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How Knowledge Transfer Impacts Performance: A Multilevel Model of Benefits and Liabilities

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When does knowledge transfer benefit performance? Combining field data from a global consulting firm with an agent-based model, we examine how efforts to supplement one's knowledge from coworkers interact with individual, organizational, and environmental characteristics to impact organizational performance. We find that once cost and interpersonal exchange are included in the analysis, the impact of knowledge transfer is highly contingent. Depending on specific characteristics and circumstances, knowledge transfer can better, matter little to, or even harm performance. Three illustrative studies clarify puzzling past results and offer specific boundary conditions: (1) At the individual level, better organizational support for employee learning diminishes the benefit of knowledge transfer for organizational performance. (2) At the organization level, broader access to organizational memory makes global knowledge transfer less beneficial to performance. (3) When the organizational environment becomes more turbulent, the organizational performance benefits of knowledge transfer decrease. The findings imply that organizations may forgo investments in both organizational memory and knowledge exchange, that wide-ranging knowledge exchange may be unimportant or even harmful for performance, and that organizations operating in turbulent environments may find that investment in knowledge exchange undermines performance rather than enhances it. At a time when practitioners are urged to make investments in facilitating knowledge transfer and collaboration, appreciation of the complex relationship between knowledge transfer and performance will help in reaping benefits while avoiding liabilities.

Key words: knowledge; exchange; social network; performance; qualitative data; agent-based model; professional service firm; consulting; knowledge management; intranet; corporate social media
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Introduction

Knowledge is a source of lasting competitive advantage (Winter 1987) and the foundation for the existence of the firm (Grant 1996). It is utilized by members of the firm, who not only use their own knowledge but also search for and transfer knowledge from social and asocial sources, such as other people and artifacts. Knowledge search and transfer have been documented across a wide variety of settings and professions: engineers and technicians (Bechky 2003, Orr 1996, Perlow and Weeks 2002, Perlow 1999), designers (Hargadon and Sutton 1997), consultants (Haas and Hansen 2005; Hansen 1999, 2002; Hansen et al. 2005, 2001), lawyers (Lazega 2001, Lazega and Pattison 1999), and judges (Lazega et al. 2011). Research has shown that the transfer (or exchange) of knowledge between members has important consequences for a plethora of organizational processes and outcomes, such as the spread of best practices (Szulanski 1996), organizational learning (e.g., Reagans et al. 2005), innovation (e.g., Hargadon and Sutton 1997, Obstfeld 2005), and, ultimately, performance (e.g., Hansen 1999).

Because of the importance of knowledge transfer, scholars sought ways to enhance organizational performance by removing obstacles to knowledge flows. Much has been achieved: we now know that obstacles result from limitations of an individual's cognition (e.g., Argote 2000) or motivation (Cabrera and Cabrera 2002, De Dreu et al. 2008, Wittenbaum et al. 2004). Such obstacles also stem from characteristics of the task (e.g., Podolny and Baron 1997), relationships between involved parties (e.g., Bunderson and Reagans 2011, Hinds et al. 2001, Levin and Cross 2004, Reagans et al. 2005), the structure of the underlying social network (e.g., Hansen 1999, Hansen and Løvås 2004), characteristics of the knowledge itself (e.g., Szulanski 1996), or a combination thereof (Argote et al. 2003). In addition to academic research, managerial interest in harnessing knowledge gave rise to initiatives and practices such as *knowledge management* (e.g., Garud and Kumaraswamy 2005, Hansen et al. 1999, Ruggles 1998) and *communities of practice* (McDermott and Archibald 2010, Wenger and Snyder 2000), *intranet* (Fulk et al. 2004) and *Enterprise 2.0* (McAfee 2006, 2009), *corporate*

social media and *corporate social networking* (Sena and Sena 2008, *Economist* 2010).

Some areas remain unexplored. We know little about the efficiency of many knowledge practices, because analyses rarely examine the impact on corporate performance. Few accounts consider the direct and indirect costs of knowledge transfer, such as the physical and technological infrastructure, the effort expended by the knowledge seeker on search, and the opportunity costs for the knowledge source. For instance, the popular managerial literature often suggests simultaneous investment in technology and social practices: capturing knowledge in databases and "structuring" social interaction to facilitate exchange (e.g., Soo et al. 2002, Wenger and Snyder 2000). But without consideration of cost, it is not clear whether it is optimal to make such dual investments in expanding information technology *and* promoting social interaction. While it is possible that the two complement each other, it is also possible that the two are substitutable, and so investment in one suffices and investment in both is inefficient.

The benefits and liabilities of knowledge exchange are likely affected by a variety of variables—for example, the microroutines of searching for knowledge, locally or globally, and the way individuals engage in exchange once knowledge is found, amiably or at arm's length. These have normative significance. It may appear that organizations should aspire for employees that are "good Samaritans," always ready to offer help to a colleague. But is such behavior desirable once the Samaritans' opportunity cost is taken into account? After all, helping others means having fewer resources to complete one's own tasks (cf. Hansen 2009b). We also know little about the interaction of knowledge exchange with variables that can threaten knowledge validity, such as turbulence in the external environment. Some criticized the reliance on existing knowledge altogether, arguing that "substituting memory for thinking" harms performance (Pfeffer and Sutton 1999, p. 71). When should an organization rely on the transfer of existing knowledge, and when should it encourage learning and exploration by its members?

The gaps in theory are highlighted by recent empirical findings exposing puzzling variations in the performance benefits of knowledge transfer. For instance, the transfer of codified knowledge, the type contained in procedures and technology, was proven beneficial in manufacturing (e.g., Epple et al. 1996) and franchised services (e.g., Argote and Darr 2000, Darr et al. 1995), but it was deemed negligible or even harmful among consulting teams (Haas and Hansen 2005). Similarly, knowledge transfer from coworkers helped create breakthroughs in a product design firm (Hargadon and Sutton 1997) but had mixed effects for consulting teams, improving outcomes but not saving time (Haas and Hansen 2007). In our own fieldwork, we witnessed managers struggling to make informed decisions when allocating resources for knowledge exchange initiatives. Urged to support them but bemused by intricacies, managers asked about research findings, leading us to weigh what we know and what remains shrouded. As scholars called for "analysis of the effects of both the benefits and the costs of knowledge transfer" (Haas and Hansen 2005, p. 19), we sought a parsimonious way to account for the empirical puzzles, illuminate paths of research to address the gaps, and suggest actionable managerial insights.

We propose a broad principle of *contingent benefits from organizational knowledge transfer*. Built on prior work, our theoretical stance is supported by a combination of qualitative fieldwork data and three experiments using an agent-based model, through which we derive propositions about the contribution of knowledge exchange to organizational performance. In the experiments, we examine the performance impact of interactions between four exchange patterns (embedded, performative ties, market, and self-learning as a baseline control) and three key characteristics of individuals, organizations, and environments (norms supporting individual learning, organizational memory capacity, and environmental turbulence). We illustrate that the impact of these interactions on performance is not simple. Rather, it is contingent: while knowledge exchange can better performance, it can also have negligible or even detrimental effects on performance.

The study makes four contributions to theory, practice, and methodology of management. First, we expand the level of analysis explored in prior work to illustrate that the benefits from knowledge transfer are contingent not only on task and team characteristics but also on those of individuals, organizations, and the external environment, supporting a general presumption of contingent benefits from knowledge exchange. We inform the study of knowledge transfer by proposing boundary conditions and supporting generalization of contingencies that were documented previously in specific settings. Second, we demonstrate the performance impact of theorized but rarely modeled constructs by integrating them into the model: the *opportunity cost* involved in knowledge transfer, for both the knowledge seeker and the source (Fulk et al. 2004, Haas and Hansen 2005, Perlow 1999), and the *exchange pattern* governing the transfer of knowledge, which includes the motivation or willingness to transfer (Cabrera and Cabrera 2002, De Dreu et al. 2008, Wittenbaum et al. 2004). These allow us to comment on the efficiency, in terms of organizational performance, of knowledge transfer. Third, as a manager considers investment to facilitate knowledge transfer, she would benefit from knowing which constructs matter in predicting the expected returns. Better predictability may be timely given managerial frustration with knowledge practices (e.g., Baker 2009, Hansen 2009b, Fahey and Prusak 1998, Pfeffer and Sutton 1999,

Soo et al. 2002). We identify three constructs whose levels likely affect returns from knowledge transfer. Methodologically speaking, we contribute to the increasing interest in seeking external validity for simulation models and abstracting from a field study to a model (Black et al. 2004, Moss and Edmonds 2005, Perlow et al. 2002, Sterman et al. 1997). Modeling may be especially suitable because empirical work in this area, as meticulous as it may be, suffers from severe data limitations. It is challenging to obtain individual-level data on knowledge and exchange and extremely difficult to gain access to sites for conducting field experiments or replicating past results. Formalization in a model allows us to conduct experimentation that is simply impossible in the field, interacting known variables to derive unobvious propositions (Cohen and Cyert 1965, Davis et al. 2007, Gibbons 1999).

We continue by briefly describing how we synthesized the qualitative data to build a model of knowledge exchange as well as the elements and settings of the model. Further details of the empirical study and the model appear in the online companion (available at http://dx.doi.org/10.1287/orsc.1110.0697). We then present three illustrative studies and attendant propositions. We conclude by discussing the implications of propositions for theory and practice.

From Qualitative Data to a Model of Knowledge Exchange

Fieldwork and Site

Our qualitative data were collected by the first author in multiple sites of a top-tier, multinational consulting firm (hereafter, the "Firm," a pseudonym). Headquartered in the United States, the Firm operated through dozens of offices worldwide and employed several thousand professionals and hundreds of support staff. Its annual revenues placed it among the top three companies in its segment, according to industry publications. As its business model turned on the creation, transfer, and reapplication of knowledge across teams and sites, the Firm combined high knowledge intensity with low capital intensity (Anand et al. 2007, Starbuck 1992, von Nordenflycht 2010). Because knowledge processes that exist in any organization were pronounced and central at the Firm, it is a particularly suitable testing ground for the impact of knowledge exchange on organizational performance.

While fieldwork excels in creating vivid accounts of organizational life, modeling requires concurrent balancing of ecological validity with representational simplicity (Burton and Obel 2011), but together can be complementary. To achieve that, we used the qualitative data to decide which constructs should be incorporated in the model and specify its parameters. We sought constructs that were prominent in the field data and related to knowledge processes in the literature. Abstracting from the data on processes of knowledge creation, exchange, and reapplication, we eventually selected those that were sufficiently distinct to represent a range of levels of analysis—individual, organizational, and environment—to rule out that contingency was hinged on a certain variable or level. The constructs, serving as building blocks of the model, were realized as variables by either substituting form variants (exchange patterns; definition follows) or modifying extents (learning norm, organizational memory, environmental turbulence; definition follows). Our interest, ultimately, was in discerning the performance implications of varying these variables in the context of a calibrated model. We report the qualitative findings here insofar as implemented in the model; further details of the fieldwork appear in the electronic companion.

Exchange Patterns: Breadth of Search and Terms of Transfer

Employees of the Firm varied in educational background, professional experience, geographical expertise, tenure, and other variables. Each individual represented an idiosyncratic combination of knowledge that only partially overlapped with others', a common heterogeneity that enables specialization, differentiation, and knowledge transfer. In the field, we observed that members of the Firm took different paths in obtaining the knowledge needed to accomplish their professional tasks. When an employee realized a gap in her knowledge, she engaged in actions that we present analytically as composed of several discrete decision steps. First, the employee decided whether to obtain the knowledge solitarily, for example, by reasoning alone through the problem, or to engage other people (Pondy and Mitroff 1979, Walsh and Ungson 1991). If the seeker decided to involve others for knowledge or referrals (i.e., ask them who can be of help; see Cross and Sproull 2004, pp. 450–451), she could search locally (among teammates and office neighbors) or globally (through the entire organization). When she found a knowledge source, a variety of exchange patterns could be invoked, just as a scholar can casually ask a colleague or hire a professional for help. If the seeker and the source came to an agreement, implicit or explicit, knowledge was transferred and incorporated by the seeker who proceeded to accomplish the task.

Merely having knowledge within an organization is insufficient; knowledge must be locatable and exchangeable to allow one to learn from another's expertise and ultimately benefit performance (Cross and Sproull 2004, Yuan et al. 2010). Following social exchange theory (Blau 1964, Homans 1958), we categorize the transfer of knowledge according to the exchange terms involved by defining prototypical *exchange patterns* (Baker et al. 1998, Flynn 2005).

Self-Learning. Upon realizing that they needed more knowledge about a topic, firm members read reports and manuals and sought information online. *Self-learning* is individualized knowledge acquisition through codified sources, such as textbooks, or self-development of new knowledge through one's existing knowledge, such as a new solution from personal experience (Gagné 1985). The efficiency and effectiveness of self-learning is directly related to the support afforded by the organizational environment. By definition, self-learning does not involve transfer of knowledge from others. It is a useful baseline to assess the benefits of such transfer.

Embedded Exchange. When seeking knowledge, firm members sometimes turned to their local social network, searching among teammates, friends, and acquaintances. Requests ranged from asking a teammate about a statistical function in Microsoft Excel to approaching a member for a comprehensive review of an industry. Following the literature, we define *embedded exchange* as involving a familiar partner under unspecified terms, colloquially known as "quid pro quo" (also known as direct reciprocal exchange; see Molm et al. 2007). Embedded exchange can lead to better performance because the intertwinement of economic and social relations allows trustful sharing and close coordination, which are absent from market exchange (e.g., Granovetter 1985, Uzzi 1997). However, embedded exchange can also harm performance because it is "deep rather than wide" (Uzzi 1997, p. 51): people often to turn to acquaintances rather than search globally (broadly) for the most capable person. Such local (narrow) search can be inefficient because it is likely to settle on a source in close proximity rather than on the global maximum (Ghoshal et al. 1994, Levine and Kurzban 2006). Similarly, laboratory experiments showed that the development and effectiveness of transactive memory can be harmed by interpersonal familiarity in certain conditions (Lewis 2004, Lewis et al. 2007). In an environment similar to that of the Firm, close relationships were found to reduce the likelihood of seeking knowledge outside the focal unit and increase transfer cost (Hansen et al. 2005).

Performative Ties. Members of the Firm sought knowledge not only from acquaintances but also approached unacquainted others: people they had neither met nor been referred to. For instance, a manager and partner in a European office called an unacquainted partner in an Australian office and had him devote considerable time, uncompensated, to supporting their wooing efforts of a potential client in Germany. This pattern of help from the unacquainted resembles similar reports in other firms (e.g., Constant et al. 1996, Lazega 2001) and among technology users (Lakhani and von Hippel 2003, Levine and Prietula 2010) and entrepreneurs (Kalnins and Chung 2006). From a practitioner's perspective, performative ties should be highly desirable. They are featured in descriptions of organizational communities and clans (e.g., Brown and Duguid 2000, 1991; Wenger and Snyder 2000). The exchange between unacquainted individuals is sustained in a "pay-it-forward" manner, one associated with community, generosity, kindness, and "good Samaritan" ethics. For instance, members of the Firm responded to requests even when it was clear that the beneficiary would be unable to reciprocate, whether because of a lack of resources or because future interaction was unlikely. It was based on generalized exchange, which is quite different from market exchange or the exchange of favors between friends and teammates, because it neither requires immediate reciprocity nor creates an obligation to a *specific* benefactor (Baker and Levine 2010, Molm et al. 2007, Yamagishi and Cook 1993). As a manager in a Canadian office told us, "I expect that when I need information I can send out a call to the system, to the company as a whole, and expect to get a response back. So again, there is very little direct reciprocation; you get reciprocation from the system, by and large."

We define a *performative tie* as a generalized exchange transaction between unacquainted individuals. It combines (1) global search for the most suitable exchange partner and (2) exchange without direct reciprocity once that partner is found. Performative ties are discussed in the popular managerial literature under a variety of terms, often involving the words "community" and "sharing." In any version, they are thought to benefit performance because they combine global search and generalized exchange. Global search for the best solution is a feature typically associated with markets. But unlike in a market exchange, once a source is identified performative ties allow obtaining the knowledge quickly, as if the seeker had a preexisting close relationship with the source, without haggling or strict bookkeeping.

Market Exchange. Based on the logic of a neoclassical economic market, *market exchange* "functions without any prolonged human or social contact among or between the parties" (Hirschman 1982, p. 1473). The responsibilities of the sides are specified: each commits to delivering a good or a payment of certain quantity and quality at a certain time. In the search for knowledge, a market setting can expand the choice of exchange partners because the search is global, extending well beyond one's circle of acquaintances. Hence, the gains are potentially greater. However, a drawback is the need for simultaneous exchange: each side must have something desirable by the counterpart, or the transaction cannot ensue. Additionally, the arms-length nature can hinder customization, increase risk, and introduce negotiations costs (Davenport and Prusak 1998, Molm et al. 2007, Uzzi 1997).

Organizational Features

Search: The Knowledge Index. To facilitate global search, and in line with recommendations for

"knowledge management," the Firm put much effort into its *knowledge index*. Meant to map sources of internal expertise, it was a large database, akin to an internal telephone book, which knowledge seekers used to identify potential sources. Popular management writers view it as a worthy effort, because "such maps [of expertise] are extremely helpful in connecting people, and people are still the best source of deep expertise" (Ruggles 1998, p. 84). The knowledge index charted the Firm's differentiated transactive memory (Hollingshead 2001; Lewis et al. 2005; Wegner 1986, p. 204), which tracked who knows what. The knowledge index provided brief descriptions of members' expertise as a way to facilitate, rather than substitute, person-to-person search, contact, and eventual exchange. It was not meant to document knowledge comprehensively, just to serve as a pointer to knowledgeable individuals. In the model, it is necessary for the two exchange patterns that rely on global search: *performative ties* and *market exchange*. Because it facilitates search, the knowledge index is an organizational feature that economizes on the cost of search and exchange. Its inclusion, therefore, makes our estimation more conservative; search without the knowledge index will be costlier.

From a practitioner perspective, the knowledge index embodied many of the recommendations associated with practices such as Enterprise 2.0, corporate social networking, and corporate social media applications (Sena and Sena 2008, *Economist* 2010). It was a single platform encompassing the entire organization, meant to help people find information and guidance quickly. It did not focus on showcasing documents, but rather on creating social connections in an organization whose norms encouraged informal collaboration and management supported it. It did not impose specific structure on the interaction or the information transmitted. In short, it seemingly met many of the prescriptions for successful implementation of knowledge systems (McAfee 2006, pp. 25–27; 2009). This is a conservative bias in our model.

The Cost of Knowledge Search and Exchange. As we observed in the field and is often recognized in the literature (Haas and Hansen 2005, Szulanski 2000), knowledge exchange is not without cost or friction. At the very least, it involves the costs associated with locating sources, querying, negotiating, engaging in transfer, and integrating the acquired knowledge. Self-learning comes at the expense of working on solving the assigned task. We model the cost as productivity delays, both direct and indirect, in three ways. First, a knowledge-seeking agent faces opportunity costs because it cannot search and self-learn simultaneously. Second, the knowledge source faces similar costs as limits on attention allocation preclude work on other tasks while exchanging (Levitt et al. 1999, Perlow and Weeks 2002). Third, costs are incurred because of errors, bias, or subjective presentation in transfer (Galbraith 1990, p. 64; Teece 1977; Wittenbaum et al. 2004). We conservatively model only some of the direct costs of transfer, not the costs associated with facilitating search (e.g., computers, manpower, communication, travel).

Learning Norms: Organizational Support for Learning. Knowledge acquisition involves learning, necessary to integrate the new knowledge. Organizations that provide stronger support for learning, i.e., possess stronger learning norms, are quicker in learning new problems, adjusting to changes in existing problems, and identifying and responding to environmental changes (Cohen and Levinthal 1990). Organizational options to support learning are the "ecological system of factors" (Argyris 1994, p. 123) that affect the pace at which individuals learn in an organization. This pace is represented in our model as a *learning norm*: a general learning rate. Although expressed here as a single parameter, we see learning norms as embodying the influences of several interrelated characteristics that define how the organization supports learning. A learning norm subsumes, for instance, past experience that facilitates present learning (Galbraith 1990), team-embodied skills (Nelson and Winter 1982), the informal practices by organizational members (Wijnhoven 2001), and the general socialization components espoused by the organization (Brown and Duguid 2000, March 1991, March et al. 1991). Because these practices vary widely across organizations (Dutton and Thomas 1984, Reagans et al. 2005), there can be substantial variance in the attendant learning rates (for a discussion, see Argote 1999, pp. 19–22; Argote and Darr 2000, p. 53). Thus, for the purposes of this model, the variation in learning rates across organizations is dominated by organizational learning norms, not by individual differences (cf. Cohen and Levinthal 1990, March 1991). In Study 1, we explore how different learning norm levels impact performance across exchange patterns.

Organizational Memory: Brains and Paper. According to a prominent definition, organizational memory is the "stored information from an organization's history that can be brought to bear on present decisions" (Walsh and Ungson 1991, p. 61). The model captures organizational memory in its entire breadth while maintaining an important distinction. As described above, members of the Firm accessed organizational memory retained in *social* and *asocial* forms, e.g., by approaching a colleague with a question or by searching a library database. Congruent with our field data, theory suggests that organizational knowledge is retained in several categories or "bins" (Walsh and Ungson 1991, p. 63); access to some requires social interaction (Galbraith 1990; Nelson and Winter 1982, pp. 96–138), while others can be accessed asocially (Argote and Darr 2000;

Walsh and Ungson 1991, p. 65). The same is echoed in the distinction between "brains and paper" (Pondy and Mitroff 1979, p. 19). Some organizational memory is stored on paper and thus accessible without interaction, e.g., job descriptions and standard operating procedures. Other organizational memory is stored in the brains of some organizational members. The model allows for both modes of retrieval: social retrieval is modeled through the exchange patterns, and asocial retrieval is modeled through access to the (nonsocial parts of) organizational memory. Asocial retrieval also includes knowledge that is contained in structure and technology (Argote and Darr 2000).

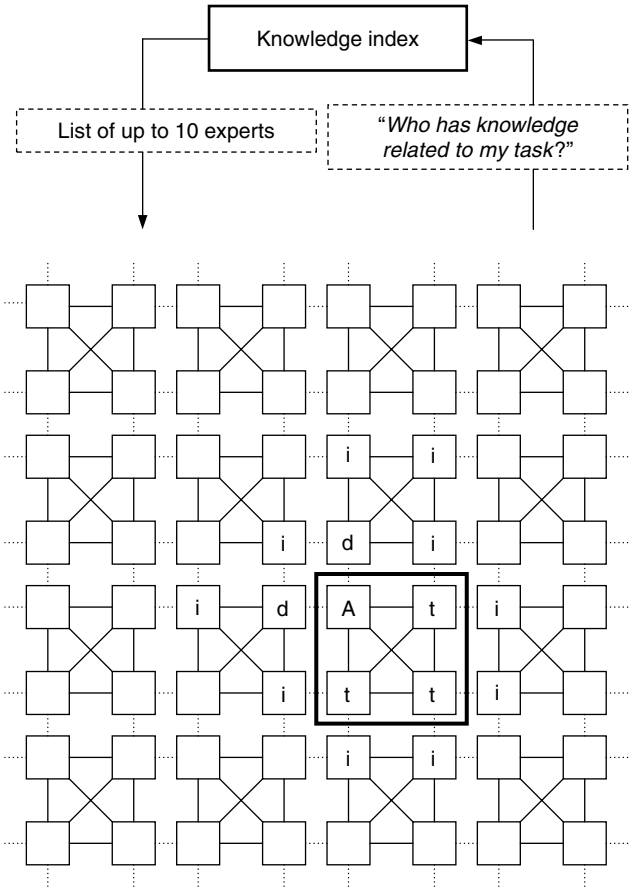
The model recognizes that even asocial organizational memory is not always a tidy library. Rather, organizational memory can be distributed or fragmented, and individuals may face difficulties accessing it (Walsh and Ungson 1991, pp. 69–70; Weick 1979, p. 206). Excessive workloads, differing experiences, and poor documentation practices are examples of access limitations, both cognitive and organizational. These are expressed in the model as a single variable reflecting the general combined capacity of an organization, through its members, to provide access to knowledge. In Study 2, we examine how different organizational memory capacities impact performance across exchange patterns by varying the comprehensiveness of the information in the organizational memory from low (each agent can asocially retrieve knowledge for one task, which is 0.4% of the organizational problem size) to moderate (10 tasks, 4%) to large (128 tasks, 50%) to full (256 tasks, 100%).

Environmental Turbulence: When Knowledge Becomes Obsolete. No two projects were identical in the Firm, leaving members struggling to determine how applicable knowledge obtained elsewhere, in a different region or industry or at an earlier time, was to a current task. Recurrent was a concern about the reusability of knowledge as circumstances change—that is, to what extent knowledge obtained in one environment is applicable to another. In the model, *environmental turbulence* is represented through the extent to which past knowledge is still applicable to a current task, as has been done in the literature (e.g., Tripsas 1997). Turbulence is modeled as a cause of knowledge invalidity, whether real or perceived, stemming from any origin (e.g., Henderson and Clark 1990, Shamsie et al. 2009, Tripsas and Gavetti 2000, Westphal and Zajac 1998). In Study 3 we examine the effects of environmental turbulence on the organization's performance over a series of five problems, across exchange patterns.

The Model

The model was implemented as an agent-based simulation embodying stylized behaviors as identified in the field and literature (e.g., Szulanski 2003): an organization is faced with a problem (e.g., a consulting project,

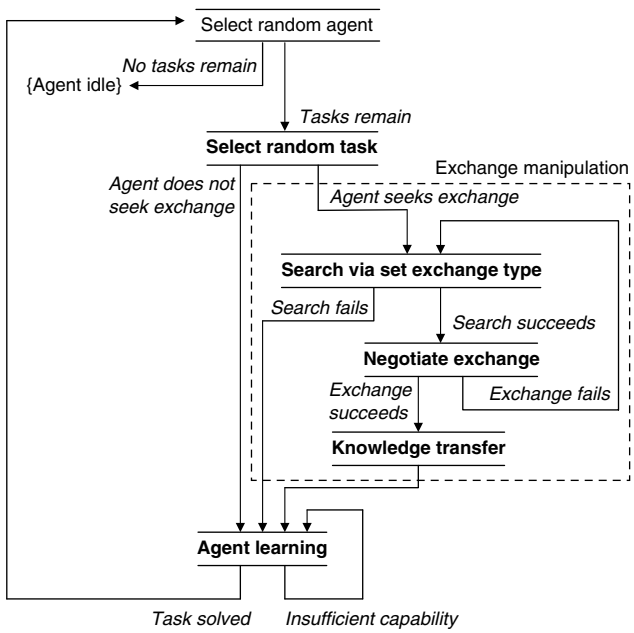
Figure 1 Sources for Knowledge: Direct and Indirect Ties and Knowledge Index



a new product development effort) that is defined as a series of unique tasks, which are assigned to agents. *Organizational performance*, which is the dependent variable in all of the studies, is the number of periods needed to solve the organizational problem (Hansen 1999, 2002; Hansen et al. 2001). To aid in comprehension, we present the marginal improvement in performance over a base case, as detailed in the graph captions. Additional technical details are included in the electronic companion.

Organizational Structure and Tasks. The organizational structure modeled is an abstraction based on field data. It remains unchanged throughout the experiments. It features closely aligned teams, interteam connections, and indirect ties. Superimposed is an indexing system that transcends structural ties. The organizational structure (see Figure 1) consists of 64 agents organized in 16 project teams. Agents maintain direct ties with team members and neighbors (Festinger et al. 1950) and can access indirect ties through referrals. In Figure 1, agent A has *direct* ties with its three team members (t) and with two neighboring agents (d), who are members of other teams. Agent A also has 11 *indirect* ties (i), through an intermediary (t or d), to members of other

Figure 2 Agent Behavioral Algorithm



Notes. Indicated are the five different core processes (in bold) and their sequences. In any given period, an agent is engaged in only one process at a time, where some processes may require several periods (e.g., learning), and some processes are contingent on the consequences of others (e.g., transfer requires successful negotiation, and that requires successful search).

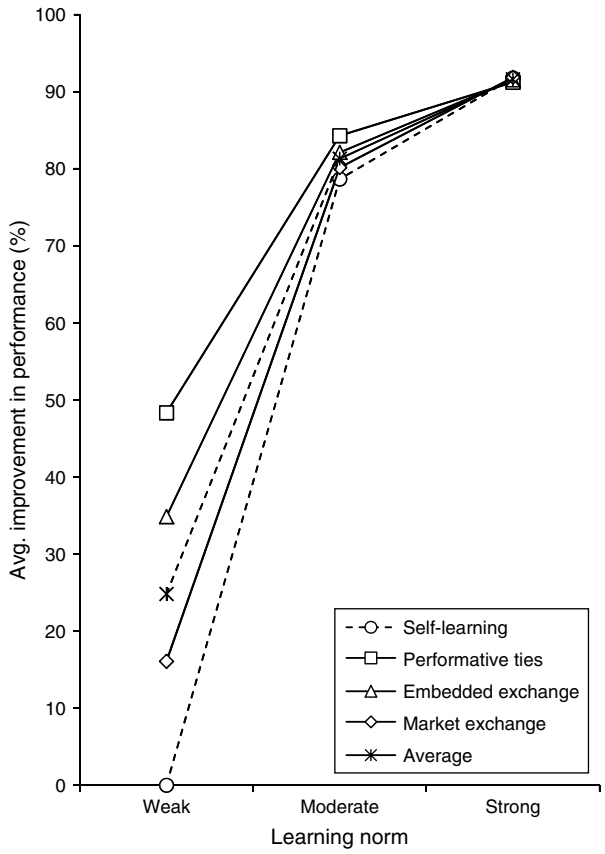
teams. Indirect tie searches reach all agents within a distance of one indirect tie (regardless of team membership). The absence of ties reaching further distances reflects the general observation that ties spanning more than one intermediary have a much lower probability of successful exchanges than more-immediate ties (Dodds et al. 2003). Thus, the set of agents connected by direct and (restricted) indirect ties forms an agent's local social network of 16 agents. Agents at the edges are connected to those at the other edge of the same row/column in a "wrap-around" structure. The knowledge index lists the agents whose expertise is associated with each task (if any) but does not contain the knowledge itself. Agents who search globally (based on their exchange pattern) query the index and receive up to 10 contacts with which they can attempt exchange. The organizational problem consists of 256 independent tasks, so each agent receives four tasks on average. Each task is randomly assigned to one agent, and all agents process their tasks in parallel. Tasks in this model are construed as nonanalogous, so knowledge is gained with strict independence. For example, completing one task does not facilitate completion of another; the current level of knowledge about a certain task does not affect the learning of a new task (Gavetti et al. 2005).

Agent Behavioral Algorithm. The processes of an agent (see Figure 2) consist of searching, negotiating with knowledge sources, learning, and responding to incoming requests for knowledge. The fundamental algorithm is simple: an agent is assigned a task, attempts to complete it by directly applying its own knowledge (if it exists), or it searches the organization (according to its exchange pattern) for some other agent that does have the knowledge and requests an exchange. If necessary, the agent will learn on its own. Upon completion, the agent is assigned another task. If no more tasks exist, the agent will become idle but can still respond to requests for knowledge.

Each agent is boundedly rational, capable of accumulating knowledge for 10 unique tasks. It has an initial knowledge endowment that is randomly determines for which tasks it has knowledge and at what level, thus simulating experience with previously encountered tasks. Therefore, when faced with the problems in the simulation, a subset of agents will have some knowledge to contribute either directly (to their own task) or indirectly (requests from other agents). In addition to knowledge, each agent is assigned an exchange pattern that determines the breadth of its search and terms of exchange. In a given manipulation, all agents are assigned the same exchange pattern. Acquisition of knowledge from others facilitates task completion but incurs a transfer cost in terms of performance delays. Knowledge accumulates as a nonlinear decreasing function of the number of periods that an agent dedicates to the task; that is, knowledge accumulates more rapidly in the early stages than in the later stages, reflecting a well-known tendency (Newell 1990, Ritter and Schooler 2001). The rate at which an agent learns serves as the expression of the learning norm and is also present to complement insufficient transfer. The default learning norm is held constant ($\alpha = 0.1$), except for when it is manipulated (see Study 1).[1]

Exchange patterns are modeled as per the descriptions above: for agents using embedded exchange, search will begin by querying direct ties, followed by indirect ones. The process ends when the agent finds the first agent with knowledge of that task. Those using performative ties or market exchange will engage in global search by using the knowledge index. In all exchanges, the source must be free to even consider transfer; transfer happens only if the seeker and the source reach an agreement based on the exchange patterns of both. Specifically, in market exchange, exchange will ensue only if *each* agent has knowledge that the other one needs. Embedded exchange and performance ties do not require immediate reciprocity. If search leads to successful exchange, then knowledge is transferred and assimilated by the seeker. The model accounts for cost and friction in knowledge transfer as described previously in the Cost of Knowledge Search and Exchange section. If search or negotiation fails, the seeker engages in self-learning as long as necessary to have sufficient knowledge for task completion.

Figure 3 Average Improvement in Organizational Performance Over the Base Case (Self-Learning, Weak Learning Norm) Across Learning Norms and Exchange Patterns (Study 1)



Experiments and Results

Study 1: Learning Norms and Exchange

We examined the performance impact of the interaction between three learning norm levels and the four exchange patterns. We calibrated the *base* learning norms to reflect three levels of norms supporting learning (cf. Simon 1991), using a logarithmic scale to capture a sufficiently diverse set: weak ($\alpha = 0.01$), moderate ($\alpha = 0.10$), and strong ($\alpha = 1.00$).[2]

Method. A total of 300 runs were made, with 25 replications per condition.[3] Each replication represented a random distribution of initial knowledge held by the agents while holding the specific organizational problem constant across replications. An analysis of variance was conducted on the resulting performance data.

Results. We found strong main effects for *learning norm* and *exchange pattern* but a less obvious interaction effect as well: the differences in performances across types of knowledge exchange are significantly lower when learning norms are strong. Put differently, the benefits of knowledge exchange are lower when organizational support for learning is high, suggesting a compensatory effect. Figure 3 illustrates the results of a 4×3 factorial analysis: higher learning norms result in better performance, albeit with decreasing marginal improvements (on the x axis, cf. the change from Weak to Moderate and from Moderate to Strong). The main effect for exchange patterns can be seen in the same figure, where *performative ties* and *embedded exchange* perform above the average line. However, performance of the various patterns converges as learning norms become higher.

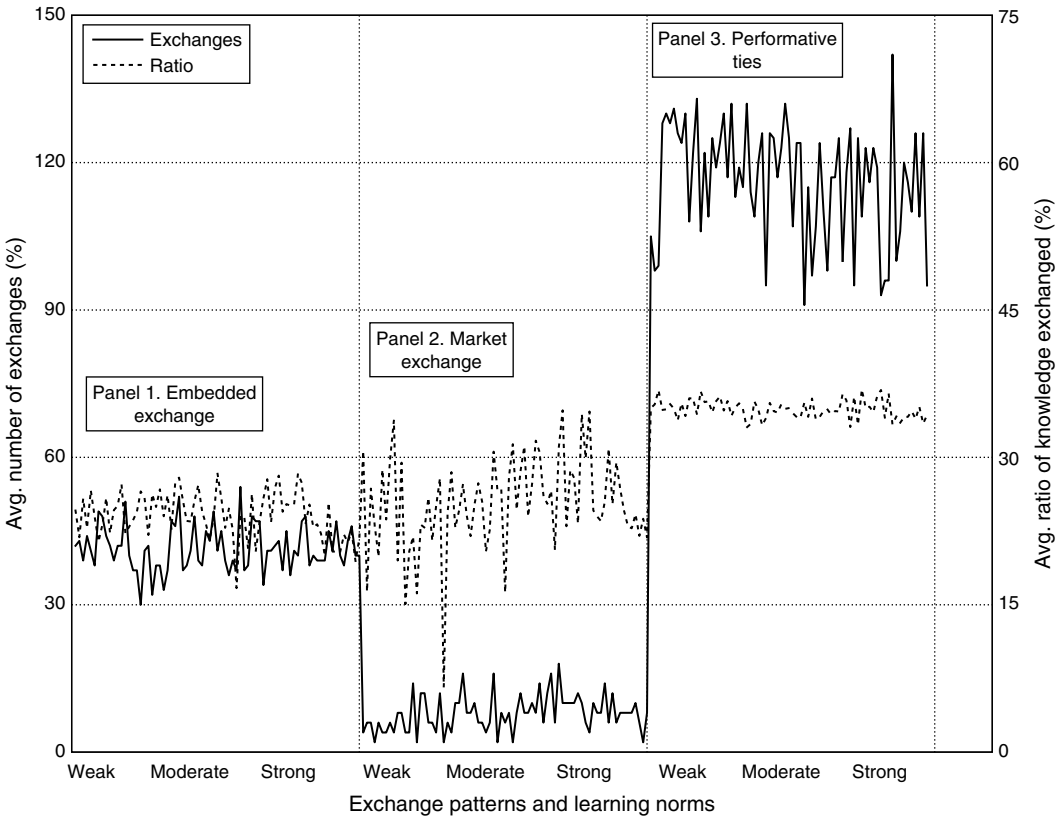
As expected, we found that over the mix of exchange patterns, stronger support of learning leads to better organizational performance but at a decreasing marginal rate. We also confirmed that over the entire mix of learning norms, exchange patterns with broader search and more generalized exchange lead to better organizational performance. Analysis shows significant differences in performance among the learning norms (see "Average" in Figure 3, strong > moderate > weak; all $p < 0.001$). Among exchange patterns, *performative ties* outperforms *market exchange* ($p < 0.05$) and *self-learning* ($p < 0.001$). When all learning norms are combined, only the *performative ties* pattern differs significantly from the group.[4] The two main effects, however expected, reproduce outcomes consistent with known empirical evidence and theoretical assertions, thus adding to the validly of the model (e.g., Argote 1999).

More revealing results were found in the interaction between exchange patterns and learning norms (see Figure 3). When learning norms are weak, the *relative* benefits of exchange patterns are significantly higher, resulting in distinct performance differences among them. However, these differences evaporate when learning norms increase. The statistical analysis confirms the observational conclusions with a prominent interaction effect ($F_{6,288} = 909.18$, $p < 0.001$, $\eta_p^2 = 0.950$), where the performance impact of exchange patterns varied with the learning norm. Under weak learning norms, the difference among the exchange patterns is significant (*performative ties* > *embedded exchange* > *market exchange* > *self-learning*; all $p < 0.001$), but under strong learning norms, these differences are statistically indistinguishable. Consequently,

Proposition 1 (Knowledge Exchange–Learning Norm Trade-off). *The marginal benefits of knowledge exchange vary inversely with organizational support for learning.*

One might expect complementarity between support of learning and knowledge exchange, because learning support increases the cache of knowledge and enables more exchange. It is easy to image some virtuous cycle of mutually reinforcing effects, where learning bolsters exchange, which in turn increases learning. The results, however, speak of substitution effect: support for learning can replace knowledge exchange. Managers can

Figure 4 Knowledge Transfer Across Exchange Patterns and Learning Norm Levels (Three Panels)



Notes. The figure shows the average number of transfers made in solving the organizational problem (left y axis, solid line) and the average contribution ratio for the transfers, i.e., the percentage of knowledge required for the task that was actually transferred = knowledge transferred/knowledge required (right y axis, dashed line). Each panel depicts one exchange pattern over three levels of learning norms.

compensate for the costs and limitations of knowledge transfer by bolstering support for learning. As shown in Figure 4, the number of exchanges and the contribution ratio remain fairly constant within each exchange pattern and over different learning norms. Thus, the performance gain associated with stronger learning norms is not the result of more numerous or more comprehensive transfers, but it comes from the compensatory nature of individual learning. Embedded exchange has limited search extent; market exchange has broader search but comes with haggling costs; and performative ties, despite easing search and exchange, still incur search and transfer costs. For that, stronger organizational support for learning can deflate the performance benefits associated with knowledge transfer.

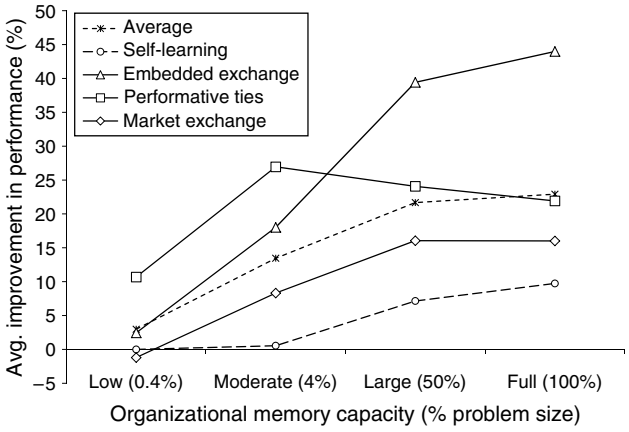
Study 2: Organizational Memory and Exchange

As discussed above, organizational memory is retained in multiple forms; some require access through social interaction and exchange ("brains"), while others can be accessed asocially ("paper"), without contacting others. We vary the capacity of asocially accessible organizational memory available to each agent over the gamut of exchange patterns, which comprise the socially accessible component of organizational memory. We examine the performance impact of the interaction.

Method. Four levels of asocially accessible organizational memory capacity (organizational memory) were examined by manipulating the size of the agents' knowledge vectors, K: low (each agent can asocially retrieve knowledge for 1 task, which is 0.4% of the organizational problem size), moderate (10 tasks, 4%), large (128 tasks, 50%), and full (256 tasks, 100%). These levels were crossed with the four exchange patterns with the learning norm held constant at moderate. All initial task knowledge and levels were assigned randomly, and a total of 400 runs were made in a 4×4 factorial experiment, with 25 replications per cell. An analysis of variance was conducted on the resulting performance data.

Results. We found a main effect for organizational memory as well as an interaction effect that highlights the contingent value of global knowledge exchange. As expected, we found that knowledge transfer improves performance: over the range of organizational memory capacities, organizations that rely on knowledge transfer outperform those that rely on self-learning. As can be

Figure 5 Improvement in Organizational Performance Over the Base Case (Self-Learning, Low Organizational Memory Capacity) Across Exchange Patterns and Organizational Memory Capacities



seen by flowing the Average line in Figure 5, increasing organizational memory capacity leads to better organizational performance over a range of exchange patterns, and any pattern of knowledge exchange leads to better performance than self-learning, on average. This observation is supported by the statistical results ($F_{3,384} = 1203.45$, $p < 0.001$, $\eta_p^2 = 0.904$) where organizational performance increased as capacity increased (low > moderate > large, full; $p < 0.01$).[5] Organizational performance differed across exchange patterns ($F_{3,384} = 1{,}400.67$, $p < 0.001$, $\eta_p^2 = 0.916$), with *self-learning* performing the worst compared with an average of the other three patterns.

While increasing organizational memory capacity improves performance, the benefits are marginally decreasing (see Figure 5, Average line). The exchange pattern plot lines show that while the benefits hold on average, each pattern responds differently to a change in organizational memory capacity. Performative ties boost performance at low and moderate organizational memory levels, but the benefits quickly diminish as memory capacity increases, causing in an inverted U-shaped relationship. In contrast, *embedded exchange* underperforms *performative ties* at the lower levels, but it dominates all exchange patterns at the large level and beyond, exhibiting increasing benefits to performance. This interaction is statistically significant ($F_{9,384} = 209.77$, $p < 0.001$, $\eta_p^2 = 0.831$).

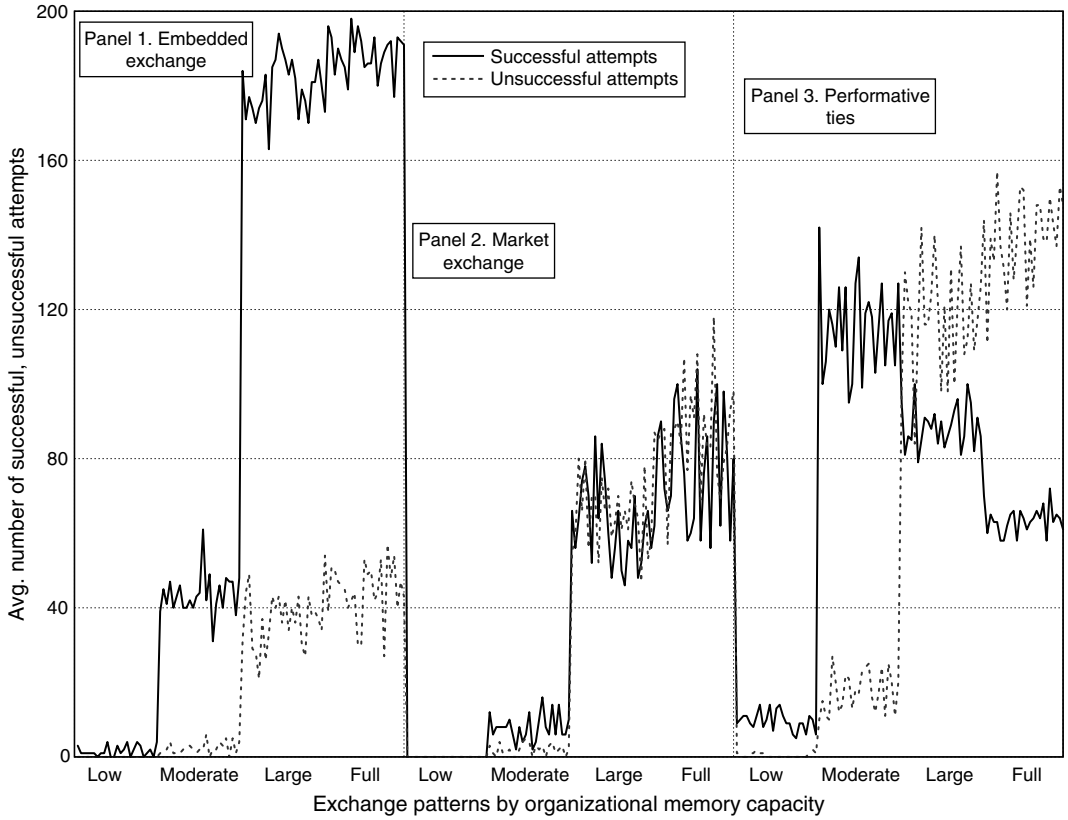
Why do the effects of exchange patterns vary with organizational memory capacity? At low memory levels, agents have little access to knowledge and therefore cannot use much or offer much to others. As a result, organizations relying on embedded or market exchange perform indistinguishably from those relying on self-learning alone. While performative ties significantly benefit performance at the low and moderate levels, the value of global search diminishes if the capacity of organizational memory is beyond that. Then, the performance benefits of both performative ties and market exchange are reduced, while embedded exchange, which relies on local search, continues to improve performance.[6] Overall, the declining benefits of global search drive down the average returns on knowledge transfer. Hence,

Proposition 2 (Organizational Memory–Global Knowledge Exchange Trade-off). *As organizational memory capacity increases, global knowledge search leads to a relatively slow improvement in organizational performance, while local search and self-learning become more effective.*

While it may appear plausible that broader exchange of knowledge is better for performance, the results suggest otherwise. Intuitively, the performance benefit of local search is driven by two mechanisms. The first is the *appearance of local experts*; when each agent has access to more organizational memory, the agent is more likely to find the knowledge it seeks *locally*. With greater access to organizational memory, more sought-after knowledge can be found without global search, either through direct access to broader organizational memory or by querying teammates and neighbors (direct ties), who also enjoy broader access to organizational memory and are thus more likely to possess sought-after knowledge. As a result, exchange patterns that rely on local search, such as embedded exchange, perform better. The increased benefits of local search interact with the rising *cost of search and exchange*, the second mechanism, modeled through a productivity loss for those engaging in exchange, a conservative approach that excludes other costs. Greater capacity of organizational memory means that an agent can accumulate enough knowledge to master not just few, but many, tasks, becoming something of a "super expert." With such broad and deep mastery, it receives queries from many knowledge-seeking agents. The volume forces such super experts to queue requests, resulting in delayed response and time-consuming search for the seekers. The burden also slows the completion of the super experts' own tasks. The two effects combine to hurt organizational performance.

Evidence of these processes can be gleaned from the pattern of successful and unsuccessful attempts at knowledge transfer (see Figure 6). At lower levels of organizational memory capacity, low levels of exchange activity are evident across all patterns. Only a global search is likely to find useful knowledge; in its absence, a seeker must engage in self-learning. As memory capacity increases, more nearby agents—teammates and neighbors—are likely to possess the sought-after knowledge, as can be seen in the steep increase of successful embedded exchange transfers. While these local experts may not be as knowledgeable as the super experts, they are less burdened and freer. In contrast, the global search inherent in performative ties saddles the super

Figure 6 Knowledge Transfer Across Exchange Patterns and Organizational Memory Capacities (Three Panels)



Notes. The figure shows the average number of successful and unsuccessful exchange attempts made in the course of solving the organizational problem. Each panel depicts one exchange pattern over four levels of organizational memory capacity.

experts and frustrates attempts to reach them (see Figure 6, right panel, dashed line). For market exchange, which employs global search and requires immediate quid pro quo, every successful exchange requires haggling, rendering both agents busy and unable to respond to other requests. When we examine the average transfer ratio, the results among the three exchange patterns are statistically indistinguishable (*embedded exchange* = 20.0%, *market exchange* = 21.4%, *performative ties* = 24.5%). Therefore, the critical element is not simply having knowledge but being able to efficiently distribute it where and when it is needed (Cross and Sproull 2004, Yuan et al. 2010).

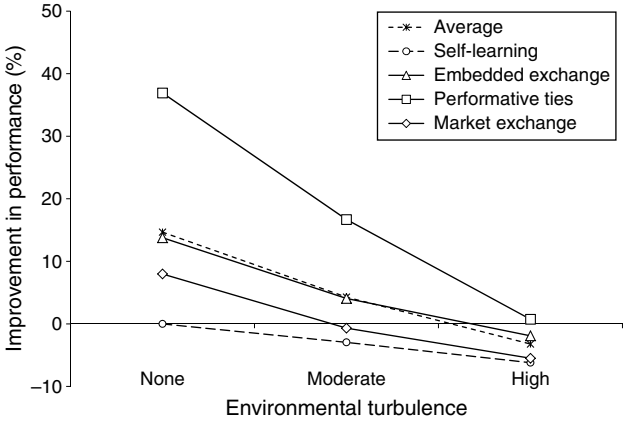
Study 3: Environmental Turbulence and Exchange

It is likely that organizations perform better in less turbulent environments, but does the value of knowledge transfer vary because environment turbulence interacts with the exchange pattern? We find that exchange patterns that perform well in a stable environment (as in Studies 1 and 2) may add little to or even harm performance in a turbulent environment (cf. Pfeffer and Sutton 1999).

Method. As in the other studies, an organization was assigned a problem, but after completing all of its 256 underlying tasks, it was presented with a new problem of the same size but not necessarily the same tasks. This was repeated sequentially until the organization solved five problems totaling 1,280 tasks. As has been done in studies of competence and environmental change (Tripsas 1997), turbulence was operationalized as the fraction of knowledge that remains usable across a series of problems; that is, the higher the turbulence, the less past knowledge can be reused on current problems. Three levels of turbulence were defined to cover the midpoint and extremes of the construct space: none (100% usable knowledge), medium (50%), and high (0%). These were crossed with the four exchange patterns. Three hundred runs yielded 1,500 problems in total in a 3×4 factorial design.

Results. Two expected main effects are evident and serve to support the validity of the model, but an unobvious interaction effect appeared as well. First, examining the Average plot line in Figure 7, it is clear that organizational performance decreases as turbulence increases over the mix of exchange patterns. Second, there are performance differences across exchange patterns: performative ties provide substantially better performance, while self-learning does poorly. These observations

Figure 7 Change in Organizational Performance Over the Base Case (Self-Learning, No Turbulence) Across Exchange Patterns and Environmental Turbulence (Study 3)



Note. Each point reflects the average performance change over five sequential problems.

are supported by the statistical analyses: organizational performance decreases as environmental turbulence increases ($F_{2,1,488} = 952.97$, $p < 0.001$, $\eta_p^2 = 0.562$),[7] and organizations that use knowledge exchange perform better than organizations that rely on self-learning across all levels of turbulence ($F_{2,1,488} = 756.50$, $p < 0.001$, $\eta_p^2 = 0.604$), with performative ties performing the best across all exchange patterns.

Once again, however, the effects of knowledge exchange are contingent: an increase in environmental turbulence results in attenuation of the performance advantages of some exchange patterns (see Figure 7). As the stability of the environment decreases, so does the performance of all exchange patterns, and the *differences* between them decrease until the advantage of knowledge transfer disappears altogether. Again, this interaction is supported by the analysis ($F_{6,1,488} = 123.00$, $p < 0.001$, $\eta_p^2 = 0.332$). Consequently,

Proposition 3 (Knowledge Exchange–Turbulence Trade-off). *Performance differences between exchange patterns diminish as environmental turbulence increases.*

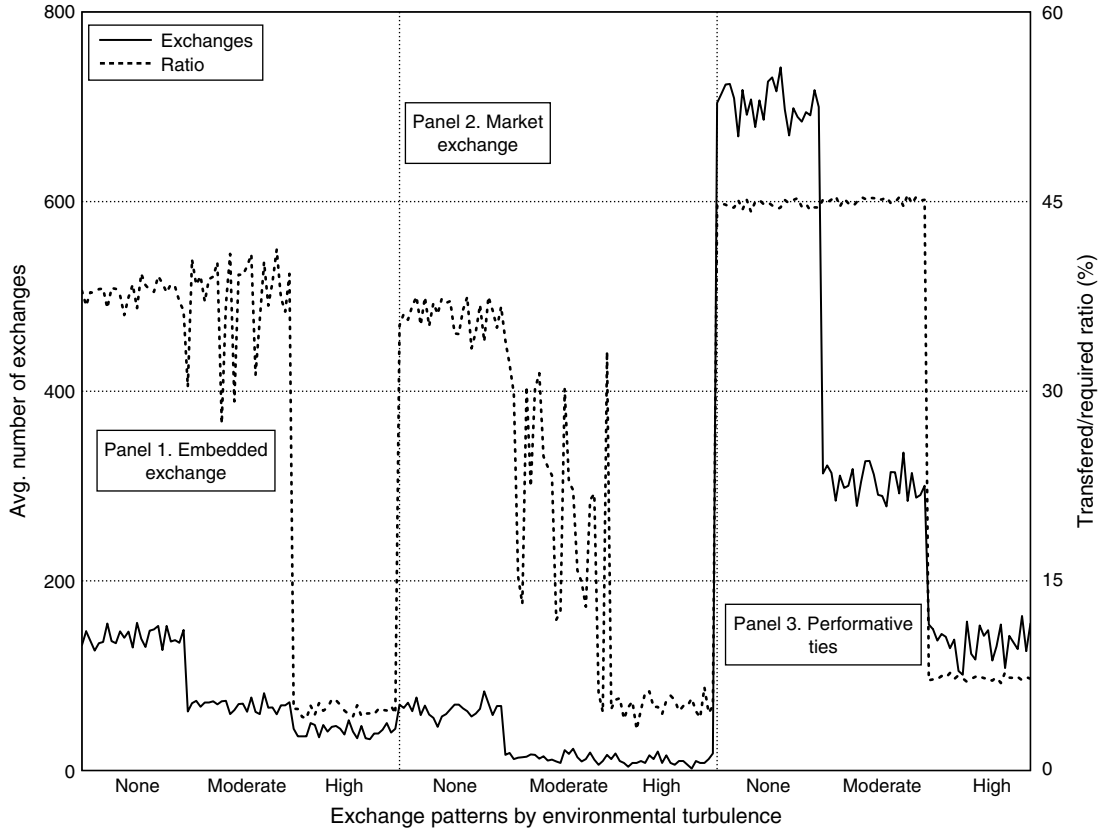
Intuitively, when knowledge is absent from the organization, attempts at exchange are wasteful because the opportunity cost associated with failed search weighs down on organizational performance. According to Figure 8, as turbulence increases, the average number of exchanges for each exchange pattern drops, but *performative ties* retains a substantial advantage over the other exchange patterns. Examining the transfer ratio shows that both embedded and market exchange suffer increased variance as turbulence increases to moderate. For the former, variance increases because local knowledge is degrading, and its is presence unstable; for the latter, it increases because of exchange constraints. For *performative ties*, the number of exchanges decreases under moderate turbulence, but the higher levels of transfer are maintained thanks to the combination of broader search and generalized exchange. However, the advantage of performative ties collapses in high turbulence, where both the number of transactions and transfer ratio drop for all exchange patterns, and performance becomes almost identical (transfer ratio for *embedded exchange* = 4.7%, *market exchange* = 5.1%, *performative ties* = 7.3%). In a stable environment, the exchange of knowledge is beneficial because knowledge developed on one occasion can be reused in subsequent problems. But when the organization operates in a highly turbulent environment, members are unlikely to receive useful knowledge from others. The knowledge seeker spends time, attention, and other resources on a search that is likely to bring about but outdated knowledge. So, while the cost for searching and exchanging is ever present, the benefit can be negligible.

Discussion and Conclusion

Managers at the Firm held strong belief in the virtues of knowledge transfer. "Belief" is the right word here, because obtaining data to justify their investments was nearly impossible. During our fieldwork we saw managers contemplating the fate of programs meant to facilitate knowledge transfer, such as an expensive "visitor program" that encouraged members to relocate and work in offices outside their home country, a generous travel budget set aside to allow international gatherings and sports tournaments, or a mandatory (but unpopular) policy of rotating desks and office space every few months so that "everybody ends up sitting next to everybody." They were following a popular prescription to "structure" social interaction to facilitate knowledge transfer. But when we were asked about the scientific prescriptions for investment in knowledge transfer, we realized how difficult it was to state equivocally whether investment in promoting interaction and knowledge transfer would lead to better performance.

Based on the three illustrative studies, we proposed a general principle of contingency in knowledge exchange. We began by reviewing gaps in our knowledge along with empirical indications of such contingency. We then presented an agent-based model constructed from field data and used it to explore the relationship between knowledge exchange and organizational performance. We exploited the strength of modeling by having two seemingly well-understood constructs interact, thereby revealing unexpected effects. The results support the notion that the performance impact of organizational knowledge exchange varies as it interacts with individual, organizational, and environmental characteristics. We found several expected effects that serve to validate the model, but we focused on the interaction effects, which support the contingency proposition.

Figure 8 Knowledge Transfer Across Exchange Patterns and Turbulence Levels (Three Panels)



Notes. The figure shows the average number of total transfers made in the course of solving the five organizational problems (left *y* axis) and the ratio of knowledge transferred to knowledge required averaged across the five problems (right *y* axis). Each panel depicts one exchange pattern over three levels of environment turbulence.

The *exchange–learning norm trade-off* (Proposition 1) implies that when the organizational support for learning is high, performance can remain high even without much knowledge exchange. As an illustration, the Firm, like many consulting firms, invested heavily in promoting individual learning through a variety of asocial sources: on-site libraries, archives of past work, and online training materials. Our model predicts that such investment will *reduce* the benefits from knowledge transfer, because support for learning substitutes, not complements, knowledge transfer. This insight is absent from the popular managerial literature, where few recognize that investments in learning support and knowledge exchange can be substitutable. In fact, much of the popular advice promotes simultaneous investments in both, which we predict to be inefficient, even wasteful. The model explicates the underlying processes to propose a general principle. Furthermore, it explores the specific form of the trade-off and allows meaningful comparisons across conditions.

The *organizational memory–global knowledge exchange trade-off* (Proposition 2) suggests that far-reaching, expansive knowledge exchange may be unimportant for or even harmful to performance. Responsive employees who are eager to share with anyone may appear desirable, but the performance implication of such behavior is highly contingent. The trade-off may account for the seemingly contradictory performance effect of codified knowledge in franchise pizzerias versus consulting firms. Because pizzerias rely on local search, they reap benefits from broader access to knowledge stored (asocially) in organizational memory (such as standard operating procedures; see Argote and Darr 2000, Darr et al. 1995) and from access to local experts, with whom seekers are already acquainted. The same may take place in industrial settings (Epple et al. 1996). In the firm, in contrast, global search through the knowledge index was routine in most projects, periodically overburdening the firm's foremost experts, forcing them to choose between responsiveness (to others) and responsibility (toward their own tasks), resulting in slow replies and work delays. The proposition is further supported by another account of performance in a consulting firm, where knowledge exchange was found to improve work quality and signal competence, but did not save time (Haas and Hansen 2007). As discussed earlier, processes such as the appearance of local experts and the rising cost of search and exchange make local search more

rewarding and global search more expensive when organizational memory is larger. For optimality, therefore, an organization's exchange pattern must fit the organizational memory features. Large organizational memory, as in the pizzerias, fits well with local search and reliance on local experts. Smaller organizational memory can be augmented by global search. But simultaneous investment in both organizational memory and global search, however popularly prescribed, may be wasteful and undermine performance altogether.

Finally, the *exchange–turbulence trade-off* (Proposition 3) implies that organizations operating in turbulent environments may find that investment in knowledge exchange harms performance, not enhances it. This can help explain the persistent value of local knowledge even in the presence of readily available distance knowledge, shown, for example, in the case of chain restaurants (Kalnins and Mayer 2004). It can also help explain the eventual failure of firms once praised for their capability in knowledge transfer. Examples include bankrupt automaker Chrysler with its "communities of practice" (Ruggles 1998, pp. 85–86); the defunct investment bank Dresdner Kleinwort Wasserstein, once an exemplar of Enterprise 2.0 principles (McAfee 2006); and ITT, once a conglomerate extolled for expansive documentation and in-person sharing of practices across its units (McCraw 1994).

Patterns of Exchange

One distinction of our inquiry is that we begin with *individual* patterns of knowledge exchange, rather than those at higher levels of aggregation, and trace a link between individual behavior and organizational performance. Theory and research place knowledge, most fundamentally, in individuals and their routines of interaction (Argote et al. 2000, Nelson and Winter 1982). Research has noted the problem of achieving cooperation in knowledge transfer (Cabrera and Cabrera 2002, De Dreu et al. 2008, Wittenbaum et al. 2004), which is exacerbated by the difficulty of observing and controlling knowledge (Arrow 1969, Szulanski 2003). We know that individuals consider costs when engaging in knowledge exchange (e.g., Borgatti and Cross 2003), and withholding can be the result of calculated self-interest (e.g., Aeppel 2002). Thus, organizational performance can be affected by individual decisions as to whether, with whom, and on what terms to transfer knowledge. Yet scholars have assigned varying degrees of importance to the willingness to transfer (cf. Szulanski 1996, p. 37). Corroborating the effect of individuals is not easy, because many studies of knowledge transfer are limited to describing action at the aggregate level, between teams, divisions, and organizations (for an exception, see Gargiulo et al. 2009). By explicitly modeling individual choices about knowledge exchange, we heed Herbert Simon's urge: "[W]e must be careful about reifying the organization and talking about it as 'knowing' something or 'learning' something. It is usually important to specify *where* in the organization particular knowledge is stored, or *who* has learned it" (1991, p. 126).

Cost of Search and Transfer

Often recognized as important but rarely explicitly addressed is the cost of knowledge exchange, whose interaction with other variables and the ultimate impact on performance we explore here. Conservatively, we model only direct costs, such as the time lost on search and exchange, while assuming away other costs of organizational knowledge exchange. Consideration of cost could help explain the contrasting performance impact of knowledge transfer, which led to breakthroughs in one design firm (Hargadon and Sutton 1997) but did not save time in consulting (Haas and Hansen 2007). In the former, designers met at designated times to give and receive knowledge, while in the latter, as in the Firm, transfer was likely ad hoc, interrupting, stressing, and compromising the knowledge source's own tasks (Perlow 1999). Furthermore, in reality the cost of facilitating knowledge search and exchange is higher than just the direct costs, because it involves indirect costs ranging from filing space to computer systems, travel and meetings, and training and socialization (Donahue 2001, Levine 2005, McDermott 1999). Hence, the contingency of knowledge transfer is likely underestimated here.

An Agent-Based Model Built on Qualitative Data

This study also contributes to the increasing interest in seeking external validity for simulation models. We abstract from a field study and build an agent-based model from qualitative data. We jointly use these two dominant approaches to theory making, triangulating and benefiting from the complementariness of theory grounded in observations and formally expressed in a model (Burton and Obel 2011, Jick 1979). As Gibbons (1999, p. 146) opined, "[T]he most successful literatures are those that blend detailed description, informal theory, and formal modeling." While qualitative accounts are rich in detail, are evocative, describe processes lucidly, and possess high external validity, they can be less than parsimonious, suffer from limited generalizability, and afford only limited field experimentation (Glaser and Strauss 1967). Agent-based models of the kind we develop here are viewed as a way to study complex social and organizational phenomena (Burton and Obel 2011, Carley 2009, Macy and Willer 2002, Prietula 2011), alleviating some limitation of qualitative inquiry while preserving its strength. Studies combining or matching empirical data and modeling have sprouted in organizational theory, economics, and sociology (e.g., Black et al. 2004, Burton and Obel 1988, Cardinal et al. 2011, Lazer et al. 2009, Lenox et al. 2010,

Lin et al. 2006, Majchrzak 1997, Moss and Edmonds 2005, Perlow et al. 2002, Sterman et al. 1997).

Our method is not a substitute to traditional models or the "thick description" of ethnography (Geertz 1973). Rather, it is a bridge between the two approaches that combines some of the benefits of both. Erecting a model built on qualitative findings required us to identify the most important constructs of the processes we witnessed and phrase, parsimoniously and unambiguously, how they relate to each other (Davis et al. 2007, Gibbons 1999). The resulting agent-based model gave us the advantage of computational experimentation: it allowed us to examine initial conditions, impose a time structure, explore different outcomes of interest, and realize complex interactions. We created synthetic experiments comparing organizations with different individual, organizational, and environmental characteristics, involving processes that are unobservable or cannot be manipulated in the field, including the interaction of constructs (Harrison and Carroll 2006, p. 31; Macy and Willer 2002). Finally, the complementary use of qualitative data and modeling addresses many of the key criticisms lobbed at such models. Building on field data ensures that the model is based on assumptions that are externally valid; using simulation methods promises internal validity (Burton and Obel 2011, Davis et al. 2007).

Managerial Implications

In addition to its scholarly contributions, this study offers several managerial implications, which may be important in perfecting the efforts to capture and transfer organizational knowledge. Study 1 offers two prominent implications. First, organizations with high learning norms will benefit less from knowledge exchange. Thus, they may be advised to invest less in creating and maintaining such exchange. The costs of elaborate computer systems, training schemes, or organizational incentives to share may exceed the benefits brought about by knowledge exchange. Second, learning may cure many exchange ills. For instance, when performative ties are prominent in an organization, it may reduce efforts to develop the individual learning skills of its members. Thus, investment in *either* learning *or* exchange can promote organizational performance, while investment in both may be wasteful. Study 2 offers a surprising implication: the benefit from knowledge exchange decreases as a member's access to (asocial) organizational memory increases. Furthermore, although global search identifies the best experts, it can overburden them with requests, leading to decreased organizational performance. Local experts, although not as knowledgeable as the global ones, can actually provide a superior alternative under realistic assumptions. Thus, investment in systems and norms that promote broad search and far-reaching sharing across geographical locations and divisions may not lead to the expected performance benefits. The propositions associated with Study 3 suggest that, because of the contingency of knowledge exchange, any investment should be balanced vis-à-vis turbulence in the organizational environment. Organizations operating in a stable environment will benefit more from knowledge exchange and would reap better returns to investing in it. The opposite is true for organizations operating in turbulent environment, where knowledge may depreciate quickly, together with the value of the organizational investment in it. In sum, the propositions identify some of the sources of cost that lead to the "collaboration penalty," the avoidance of which is possible only when both costs and benefits are considered (Hansen 2009a, b).

The propositions here can help specify empirical tests of the benefits and liabilities of knowledge transfer. The constructs we include in the model are prominent both in the field and in the literature. They can be defined, operationalized, and put to empirical tests that can resolve lingering questions. For example, practitioners often blame implementation and execution when the anticipated benefits of knowledge exchange fail to materialize (e.g., Bughin 2008; Donahue 2001; McAfee 2006, 2009). But the findings here propose that even well-thought-out and meticulously executed practices can fail to improve performance if they are incongruent with characteristics of individuals, the organization, or its environment. The most general managerial implication of this study is contained in the title: knowledge transfer has benefits and liabilities, which can vary dramatically between organizations. While this study may not provide unequivocal prescriptions for managers in the firm studied here, an assumption of contingency is a good starting point for discussing knowledge transfer.

Electronic Companion

An electronic companion to this paper is available as part of the online version at http://dx.doi.org/10.1287/orsc.1110.0697.

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Endnotes

[1]Learning norm values for any given agent are selected from a Gaussian distribution of the learning rate, α, with a mean of α and a standard deviation of 0.1α, augmented with an inflation factor when accompanied by knowledge transfer (see the electronic companion for details).

[2]The manipulation levels were determined by calibration to the model (see the electronic companion).

[3]For all three studies, cell sample sizes (replications) were planned to detect absolute effect sizes with $\alpha = 0.05$ for all main effects and interaction contrasts with predicted power ≥ 0.80 (Lenth 2001).

[4]Because the overall Levene's (1960) test suggested a lack of variance homogeneity ($F_{11,288} = 20.1$, $p < 0.001$), we conducted post hoc analyses on the difference of means with the Games and Howell (1976) test.

[5]Levene's (1960) test was significant ($F_{15,384} = 3.70$, $p > 0.001$), so all post hoc analyses were conducted with the Games and Howell (1976) test.

[6]Specifically, *embedded exchange* > *performative ties* > *market exchange* > *self-learning* (all $p < 0.001$, except for *embedded exchange* > *performative ties*; $p > 0.05$). *Embedded exchange* performed the best.

[7]Levene's (1960) test was significant ($F_{11,1,488} = 43.9$, $p < 0.001$), so all post hoc means were compared using the Games and Howell (1976) test.

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