic capability knowledge creates.

Barney (1991) defined resources as any asset, capability, organizational process, attribute, information, or knowledge that a firm possesses. Most scholars agree that knowledge falls into the ‘intangible resource’ category (Grant, 1996, 2002; Kogut & Zander, 1992, 1995, 1996; Nahapiet & Ghoshal, 1998; Nonaka, 1994; Van den Bosch et al., 1999). Intangible resources are non-physical resources that are typically embedded in routines and practices and have intrinsic productive value that has evolved over time to create distinctive organizational capabilities. In this paper, knowledge is defined as an intangible resource that consists of interpreted information useful for creating strategic capability (Davenport & Prusak, 1998; Grant, 2002; Lengnick-Hall & Griffith, 2005).

Not all resources have the same strategic utility or, in other words, not all resources possess the ability to create competitive advantage. Five attributes signify how strategically useful a resource is for sustaining competitive advantage: (1) its *value* in the marketplace, (2) *rareness* or scarcity, (c) *inimitability* or difficulty in duplicating the resource, (4) difficulty in finding *substitutes* or replacements, and (5) a firm’s ability to *exploit* the resource (Barney, 1991). The conventional approach for dealing with knowledge from a philosophical or epistemological perspective (e.g., tacit vs. explicit, codified vs. non-codified) provides no consistent correlation with the way in which knowledge would be classified from a strategic RBV perspective. A few examples illustrate this discontinuity.

Tacit knowledge can be valuable (i.e. a physician who knows how to diagnose a tumor by touch) or it can be competitively useless (i.e. a physician who knows how to ride a unicycle). Context makes a difference.

While most strategists would say that codified knowledge is not a source of competitive advantage because it can be readily duplicated, this is difficult to determine on the basis of codifiability alone. For instance, a codified instructions manual for a new and rare grafting procedure that substantially increases the likelihood of successful transplants can be a significant strategic resource if it is proprietary. In addition, codified knowledge can be a foundation for competitive advantage if one firm is better able to use that knowledge than another. Health facilities such as the Mayo Clinic which undertake rare procedures more frequently might be able to more fully capitalize on these codified instructions than a rural hospital that rarely performs transplants.

Even the degree of the complexity of a knowledge resource does not substantiate its strategic potential. Expertise in creating hand-made tamales may be valuable, unique, difficult to imitate, and a substantial strategic capability in some regions of the country, but if the local demand for tamales is minimal then the knowledge is of marginal strategic utility at best. Conversely, knowing when and how to renew a liquor license may be very simple and easy to replicate, but is a critical piece of knowledge to a tavern owner. Knowing how to renew a license is valuable but not rare, so will not provide a sustained advantage. It is, however, a basic business requirement that enables a firm to use its other resources to achieve such an advantage.

Whether a resource is specific or general (script-like versus broad) does not signal its potential as a strategic resource either. While having a specified process for resolving labor disputes that has proven to be effective may be a strategic resource for a firm with a union, a supervisor who has superb managerial skills may render the dispute process unnecessary.

Finally, the declarative nature of knowledge does not indicate its potential as a strategic resource. Possessing a unique ability to tell people in plain language how to fix their cars may be

an important strategic resource for an auto parts store or for an auto mechanics instructor. On the other hand, it is not likely to be strategically useful for a waiter or a business professor.

Each of these examples demonstrates that relying on characteristics of knowledge such as tacitness, codifiability, complexity, specificity, and declarative properties is insufficient to describe the *strategic* potential of a knowledge resource because these labels are independent of strategic resource-related attributes. The resource-based view argues that the competitive or strategic significance of a resource cannot be determined without considering issues such as value, scarcity, inimitability, substitutability, the embedded context in which it will be used and the purpose toward which it is to be applied (Barney, 1995). Therefore, we propose a knowledge classification approach that reflects characteristics of a knowledge resource that are consistent with specific types of strategic capability the resource creates.

Evidence-Based Knowledge Resources

Evidence-based knowledge resources consist of *comprehension of something (know-what) or how to do something (know-how) or an understanding of relationships (know-why) that is based on established facts, objective analysis, sound causal logic, and repeated observation leading to consistent results from careful implementation and demonstrated utility for a specified purpose*. This definition is derived from the emerging literature on evidence-based management and evidence-based medicine (Clancy & Cronin, 2005; DeAngelis, 2005; Goodman & Rousseau, 2004; Jadad, Haynes, Hunt, & Browman, 2000; Kovner, Elton, & Billings, 2005; Kovner & Rundall, 2006; Pfeffer & Sutton, 2006a, 2006b; Rousseau, 2006; Sackett, Straus, Richardson, Rosenberg, & Haynes, 2000). The definition explicitly recognizes the type of value that can be created and the conditions for effective use.

Evidence-based medicine is the “conscientious, explicit, and judicious use of current best evidence in making decisions about the care of individual patients” (Sackett, Rosenberg, Gray, Haynes, & Richardson, 1996). In a broad context, it is a technique for using scientific evidence to make clinical decisions, recognizing the hierarchical value of various types of evidence in terms of its ability to produce a desired effect. To describe what evidence-based medicine is it is perhaps necessary to outline what evidence-based medicine is not. Evidence-based medicine is not about doing what everyone else is doing. Being widely used does not make a procedure a “best practice.” Nor is it a “cookbook” medicine approach as some proclaim or a framework that reduces the physician to a data gatherer (Sackett et al., 1996). Rather, it is an approach to medical treatment that blends the best external evidence with individual physician expertise and specific patient concerns. Additionally, evidence-based medicine is not merely collecting data in a random manner but involves identifying the best objective and empirically tested external facts with which to answer the current clinical question. The success of evidence-based medicine is promising. Recent studies suggest that physicians trained in evidence-based medicine are better informed than their colleagues even 15 years after medical school and that positive patient outcomes increase with the use of evidence-based medicine. Thus evidence-based knowledge resources clearly have strategic value in the health care arena.

Pfeffer and Sutton (2006a; 2006b), Goodman and Rousseau (2004) and others have tackled the task of extending the principles of evidence-based medicine to the business world. They found that to implement evidence-based principles, leaders must substitute facts for conventional wisdom, make a commitment to fact-based decision making, and embrace an attitude of action based on verified facts. As with evidence-based medicine, results demonstrate that evidence-based approaches make a difference. One prime example is provided by Gary

Loveman, CEO of Harrah's Entertainment. Conventional wisdom said that the most profitable Las Vegas guests were high rollers from out-of-town (Pfeffer & Sutton, 2006a). Using evidence from statistics, however, he discovered that his firm was much more profitable targeting those living nearby with marketing promotions of free meals and gambling chips instead of offering discounted hotel rooms to out-of-town guests.

Despite the potential benefits from using evidence-based management, determining what constitutes evidence is somewhat difficult. Evidence is often socially constructed, different professions possess different hierarchies of evidence, and professional networks repeatedly shape behavior (Dopson, FitzGerald, Ferlie, Gabbay, & Locock, 2002). And, while Kovner and Rundall (2006) highlighted nine attributes that could be used to assess the quality of evidence, Damore (2006) accurately points out that getting everyone to agree on which to use is a challenge. This suggests that evidence-based knowledge resources can be rare and difficult to imitate as well as valuable.

Our synthesis of work in evidence-based medicine and evidence-based management with strategy research suggests a number of salient characteristics of evidence-based knowledge resources that help to identify them and distinguish these resources from other types of knowledge. First, evidence-based knowledge resources are intended for unaltered use in a new location. An important feature of evidence-based knowledge is its completeness. The necessary components, descriptions, procedures, sequences, boundary condition requirements, and related elements are fully developed, making this type of knowledge resource ready for use in a new setting. Therefore, firms must be able to apply knowledge without making alterations to fully use evidence-based knowledge. Often the complete knowledge package contains tacit, explicit, codified, and undocumented elements. Intel's "Copy Exactly" replication incorporates this level

of knowledge complexity. Other examples include a water purification system that is ready for turnkey adoption by multiple firms, or a specific protocol for completing a purchase order.

A second critical feature is a high degree of proven success. Evidence-based knowledge is robust within a defined context and has been demonstrated through repeated trials to consistently lead to the intended outcome. Generally this requires repeated applications across diverse settings to establish reliability and to define the boundary conditions for the implementation context. Best practices for improving performance by using goals that are clear, specific, difficult but achievable, and accepted by those who are responsible for achieving them is an example of this feature (Latham & Locke, 1979).

Third, because of the demonstrated pattern of success, evidence-based knowledge resources also possess immediate utility. This means evidence-based knowledge can provide a significant positive impact for an individual, group, business unit, or organization once it is correctly applied. Nucor's mini-mill steel manufacturing process is a good example of all these characteristics. In the 1980s Nucor developed into one of the best steel companies in the industry through a number of knowledge management-intensive practices and in particular, thin-slab casting (Gupta & Govindarajan, 2000). Nucor replicated its own facility in 1997, demonstrating the completeness of the process. The process produced strong enough results that Nucor achieved profit margins well above industry medians from 1968 to 1998. In the truest sense, Nucor's thin-slab casting process system was an evidence-based knowledge resource that was valuable, rare, difficult to imitate, non-substitutable, and clearly exploited by Nucor.

Tinkerable Knowledge Resources

Tinkerable knowledge resources contrast in nearly every respect with evidence-based knowledge. Tinkerable knowledge resources consists of *knowledge about something* (*know-*

what) or how to do something (know-how) or an understanding of relationships (know-why) that is based on insight, intuition, acumen, perception, and speculation that captures idiosyncratic understanding and creative ideas that are amenable to combination and reconfiguration. Our definition of tinkerable knowledge draws from the emerging work blending design principles, education, and complex systems (Collins, 1994; Flake, 1998; Papert, 1980; Resnick, 1993; Resnick, Martin, Sargent, & Silverman, 1996; Schrage, 1999). Tinkerable knowledge enhances knowledge stocks and builds capabilities by facilitating and expanding understanding and problem-solving skills or underscoring relevance and importance. Customization of tinkerable knowledge is expected before it is used in a new location. Therefore, a particularly crucial feature of this type of knowledge resource is its malleability. Tinkerable knowledge resources are readily adapted, interpreted, blended, analyzed, and manipulated for use in a variety of environments. Galileo's lenses which can be assembled in one way to create a telescope, put together in another way to produce a microscope, and combined with mirrors and prisms to enable an analysis of light spectra illustrate tinkerability (Collins, 1994; Osborne & Rose, 1999).

Tinkerable knowledge is often stated in fairly general terms making the ideas accessible to a wide range of audiences rather than only understandable to those with specialized knowledge or expertise. Tinkerable knowledge does not include specific protocols, or directions, and tends to incorporate limited requirements or other constraints since these are part of the adaptation process. Because tinkerable ideas are relatively untested and forward thinking they are often more pliable than established routines. Tinkerable knowledge resources complement other resources and serve as linking pins to a variety of organizational assets giving them high leverage potential. Often these complementarities result in unforeseen or unpredicted future success. Tinkerable resources have an inherently strong potential combinative capability (Kogut

& Zander, 1992) because they are compatible with existing knowledge stocks, and are user-friendly so therefore are easily leveraged through familiar social integration mechanisms. In this way tinkerable knowledge resources tend to enhance a firm's overall absorptive capacity (Cohen & Levinthal, 1990; Van den Bosch et al., 1999; Zahra & George, 2002) At times, tinkerable knowledge resources take the form of insights about what does not work, mistakes, or recognition of negative learning (Cohen & Bacdayan, 1994; Kogut & Zander, 1996). Tinkerable knowledge resources serve as catalysts that trigger creativity, innovation, resourcefulness, and new insights. This means that tinkerable knowledge is interesting, provocative, suggests desirable outcomes, and stimulates motivated action.

An example of this type of knowledge resource is outcomes of the Department of Veteran's Affairs VERDICT research initiative. VERDICT is a collaborative research program designed for the purpose of inspiring others to expand and improve existing treatment repertoires or to create new methods. The research being conducted at this center is experimental and by nature is engaging, thought-provoking, new, invigorating and challenging. Research activities draw from a broad array of specialties to insure diverse perspectives and multiple interpretations. There is very little proven success in the program because they are breaking ground on new research. Therefore, knowledge coming out of the program is ripe for integration and application in opportunistic ways across many arenas. Knowledge resources emerging from the research are not directed toward specific goals or functional outcomes so even the researchers are unable to predict precisely how what they learn now will be used.

Distinctions, Tensions, and Roots of Ambidexterity

Six characteristics (See [Table I](#)) identify and distinguish evidence-based knowledge resources and tinkerable knowledge resources: (1) completeness, (2) proven success, (3)

immediate utility, (4) malleability, (5) leverage potential, and (6) catalytic capacity. Evidence-based knowledge resources are strong on completeness, proven success, and immediate utility but very weak on the other three. Conversely, tinkerable knowledge resources are strong on the malleability, leverage potential, and catalytic capacity but weak on the first three characteristics. Because the nature and properties of these knowledge resources are different and contradictory, the outcomes to which the two types of knowledge resources effectively contribute contrast as well. We propose that evidence-based knowledge resources are particularly effective and efficient when used for exploitation activities and that tinkerable resources are particularly effective and efficient when used for exploration because these combinations offer a solid match between resource characteristics, process requirements, and intended outcome.

 INSERT TABLE I ABOUT HERE

Evidence-based knowledge resources are designed for rapid, efficient, comprehensive, and relatively error-free implementation and embody characteristics that facilitate effective exploitation. Because the knowledge resources are complete and have proven success they are worthy of exploiting, and because they have immediate utility they set in motion a reinforcing trajectory of achievement. Tinkerable knowledge resources, in contrast, are designed to be combined, manipulated, reinterpreted, stretched and transformed. Due to their malleability and leverage potential, tinkerable knowledge facilitates and accelerates experimentation and innovation. The catalytic capacity of tinkerable knowledge resources activates exploration processes.

Recognizing and articulating the differences in knowledge resources best used for exploitation and those most effective for exploration introduces a new perspective on the tensions and distinctions between these processes. Moreover, in much the same way that

manufacturing systems can be designed to achieve the competing goals of high efficiency and high levels of product variation by managing the interplay among component parts, we suggest that the competing goals of exploration and exploitation can be achieved simultaneously by actively managing component knowledge resources. Looking at ambidexterity from an elemental, or knowledge resource vantage point, introduces options that may be overlooked if exploration and exploitation are only considered in terms of integrative processes and organizational routines.

KNOWLEDGE FLOW, EXPLORATION AND EXPLOITATION

Knowledge flow or dissemination is characterized in many ways throughout literature. Terms such as knowledge management (Davenport & Prusak, 1998), dissemination (DiBella, Nevis, & Gould, 1998), distributing (Van der Spek & Spijkeervet, 1997), flow (Gupta & Govindarajan, 1991), transmission (Schulz, 2001), exchange (Kotabe, Martin, & Domoto, 2003), transfer (Alavi & Leidner, 2001; Kogut & Zander, 1992; Szulanski, 1996), and sharing (Appleyard, 1996; Hansen, 1999) are among the constructs regularly used to describe such processes. Lengnick-Hall and Griffith (2005) argued that even among three of the most popular terms, (knowledge flow, knowledge transfer, and knowledge sharing) the literature does not clearly or consistently distinguish particular actions as associated with specific constructs. As they explain, this creates a number of problems including an inability to draw unequivocal conclusions about the relationships between particular behaviors and intended results.

The exploration/exploitation literature can bridge resource-based strategy and knowledge management literatures and reduce the language problems that have emerged in describing knowledge flow. Exploitation involves rapid conformity to practices, along with the maintenance and refinement of current activities, and is best used in stable contexts (Gupta et al.,

2006; March, 1991). Conversely, exploration refers to innovation, new knowledge acquisition, participation in events and activities of uncertain value, and something particularly well-suited for dynamic contexts (March, 1991; Miller, Zhao, & Calantone, 2006). Using definitions of exploration and exploitation as a basis for sorting or categorizing various types of activities used to move knowledge provides a theory-based rationale for reducing the confusion, and in addition, ties particular behaviors to intended results. Consequently, when activities used to move knowledge are intended to create comprehensive knowledge overlap between senders and receivers and enable behaviors or procedures to be duplicated in a way that reduces variation, we refer to this as *exploitive knowledge flow behaviors*. Behaviors and activities that are directive, formal, hierarchically linked, well-documented, impersonal, specified, procedure-oriented, and precise fall into this category. When the intent is to provide understanding and insight into a phenomenon that blends sender and recipient perspectives and provides a foundation for creativity, insight, and innovation, we refer to these activities as *exploration knowledge flow behaviors*. Behaviors and actions that are discretionary, informal, spontaneous, personalized, advice-oriented, tentative, focused on inquiry, and interactive fall into this category. These categorizations are similar to Kogut and Zander's (1996) description of knowledge flow aimed at imitation and knowledge flow designed to build combinative capabilities.

A review of the literature suggests a menu of knowledge management activities and behaviors that are important drivers of each of these types of knowledge flows (Baldwin & Ford, 1998; Dixon, 2000; George, Rowlands, & Kastle, 2004; Hansen, 1999; Kogut & Zander, 1995; Lengnick-Hall & Lengnick-Hall, 2003; March, 2006; Siggelkow & Rivkin, 2006; Van Looy, Martens, & Debackere, 2005). Tushman and O'Reilly (1996), for example, indicate that designating a dominant design, using feedback to refine processes and reduce variation, creating

stories to solidify congruent social perceptions, institutionalizing systems for analyzing and distributing knowledge, crafting formal plans of action, and similar knowledge management actions facilitate exploitation. Other scholars offer additional examples of exploitive knowledge flow activities such as templating, using rules and procedures, mandatory protocols, requiring codification and documentation, sharing knowledge through strong ties, documenting knowledge to promote teachability, using expert-to-novice training formats, transmitting information through hierarchical channels, truncating debate, using temporary transfer teams. Very different knowledge management activities such as presenting a new cultural lens for interpreting information, deliberately disrupting structural and cultural inertia, asking more questions and providing fewer answers, and encouraging employees to express conflicting judgments are provided as examples of knowledge management activities that promote exploration (Tushman & O'Reilly, 1996). Additional exploratory knowledge flow activities include encouraging informal and spontaneous conversations, engaging in extensive dialog and constructive dissent, enhancing technological complexity, communicating through weak ties, requiring a second right answer, engaging in after-action-review, articulating trade-offs. It appears that exploration and exploitation constructs provide a foundation for categorizing various knowledge flow behaviors that has conceptual utility and practical relevance.

Furthermore, when knowledge flow behaviors are categorized using exploration and exploitation as criteria, these behaviors can be juxtaposed with differences in knowledge resources to determine level of fit. When evidence-based knowledge is transmitted using exploitation behaviors, there is a good fit between the resource and the intended use. For example, a hospital may use exploitation-related behaviors such as established rules and procedures, demonstrations by experts, and step-by-step instructions to spread a new, more

effective protocol for coordinating across a patient's specialty team. The benefits of completeness, proven success, and immediate utility are capitalized upon by using behaviors that signal the need to replicate and apply rather than innovate and manipulate. Likewise, when tinkerable knowledge is transmitted using exploration behaviors there is also a good fit between the resource and the intended result. The same hospital may use exploration behaviors such as discussions during a staff meeting, introduction of new techniques by informal leaders, and impromptu conversations among employees to spread the word about effective ways to calm down an angry patient or family member. These behaviors signal the need to adapt the knowledge resource to the situation and to combine the new ideas with personal experience and intuition. The benefits of malleability, leverage potential, and catalytic capacity are highlighted by the informal, interactive, suggestive behaviors associated with exploratory knowledge flows. If, on the other hand, rules and procedures or step-by-step instructions were used as the mechanism for letting employees know of new techniques for calming patients or their families, there would be little opportunity for the customization or adaptation needed to achieve effective results under very diverse circumstances.

Organizations routinely use a variety of different activities to make use of many different kinds of resources simultaneously. So it is reasonable to expect that a firm can become adept at using exploitive knowledge flow behaviors to capitalize on evidence-based knowledge resources at the same time that they are using exploratory knowledge flow activities to capitalize on tinkerable resources. This simultaneous use of both evidence-based knowledge and tinkerable knowledge in ways that reflect a tight fit between knowledge resources and knowledge flow behaviors can be one important source of organizational ambidexterity.

An important question, then, is what happens when knowledge resources are paired with poorly matched knowledge flow activities? In one scenario, tinkerable knowledge can be distributed in a unit or organization using exploitation-related behaviors that send signals indicating application should be tightly controlled, and that the know-how, know-what, or know-why should be replicated without any modification. One likely consequence that is the expected results simply would not materialize and the knowledge resource would be wasted. Another equally plausible outcome is that the firm would invest a great deal of effort and expense engaging in counterproductive activity and that ‘negative learning’ (Kogut & Zander, 1996) would occur. In an alternate scenario, evidence-based knowledge could be shared using exploratory knowledge flow mechanisms. For example a proven technique for reducing infection could be transmitted in a tentative and experimental way. In this case the demonstrated value of the knowledge resource would be diluted, but it is also possible that new insights or applications could emerge. The combinative capability of the knowledge resource would be reduced and any new insights would likely develop more slowly because completeness would make it difficult to unpack and re-bundle useful ideas. These proposed relationships and consequences are depicted in [Figure 1](#). Positions that represent nearly all white (exploitation) or all grey (exploration) knowledge flow activities rely on one process at the expense of the other for a given knowledge resource. This is what we recommend. Organizational ambidexterity is obtained by engaging simultaneously in *different kinds of knowledge flow activities using different types of knowledge resources*. Ideally this would be positions yielding effective replication & exploitation along with different combinations yielding insight and effective exploration. Hybrid positions that blend exploratory and exploitive knowledge flows when using evidence-based knowledge (the upper continuum) can also take place, but trade-offs between

efficiency and effectiveness are expected to be more pronounced. The use of hybrid knowledge flows with tinkerable knowledge is potentially more disadvantageous, and at the extreme, using exclusively exploitive flows to disseminate tinkerable knowledge could lead to unintended problems from implementing dysfunctional solutions.

INSERT FIGURE 1 ABOUT HERE

Clearly, knowledge flow is just a subset of the broad range of exploration and exploitation actions organizations employ. However, a more comprehensive and precise understanding of particular knowledge flow activities that differentially encourage exploration or exploitation is another tool available to managers for promoting organizational ambidexterity from a resource-based perspective.

KNOWLEDGE RESOURCES, KNOWLEDGE FLOW AND PERFORMANCE

One familiar notion of fit is a “theoretically defined match between two related variables” (Venkatraman, 1989: 430). A large body of work demonstrates that organizational performance is enhanced when fit is achieved between such organizational elements as strategy and structure (Chandler, 1962), the person and the situation (Joyce, Slocum Jr., & Von Glinow, 1982), human resource practices and strategy (Wright, Smart, & McMahon, 1995) structure and technology (Woodward, 1965) and a variety of other contingent relationships. Alexander and Randolph (1985) for example, examined the fit between technology and structure as a predictor of performance in twenty-seven nursing units and found that a simple measure of fit or matching between technology and structure better predicted quality of care than either factor alone or both of them together. The underlying premise followed previous conceptual and empirical research (Dalton, Todor, Spendolini, Fielding, & Porter, 1980; Miles, Snow, Meyer, & Coleman, 1978) to demonstrate that technology and structure fit is prerequisite for effective firm performance.

Following this same logic, we propose that effective organizational performance results when there is a conceptual and behavioral match between knowledge resource types and knowledge flow activities. Specifically, we suggest that the strongest performance occurs when evidence-based knowledge is applied using exploitation knowledge flow mechanisms to achieve variation reduction objectives and when tinkerable knowledge resources are employed using exploratory knowledge flow activities to achieve variation increasing objectives. Thus, organizational performance goals are most likely to be met when (1) knowledge resources are correctly classified as either evidence-based or tinkerable, (2) knowledge flow mechanisms are appropriately matched to the type of knowledge resource being moved, and (3) the combined knowledge resource/knowledge flow package is consistent with the target objective.

Both the strategy literature and research on exploration and exploitation highlight the notion of trade-offs. Porter (1996) explained the need for trade-offs using the following logic. Sustained superior performance requires both operational efficiency and strategic effectiveness. Effective strategies depend on distinctiveness. Distinction requires choices and boundaries. Effective choices require trade-offs between incompatible activities that occur due to image inconsistency, contradictory capabilities, or infrastructure and resource limitations. There is ample evidence that exploration and exploitation depend upon contrasting activities, promote different images of the organization, require contradictory capabilities, and place competing demands on resources and a firm's infrastructure (Cheng & March, 1996; March, 1991, 2006). Yet, the ambidexterity hypothesis argues that firms achieve superior performance when they are able to obtain a sustained and simultaneous balance across these two processes (Tushman & O'Reilly, 1996).

We propose the notion that trade-offs should occur at multiple micro levels of organizational activity rather than at a more global, total-organization level that can limit a firm to either innovation and creativity or productivity and efficiency. This helps prevent firms from falling into a ‘conformance trap’ (Tushman & O'Reilly, 1996) or becoming caricatures of their former source of excellence (Miller, 1990). In this way the ambidexterity hypothesis is consistent with a cumulative view of organizational activity which argues that sustained superior performance comes from high levels of achievement across very different, and often competing, types of outcomes (D'Aveni, 1994; Flynn & Flynn, 2004; Quinn, 1988; Quinn & Rohrbaugh, 1983; Yip, 1995). Through a culture of competing values (Quinn & Rohrbaugh, 1983), development of dynamic capabilities (Eisenhardt & Martin, 2000), modular organization designs (Miles et al., 1978), deliberate resource prioritization (He & Wong, 2004), versatile leadership (March, 2006), ambidextrous organization structures (O'Reilly & Tushman, 2004) and other intermediate-level organizational choices, firms can become adept at both exploration and exploitation despite competing requirements. This is crucial because in order to thrive, firms must both be able to learn and to apply what they learn. Viewing ambidexterity from a knowledge resource perspective illuminates one additional way in which an organization can accomplish the kind of contradictory outcomes that contribute to sustained success.

Anecdotal Support from the Field

The health care environment requires attainment of multiple, competing types of results on an on-going basis. Clearly, ambidexterity, rather than punctuated equilibrium, is essential if hospitals and other health care providers are to achieve both consistent high standards of care and customer satisfaction. Efficiency, especially performing error-free procedures using as few resources as possible, is an important indicator of high levels of care since it captures both

effectiveness and resource utilization. Efficiency generally requires consistency, predictability, and preciseness. Harrison, Coppola, & Wakefield (2004) identified at least six different types of efficiency that can be measured in a health care environment: cost, productivity, economic, response time, operational efficiency, and technical efficiency. Based on the previous discussion fit between knowledge resource type and knowledge flow activities, a combination of evidence-based knowledge deployed using exploitive knowledge flow activities would be expected to yield high levels of efficiency across these dimensions.

One example of linking evidence-based knowledge with exploitive knowledge flow comes from a ten-facility hospital system in the southeastern United States. To improve efficiency and productivity the hospital developed mandatory protocols for proper designation of employee time in the accounting system, procedures to manage appointment templates, and coding controls for providers. The employee time protocols provided coding examples of the most common events for all types of employees. Steps to scrutinize appointment templates were developed and results were examined to identify days and time periods where slack occurred and when flexible (on-call) employees were needed so that unused patient appointments were minimized. When detailed analysis of coding records found that very few records were coded and closed after three days, controls were put in place that not only required providers to complete coding within 72 hours but showed individual compliance rates. Implementing these initiatives throughout the multi-hospital system led to multiple outcomes. Employee time spent in unproductive activities with patients decreased. More appointments became available and fewer personnel were used to fill the appointments. Finally, revenues increased as more visits were closed out and billed. With revenues increasing at a higher rate than resources expended, efficiency and productivity increased to all-time highs.

In contrast to efficiency concerns, customer satisfaction often depends on a health care provider's ability to customize care to meet the idiosyncratic needs and preferences of specific patients and their families. Innovative approaches, new resource combinations, intuition, and flexibility are often crucial for achieving high levels of patient satisfaction. Behavioral scripts that are very appropriate in one location may not work in a different setting. In fact, such scripts could result in poor satisfaction if they are not customized to the new environment. One patient recovering from surgery may want a great deal of attention and interaction with nursing staff and another may want to be left alone as much as possible. This suggests that when the outcome intent is customer satisfaction, exploitation knowledge flow should be minimized and exploratory knowledge flow should be employed. As noted previously, tinkerable knowledge is most useful for exploration since it is designed to be manipulated, recombined, adjusted, and interpreted. This suggests that tinkerable knowledge applied through exploratory knowledge flow activities should yield the highest levels of patient satisfaction.

There are also many instances within this same healthcare system when tinkerable knowledge resources were effectively managed through exploratory actions. One example is sharing expertise on how to assist a suicidal patient. There are many different signs of suicide and consequently suicidal individuals exhibit a wide variety of behaviors. Most training sessions on how to handle a suicidal individual are exploratory in nature. Instead of providing employees with a list of do's and don'ts when confronting a suicidal patient, training sessions become discussions of what helped with specific individuals, signs to look for, and how a particular situation could have been handled better. In some cases the trainer becomes a facilitator so that those involved can interactively suggest behaviors that may work. The result of these exploratory activities is not a group of employees who know exactly what to do the next time

they face a suicidal person but rather employees who have a vast array of tools to draw upon and employ if the occasion arises. Other situations requiring employees to customize and leverage their knowledge to fit the individual and situation rather than follow a rigid set of procedures include dealing with angry individuals, grieving patients, and those who are victims of crimes.

Evidence-based knowledge could be used in an exploratory manner, but the characteristics of the knowledge resource (completeness, proven success, immediate utility) make this combination more cumbersome and inefficient, and can lead to serious problems. An example of the pitfalls of handling evidence-based knowledge in an exploratory manner includes the experience of the same hospital system when preparing for accreditation visits. Accreditation is a crucial issue for today's healthcare facilities and scoring high on an accreditation visit demonstrates a facility's quality. The personnel training folder review is an integral part of an accreditation visit for hospitals. A few years ago a nurse at one location in the large healthcare organization developed a nursing personnel training folder process that received commendatory remarks on the next accreditation. She took that process to her subsequent duty at the organization's corporate headquarters with the intention of replicating the process throughout the system. Despite her attempts to do so, some leaders at intermediate levels in the organization made changes to the process. Others steadfastly refused to implement the process. Instead of a consistent and dependable process at every facility, the organization ended up with nearly 75 different systems, some of which are dysfunctional. Similar pitfalls arise when firms attempt to modify and experiment with evidence-based knowledge in safety and infection control programs.

DISCUSSION AND IMPLICATIONS FOR FUTURE RESEARCH

Evidence-based management can only work if there is evidence-based knowledge to apply. Likewise, successful innovation depends on ideas, combinations, and knowledge that can be mixed and harmonized and blended to contribute to a variety of conditions and circumstances. To date, much of the work regarding exploration and exploitation appears to presume that the necessary knowledge is available, recognized and used to its best advantage. In this paper, we offer a way to assess this assumption. Examining exploration and exploitation in terms of the knowledge resources that become primary ingredients for these processes offers a new perspective for answering some of the seminal questions in this research domain.

First, what are important sources of distinction between exploration and exploitation? Looking at exploration and exploitation in terms of the knowledge resources needed to accomplish these processes suggests that distinctions begin with the raw ingredients. A knowledge resource lens introduces a different level of analysis than is typically applied to exploration and exploitation research. The knowledge resources best suited for each of these processes are quite different. Consequently, the actions, structures, procedures, and behaviors designed to transfer or share knowledge resources so that they are used to their best advantage are also very different. The conceptualization presented here suggests that managers would benefit from being trained to distinguish between evidence-based knowledge and tinkerable knowledge and they would profit from learning which specific knowledge flow activities best fit the kind of resource being used and the type of strategic outcome they are trying to achieve. This is a more tactical and incremental approach to achieving exploration and exploitation than has typically been the focus.

Second, what are the major sources of tension between exploration and exploitation? In some respects a knowledge resource-based view conceptualizes the friction between exploration and exploitation in terms of a lack of fit between knowledge resources, knowledge flow, and intended results rather than as a conflict between inherently competing objectives. A poor fit between knowledge resource type and knowledge flow implementation activities results in lower goal attainment or counterproductive activity. Exploitation and exploration are not seen as opposing ends of a continuum but, rather, as different objectives. If evidence-based knowledge is shared using exploratory knowledge flow behaviors (a misfit), it will be challenging to experience high levels of innovation and discovery and, at the same time, there is a reduced probability that the potential benefits from applying a demonstrated competency will be achieved. However, using exploitive knowledge flow behaviors to transmit evidence-based knowledge does nothing to undermine a firm's ability to share tinkerable knowledge using exploratory knowledge flow techniques. The level of versatility needed to do this is not uncommon among individuals, units, or entire organizations. Individuals routinely exploit traffic rules by stopping at red lights and driving on the correct side of the road for the country in which they are traveling, and at the same time, they discover new routes to their destination to avoid traffic jams and take side trips to explore unexpected sites of interest. A marketing division may comply with rigid procedures for processing payroll information, and at the same time, develop a creative advertising campaign. Recognizing the benefits from more deliberate choices regarding knowledge resources and knowledge flow may unlock latent opportunities to achieve both exploration and exploitation.

Three, what factors enable a firm to achieve a balance between exploitation and exploration simultaneously (the ambidexterity hypothesis) rather than sequentially (a punctuated

equilibrium approach)? Several specific recommendations emerge from an understanding of the relationships among knowledge resources, knowledge flow, and organizational ambidexterity. A comprehensive and empirically tested set of criteria for identifying and categorizing evidence-based knowledge and tinkerable knowledge needs to be developed. Not all knowledge falls into one of these two categories. Some knowledge is firmly believed and advocated, but not sufficiently tested to qualify as evidence-based yet it may not be easy to combine with other ideas. Some knowledge is insightful, but difficult to generalize, extend or manipulate. These kinds of knowledge do not fit either category. In this paper we suggest criteria for knowledge resource classifications that emerge from the literature and from limited focus group and expert panel discussions, but a more systematic and comprehensive investigation of differentiating criteria is needed. In addition, it appears that there are three general categories of knowledge flow activity: (1) exploitive knowledge flow activities (i.e., rules, procedures), (2) exploratory knowledge flow activities (i.e., brainstorming, after-action-review), (3) multipurpose or baseline knowledge flow activities (i.e. sending a message through email). Specific benefits and liabilities of particular knowledge flow behaviors should be empirically examined to enable a correct match between knowledge resources and knowledge flows. Organizations are likely to benefit from individuals and units with a diverse knowledge flow repertoire and a keen understanding of which actions are best used for which purposes. Finally, it appears that organizations would profit from intentionally creating opportunities for individuals and groups to practice ambidexterity. When viewed from a knowledge resource-based perspective, organizational ambidexterity appears to be a dynamic capability, which, can be honed and improved through learning, rehearsal, and feedback. Moreover, a knowledge resource based perspective somewhat redefines the notion of balanced exploration/exploitation from a dynamic

tension between the two processes to sufficient organizational versatility and resource diversity to make both processes feasible to implement.

Four, what mechanisms are available for organizations allocate and manage their knowledge resources to achieve both exploration and exploitation? Other resources have been specifically allocated to achieve innovation and increased productivity – but the need to allocate knowledge resources has been overlooked. We suggest that organizations should deliberately build knowledge stocks that contain both types of knowledge and should train employees to recognize the difference and behave accordingly. These knowledge stocks should be easily accessible organization-wide, and knowledge management techniques ranging from knowledge fairs to knowledge brokers to embedding knowledge management in performance appraisal should be used to promote pervasive and appropriate use of these resources. Determining whether resources are evidence-based also helps answer questions regarding how managers can recognize good ideas to exploit.

Comparable to their efforts to build knowledge stocks, organizations may benefit from individuals and units with diverse knowledge flow tool kits and a keen understanding of which tools are best used for which purposes. This can help ensure that neither organizational units nor individuals become trapped into engaging in only exploitation or only exploration.

In summary, a knowledge resource based perspective shifts the level of analysis and suggests new approaches for achieving exploration and exploitation. The conceptualization presented in this paper suggests that exploration and exploitation processes may compete for the attention of organizational members or the allocation of scarce resources, but that these two activities can occur simultaneously in organizations without creating contradictions.

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TABLE I

Characteristics That Identify and Distinguish Evidence-Based Knowledge Resources from Tinkerable Knowledge Resources

Characteristic	Definition	Presence in Evidence-Based Knowledge Resource	Presence in Tinkerable Knowledge Resource
Completeness	Contains all necessary information elements, interpretations, connections, procedures, and sequences for effective application without further manipulation or analysis. Example: Turn-key operations and off-the-shelf products.	HIGH	LOW
Proven Success	Specific (focused), objective, measured, and tested demonstration of consistent desired outcomes resulting from application. Example: Intel’s “Copy Exactly” manufacturing.	HIGH	LOW
Immediate Utility	Able to achieve measurable and predictable performance gains as soon as it is fully implemented or applied in a new setting. Example: Cost savings from implementing a reengineered inventory processing method.	HIGH	LOW
Malleability	Readily customized, interpreted, blended, analyzed, and manipulated to be useful for a variety of different applications – highly flexible and easily modified to complement other resources. Example: Concept of using cute animals or children in advertising.	LOW	HIGH
Leverage Potential	Readily complements other resources and serves as a linking pin across a firm’s tangible, intangible, and capability assets. Example: Firm-specific definition of high quality.	LOW	HIGH
Catalytic Capacity	Potential of a knowledge resource to trigger creativity, innovation, resourcefulness, and new insights – knowledge that is provocative, engaging, unconventional, and surprising. Example: Chromosome sequences mapped by the Human Genome Project.	LOW	HIGH

FIGURE 1
Consequences of Various Knowledge-Flow Activities Using Different Types of Knowledge Resources

