Social retrieval and risk-based storage framework of organizational memory: Testing the performance impact of access to social and non-social sources

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Abstract

This paper introduces two constructs that help develop the concept of organizational memory. A demand-side construct of social retrieval involves social and non-social sources, differentiated by the human interaction requirement. A supply-side construct of risk-based storage involves high-risk and low-risk archives, differentiated by the probability of information loss linked to employee turnover. Empirically, we focus on the demand-side construct, which traditional studies have under-emphasized, and test the effects of access to social and non-social sources of organizational memory on task performance. The tests utilize data from a multi-factor experiment of 246 business students trained to solve business plan problems over an 11-hour period. Results show, controlling for personal knowledge, (1) access to social sources has greater benefits for task performance than access to non-social sources, and (2) given a decline in the aggregate task performance benefits when users with access to both sources do not utilize all available information, the benefits from access to social sources decline less than the benefits from access to non-social sources. These results provide explanations for ambiguous findings on the effects of employee turnover and knowledge management systems in existing empirical literatures.

Key words: organizational memory, organizational learning, organization theory
Organization theorists, economists, and strategists have long sought to determine when organizations will be able to retrieve relevant information from their history (Nelson and Winter, 1982; Levitt and March, 1988; Walsh and Ungson, 1991; Kogut and Zander, 1992; Anand, Manz, and Glick, 1998; Huber, 2001). Although firms can sometimes learn from their past experiences (Levitt and March, 1988; Huber, 1991), we know that organizations and individuals frequently suffer from memory loss (Benkard, 2000; Oberg, 2000). Moreover, firms invest deeply in attempts to capture organizational memory in knowledge management systems, but employees commonly underutilize these systems (Markus and Keil, 1994; Carr, 2003; Dedrick, Gurbaxani, and Kraemer, 2003). As yet, we have only limited understanding of the factors that shape the degree to which people can successfully retrieve information stored in different sources of organizational memory when they need to make current decisions. We believe the limits stem from an incomplete conceptualization of information storage and retrieval and, in turn, from incomplete empirical tests.

The notions of information storage and retrieval represent supply-side and demand-side views of organizational memory. The supply-side view focuses on information storage. This view typically arises in many existing conceptualizations of organizational memory. For instance, ISIHighlyCited.com (2006) reports 154 references citing Walsh and Ungson’s 1991 paper, which defines organizational memory as “stored information from an organization’s history that the firm can bring to bear on present decisions” (1991:61). Walsh and Ungson’s commonly-accepted storage-bin framework of organizational memory describes five internal archives for storing information within the organization (individuals, structure, ecology, culture, and transformation), plus multiple external archives for storing information outside the organization (e.g., news agencies and professional databases). Although this supply-side
framework provides important insights on the distributed and overlapping structure of organizational memory, it lacks empirical measures necessary to test its performance impact. As Walsh and Ungson (1991:81) note, because stored information exists in multiple forms and locations, “any attempt to directly measure or assess organizational memory is doomed to be partial and incomplete, unless one rigorously examines all the bins”.

By contrast, the demand-side view of organizational memory centers on information retrieval from different sources. Although the demand-side view has not been a central focus of previous organizational memory research, this view offers empirical measures to study how organizational memory influences performance, because organizational memory has no impact unless it is retrieved. We adopt the demand-side view to examine the performance impact of access to information from social and non-social sources under carefully controlled conditions.

On the whole, organizational memory consists of archives in which organizations store and retrieve information about their activities. Both storage and retrieval require human interaction, which varies on two important dimensions. First, storage and retrieval sometimes involve widely-held information and other times involve information held by single individuals that may fade from organizational memory following employee turnover. Second, storage and retrieval sometimes require direct human communication and other times occur independent of person-to-person exchange via multiple types of codified archives. We will develop the supply-side construct of risk-based storage and demand-side construct of social retrieval to address these dimensions in the section on organizational memory framework.

Reflecting the importance of human interaction in the storage and retrieval of information within an organization, we define organizational memory as *information stored in high-risk and low-risk archives within the organization that people can retrieve from social and/or non-social*
sources when they need to make current decisions. Under this definition, we consider organizational memory as synonymous with information, except for the specification of risk-based storage and social retrieval. Hence, throughout this paper, we will use the two terms interchangeably.

This paper has two objectives: (1) build a conceptual framework of organizational memory that incorporates the supply-side construct of archival storage and the demand-side construct of social retrieval, and (2) examine the effects of organizational memory on task performance using the social retrieval construct. We test hypotheses concerning direct and interactive benefits from access to social and non-social sources of organizational memory for individual task performance while controlling for personal knowledge. Exploratory analysis also examines the role of personal knowledge and how it interacts with social and non-social sources.

ORGANIZATIONAL MEMORY FRAMEWORK

This section develops a conceptual framework of organizational memory. We review related literatures, describe the distributed and overlapping structure of organizational memory, and explain the constructs of social retrieval and risk-based storage.

Literatures related to organizational memory

Issues that are relevant to organizational memory arise in several existing literatures, including human memory, social psychology, situated cognition, organization theory, strategy, and economics. None of these literatures, though, has yet developed a cohesive framework.

The human memory literature demonstrates individual recall of memory is imperfect (Bartlett, 1932; Tulving, 1972; Rubin, 1996; Baddeley, 1998). Many factors influence recall, including information availability (Kahneman and Tversky, 1982), social desirability (Fisher, 1993), and retention interval (Rubin and Wenzel, 1996). Although such human memory studies
provide important insights on imperfect human recall, they pay little attention to the benefits of memory and the interplay between personal memories and external memory aids such as other people or external representations (Wegner, 1987; Clancey, 1993; Glenberg, 1997).

Social psychology and situated cognition literatures provide insights on the interplay between personal memories and external memory aids (Wegner, Giuliano, and Hertel, 1985; Zhang and Norman, 1994; McGrath, Arrow, and Berdahl, 2000; McGrath and Argote, 2001). External memory aids involving human interactions can enhance memory storage and recall (Wegner, 1987; Lewis, 2003, 2004). Other external memory aids involving external representations (i.e., not involving human interaction) can improve performance in problem-solving tasks (Zhang and Norman, 1994; Zhang, 2000; Zhang and Wang, 2005). Nonetheless, it is not clear in these studies whether external memory aids that involve human interactions are more effective than those that do not involve human interactions.

Organization theory, strategy, and economic literatures address the diffusion of organizational memory, with and without human interaction (Gladstein, 1984; Levitt and March, 1988; Weick and Roberts, 1993; Walsh, 1995; Hansen, 1999; Edmondson, Bohmer, and Pisano, 2001). One key argument in these literatures is that employee turnover is a common reason for failure to retrieve organizational memory because turnover leads to loss of information embedded in specific people (Huber, 1991; Becker, 1993). Other factors that influence the retrieval of organizational memory include ability to codify information (Foray and Steinmueller, 2003), presence of external memory aids such as people and representations (Wegner, 1987; Zhang and Wang, 2005), knowledge tacitness (Nonaka and Toyama, 2003), existence of routines (Nelson and Winter, 1982), improvisation (Moorman and Miner, 1998), communities of practice (Brown and Duguid, 1991), and relational networks (Borgatti and Cross, 2003).
Supply and demand sides of organizational memory

On the supply side of organizational memory, formal conceptualizations often describe a distributed and overlapping structure of information within the organization. This unique structure makes it difficult for empirical researchers to determine the sources of organizational memory that people draw on, and whether different sources offer greater or lesser retrieval potential (Walsh and Ungson, 1991). Distributed structure means that different information components are stored in multiple locations in an organization. For instance, knowledge of how to weld metal exists in welding instruction manuals and in the heads of expert welders. Instruction manuals provide general information on how to weld, but expert welders have unique implementation skills that instruction manuals often do not capture. Overlapping structure means that the same information is stored in multiple locations within the organization. Continuing the welding example, general descriptive information about welding tools exists both in manuals and in the heads of experts (overlap between codified and non-codified information). In addition, welding instructions can appear in many books and computer websites (overlap of codified information).

On the demand side of organizational memory, studies within several disciplines have generated insights about the sources from which users tend to retrieve information. Psychology research demonstrates that users tend to retrieve information from themselves rather than from others (Kahneman and Tversky, 1982). Information studies research shows that users prefer human sources over documentary sources (Bystrom and Järvelin, 1995; Bystrom, 2002). Knowledge management research shows that users find centralized information more accessible than dispersed information (Alavi and Leidner, 1999; Olivera, 2000). Finally, organizational learning and economics of information research show that users can transfer codified and/or
explicit information more easily than non-codified or tacit information (Kogut and Zander, 1992; Nonaka and Takeuchi, 1995; Foray and Steinmueller, 2003).

On the whole, we still have limited understanding about the success or failure of using different sources of organizational memory (Walsh, 1995; Argote, 1999; Argote and Ingram, 2000; Huber, 2001). This lack of understanding relates to the distributed and overlapping structure of organizational memory.

This paper develops two organizational memory constructs to help resolve these issues. The demand-side construct of social retrieval isolates sources of information by whether human interaction is required during retrieval. The supply-side construct of risk-based storage considers the probability of information loss when employees leave the organization. These constructs distinguish organizational memory first by its sources (information users v. others), and only subsequently by its form (degree of codification and/or explicitness of information) and location (degree of centralization).

**Demand-side construct: Information retrieval from social and non-social sources**

The demand-side construct of social retrieval encompasses social and non-social sources of organizational memory. The nature of human interaction required for retrieval to occur differentiates these sources. Key differentiating factors include whether users can retrieve stored information from self v. others and, if from others, whether information is both codified and centralized (i.e., users have options for retrieving information from social and non-social sources) or otherwise (i.e., users can only retrieve information from social sources). Figure 1 describes these differentiating factors.

*** Figure 1 about here ***

Social sources consist of other people providing information via human interaction.
From social sources, users can retrieve all different types of information, including information that users cannot normally retrieve from non-social sources, such as non-codified information within human heads or codified information in private offices. For example, a welder may have a particular list of welding tools that resides in her head and/or private office. To obtain this particular list, an information user must interact with the welder, even if the list contains explicit and codified information; as long as the information is in the source’s private possession, a user cannot obtain the information without the source’s permission.

Non-social sources consist of the self (users) and others (non-human sources) providing information without requiring human interaction. Users can retrieve all types of information in their personal archives (the self), but only some types of information available in other archives. Users’ personal archives contain information that is either non-codified (in their heads) or codified (in their private offices). Other archives contain information that must be both codified and centralized in order for retrieval to occur without requiring human interaction; e.g., web-based public lists of welding tools.

Social and non-social sources are complementary categories separated by the human interaction requirement in information retrieval, but are not mutually exclusive sources of access to stored information. Social sources offer access to all types of information in the organization, including information that is normally available from non-social sources. For example, a corporate intranet provides information that people can access from both social and non-social sources, because even a worker who lacks access to the computer (a non-social source) can ask a colleague (a social source) who does have intranet access to retrieve the information.

**Supply-side construct: Information storage in high-risk and low-risk archives**

The supply-side construct of risk-based storage includes archives with high-risk and low-
risk of information loss. These archives are differentiated by factors that influence the probability of information loss, particularly loss that occurs when knowledgeable people leave the organization. These factors identify information by its unique content and the human control over its access. Figure 2 describes these factors.

*** Figure 2 about here ***

High-risk archives contain information that has a high probability of loss if people leave the organization. The information can be retrieved only by its own archivists. The information can exist in any form (degree of codification, explicitness, centralization), provided that its content is unique and that unique individuals control its access. For example, unique information that is non-codified and centralized, such as ideas in a leader’s head that she does not share with other members, incurs high risk of loss. Moreover, other unique information that is codified but not centralized, such as files in private offices, also faces high risk of loss.

Low-risk archives contain information that has a low probability of loss even if knowledgeable personnel leave the organization. The information can be retrieved by multiple users, including non-archivists, and can exist in any form (codification, explicitness, centralization) provided that it exists in multiple locations (e.g., multiple copies of reference manuals and knowledge held by multiple people). In addition, the information can also exist in a single location provided that it is both codified and centralized, such as a knowledge management system.

The risk-based storage concept accommodates external archives as a complementary source of information, although we do not include it in our definition of organizational memory. Multiple individuals inside and outside the organization can retrieve information in external archives (e.g., news agencies and professional databases), which creates less risk of loss.
following employee turnover. Figure 3 describes the structure of organizational memory.

*** Figure 3 about here***

THE PERFORMANCE IMPACT OF ORGANIZATIONAL MEMORY

The use of organizational memory can enhance or constrain performance (Cohen and Levinthal, 1990; Huber, 1991; Henderson, 1992; Leonard-Barton, 1995; Zander and Kogut, 1995; Ackerman, 1996; Arthur, 1996). Relevant dimensions of performance include individual task success (Berry and Broadbent, 1987), team product development effectiveness (Moorman and Miner, 1997), and firm productivity and innovation (Cohen and Levinthal, 1990; Arthur, 1996). This study focuses on individual task success, by examining the potential positive aspects of access to social and non-social sources of organizational memory on individuals’ ability to solve business plan problems through the use of decision information.¹

The information processing framework suggests greater information can lead to better task performance (Galbraith, 1977; Tushman and Nadler, 1979; Simon, 1990). According to Simon (1990:7), a human’s ability to process information depends on “the structure of the task environments and the computational capabilities of the actor.” Controlling for the task environment, the computational capabilities depend on personal memories (personal knowledge) and external memory aids (memory stored in multiple archives).

The information processing framework does not specify the effect of information at storage or retrieval. This research focuses on retrieval via access to social and non-social sources of organizational memory. We develop hypotheses on the direct and interaction effects of access to social and non-social sources (external memory aids) while controlling for the effects of access to personal memories (personal knowledge).
Direct effect of separate access to social and non-social sources

Tasks within organizations are often complex, requiring individuals to process more information than they have within their personal archives. To accomplish many organizational tasks, individuals frequently rely on sources other than their own memories to aid both the retrieval and processing of task-relevant information. Retrieval of information includes users recalling information from personal memory or notes and exchanging information (either giving or receiving) with social and/or non-social sources. Processing of information involves users assessing the cognitive and social implications of the retrieved information and applying it into organizational tasks (Dennis, 1996). At the same time, however, individuals have a limited amount of cognitive resources to spread across both retrieval and processing activities (Ball and Zuckerman 1992; Norman 1976; Simon, 1990; Kahneman & Tversky, 1982), so that they typically cannot benefit from all potential sources.

This research contrasts the task performance benefits for users with access to either social or non-social sources. We suggest users will benefit from access to social sources more than from access to non-social sources, for two reasons. First, users commonly prefer social sources to non-social sources (Bystrom and Järvelin, 1995; Bystrom, 2002). Due to this preference, users not only retrieve, but also utilize information from social sources to a greater extent than information from non-social sources (Bystrom and Järvelin, 1995; Bystrom, 2002). This pattern of behavior occurs even when non-social sources can provide information that could improve their task performance. For example, studies in the information management literature have shown that people consistently use one information retrieval method more than another method because they prefer it, even though they have tried the non-preferred method and experienced better performance (Grudin and MacLean, 1984; MacLean, Barnard, and Wilson, 1985). This
human preference for social sources over non-social sources continues to pose a challenge for information technology (IT) managers; i.e., IT managers may be able to lead users to information but they cannot force users to obtain the benefits offered by the available information (Nielsen and Levy, 1994; Dennis, 1996).

Second, we suggest users will benefit from access to social sources more than access to non-social sources because social sources enable users to retrieve and process information more effectively than non-social sources (Wegner, Giuliano, and Hertel, 1985; Moreland, Argote, and Krishnan, 1996; McGrath and Argote, 2001; Hollingshead and Brandon, 2003; Lewis, 2003, 2004). Studies in the transactive memory and small group literatures have shown that individuals can retrieve more information when working with other people than when working alone (Wegner, 1987; McGrath, 1991; Wegner, Erber, and Raymond, 1991).

A useful way of thinking about how social sources differ from non-social sources is that social sources interact with users to provide not only task-relevant information but also instructions and assistance to process the information. For example, an information user asks a welder for a list of welding tools. The welder not only provides the list, but also instructions and commentary on the quality of different brands. By contrast, although non-social sources can also cue users to multiple information sources, the interactive nature of information exchange between non-social sources and users is constrained by the technology of the non-social sources and the users’ preference for and understanding of the technology (Dennis, 1996).

An important aspect of the interactive nature of information exchange between users and sources concerns opportunities for coordination. Users can coordinate with both social and non-social sources not only in the retrieval, but also the processing of information. Classic organization theories emphasize the benefits of coordination to the extent that it can justify
firm’s existence (March and Simon, 1958; Thompson, 1967; Williamson, 1985; Kogut and Zander, 1996). In turn, we suggest information users will benefit from social sources more than non-social sources because they can coordinate with social sources for both the retrieval and processing of information to a greater extent than they can with non-social sources. Although users can coordinate with both social and non-social sources, they can coordinate with social sources (involving people) to a greater extent than with non-social sources (not involving people) (Ching, Holsapple, and Whinston, 1992).

We illustrate this idea with examples of mechanistic and organic coordination from contingency theories of organization (Lawrence and Lorsch, 1967). Mechanistic coordination (by programming) involves relatively static methods such as division of labor, regulations, or standard operating procedures whereas organic coordination (by feedback) involves relatively informal and unstructured communication allowing users and social sources to exchange information about their current states and adjust their behavior to others’ goals and actions (March and Simon, 1958; Thompson, 1967; Van De Ven, Delbecq, and Koenig, 1976). Although each type of coordination may be possible with both social and non-social sources, organic coordination between users and social sources is more likely than organic coordination between users and non-social sources. This is because non-social sources will tend to conflict with organic coordination; the former is formal and structured (through codification), whereas the latter is informal and unstructured.

Overall, in conditions where social and non-social sources offer similar information, users with access to only social sources will perform tasks more effectively than users with access to only non-social sources, for two reasons. First, because users prefer social sources, they retrieve and utilize information from social sources more extensively than from non-social
sources. Second, because users can coordinate with social sources for both the retrieval and processing of information to a greater extent than with non-social sources, they will be able to retrieve and process information from social sources more effectively than from non-social sources. Hence, we hypothesize:

\textit{H1: Controlling for personal knowledge, access to social sources has greater benefits for task performance than access to non-social sources.}

**Interaction effect of combined access to both social and non-social sources**

It is also useful to consider the discrete task performance benefits from access to social and non-social sources when users have opportunities to access both sources. More information can lead to better task performance, but people often do not utilize all the information that is available to them (March and Simon, 1958; Galbraith, 1977; Kahneman and Tversky, 1982; Simon, 1990). Behavioral decision theorists explain this information processing limitation, or the use of heuristics, as a tradeoff between decision cost and outcome benefit (Shugan, 1980; Payne, 1982; Payne, Bettman, and Johnson, 1988; Payne, Bettman, and Luce, 1996). In particular, information users will develop different decision-making strategies depending on their task environments (Payne, Bettman, and Johnson, 1988). To reduce cognitive efforts at the cost of losing outcome benefits, information users will employ simplifying processing procedures such as ignoring information deemed of small importance (dimensional reduction) and ignoring magnitudes and giving directional, but equal importance to all information attributes (majority of confirming dimensions) (Russo and Dosher, 1983).

In common organizational settings, where tasks are often complex, time is constrained, and information is readily available from both social and non-social sources, the information processing limitation introduces an important question for organizational memory research.
Given a decline in the aggregate task performance benefits because users with access to both social and non-social sources do not utilize all information available to them, will the benefits from access to social sources decline more or less than the benefits from access to non-social sources when users have access to both sources?

We approach this question in three steps. First, we have previously argued that users will retrieve, utilize, and process information from social sources more effectively than non-social sources because users prefer social sources and social sources create more opportunities for coordination in both the retrieval and processing of information.

Second, we address the information processing limitation by examining the costs and benefits of utilizing information available from social sources. With costs, the use of information from social sources involves managing human emotions that can interrupt and distract information processing (Simon, 1967; Eysenck and Calvo, 1992). With benefits, the same human emotions uniquely associated with social sources can also serve as valuable information cues, informing users where and how to focus attention, especially when the information processing situation is problematic (Schwarz and Clore, 1983; Huy, 2002; Schwarz and Clore, 2003). Considering these costs and benefits, users will likely pay attention to information from social sources (providing valuable information cues) more than information from non-social sources especially when social sources share similar goals and incentives (focusing on information processing with minimal interruption and distraction).

Finally, unlike non-social sources, social sources can consist of people working together as interactive members of complex, adaptive, dynamic systems (McGrath, Arrow, and Berdahl, 2000; McGrath and Argote, 2001). Users and social sources can elaborate, enact, monitor, and modify their behavior to meet the demands of the task. Users and social sources can learn from
their own experience and adapt to events occurring in the task contexts (Weick, 1993; Weick and Roberts, 1993; Sutton and Hargadon, 1996; McGrath, Arrow, and Berdahl, 2000). Thus, users will likely pay attention to social sources more than non-social sources because social sources uniquely can interact with users, learn from their experience, and adapt to meet their information needs.

In combination, these arguments suggest that users with access to both sources will utilize, benefit from, and pay attention to information from social sources to a greater extent than information from non-social sources. Thus, when information processing limitations prevent users from utilizing all information available from both social and non-social sources, potentially causing a decline in the aggregate task performance benefits, the task performance benefits from access to social sources will likely decline less than the task performance benefits from access to non-social sources. Hence, we hypothesize:

H2: Given a decline in the aggregate task performance benefits when users with access to both sources do not utilize all available information, the decline in benefits from access to non-social sources is greater than the decline in benefits from access to social sources.

These hypotheses provide insights on the direct and interaction effects of having access to social and non-social sources on individual task performance. At the same time, we need to be clear about boundary conditions for the arguments: the predications apply to cases in which (1) social sources are substitutes, not complements, for non-social sources, and (2) all task conditions face time constraints.

Moreover, we recognize recent advances in computer technology might allow non-social sources to mimic social sources in cueing users to retrieve and process information effectively (Anand, Manz, and Glick, 1998). Such technology sometimes offers better ease of search than
Organizational memory via social sources. For example, computer search engines can help bring information from dispersed locations to the users’ desktop with minimal effort on the users. Some technology enables categorical and full-text search that can potentially make non-social sources more efficient than social sources. Hence, it is possible that cases in which non-social sources employ computer search technology might condition the predictions. Nonetheless, such technologies can mimic social sources only with the cooperation of social sources; e.g., advanced computer expert systems connecting information users and human sources (Ackerman and Halverson, 2000).

METHODS

Challenges of memory research & experimental method

As we noted earlier, Walsh and Ungson (1991) argue that attempts to assess organizational memory need to examine relevant storage locations. We heed this warning and adopt the experimental method, a hallmark of memory research in the fields of cognitive and social psychology. Experiments offer benefits relative to surveys and case studies because of the methodological challenges uniquely associated with organizational memory research.

In designing the experiment, we use four approaches to address the challenges associated with organizational memory research. First, the structure of organizational memory is distributed and overlapped. We separate it with a 2x2 experimental design (users have access/no access to social/non-social sources). Second, people rely on external memory aids when they cannot rely on their personal memories; measuring the effects of access to external memory aids requires controlling for the effects of access to personal memories. We control for access to personal memories by measuring people’s knowledge of the task immediately before putting them into different information retrieval conditions. Third, people cannot accurately report their task performance resulting from having access to external memory sources. Hence, we do not
rly on people’s self-reports of events; rather, we measure performance outcomes as they occur. Finally, endogeneity issues may arise due to individual differences; e.g., people with social skills tend to self-select themselves into environments maximizing those skills; thus they benefit from access to social sources more than access to non-social sources. We address these issues by stratified random assignment of participants into different training and information retrieval conditions. In addition, we employ a statistical model that examines both within- and between-subject differences.

Although uniquely positioned to deal with the methodological challenges of organizational memory research, the experimental method commonly faces criticisms of lack of mundane realism and sampling bias. We address these criticisms with careful designs of incentive structure and task environment. First, we reward participants by time and performance. Participants received payment for the number of hours worked. In addition, they made money for every correct answer, lost money for every incorrect answer, and received nothing if they did not answer; as described in the next section, the rewards could be substantial. Second, we create relevant real-life problems for participants to solve over 120 repeated trials; business school students solved 120 business plan problems for which they have been trained to solve during the course of their college education. These incentives and task designs are intended to motivate participants to try their best at optimizing the use of organizational memory in an environment that approximates their future careers.

**Description of the experiment**

**Sample:** Two hundred and forty six undergraduate members of the Finance Club of a top business school in Ho Chi Minh City, Vietnam, participated in the experiment on July 11, 2004. Among them were 72% females, 72% finance majors, and 73% rising fourth year students in a
five-year business undergraduate program.

**Language**: The experiment was conducted in Vietnamese. The first author prepared all documents for the experiment in English and professional translators of KPMG Vietnam translated them into Vietnamese. Three faculty members of the Ho Chi Minh City Economic University double-checked the translation, making changes to the Vietnamese documents for consistency with standard terminology employed in local business schools. The first author (a native Vietnamese speaker) final-checked the translation, ensuring the key content of the original English documents has not been altered before re-translating them into English.

**Compensation**: Students received payment for time and performance. For time, they received at least 5,000 Vietnamese dong (VND) per hour, and VND 100,000 for the whole 11-hour day. For performance, they received VND 1,000 credit for each correct response, nothing for blank response, and either VND 500 or VND 1,000 debit for each incorrect response depending on the number of choices presented in the question. Although it was possible to net a negative amount (in case they submitted more incorrect than correct responses), students were told that they would not need to make reverse payments. The experiment included 180 objective multiple-choice questions (60 competency questions and 120 business plan questions). The average performance-based payment was VND 48,000.\(^2\) Students received time-based payment at the end of the experiment day and performance-based payment one week after the experiment.

**Students’ role and task**: Students assumed the role of entry-level banking executives in an experiment that had a three-step process. First, they acquired conceptual knowledge for the task through training. Second, they demonstrated conceptual knowledge needed to solve the task by answering 60 competency questions. Third, they applied conceptual knowledge to solve 120 business plan problems. In the third step, we employed experimental manipulations of access/no
access to social/non-social sources to aid users in their problem-solving task. Figure 4 describes
the experiment schedule.

*** Figure 4 about here***

In the morning, students provided demographic information, received training, and
demonstrated their competency for the task. We drew training materials from widely used
textbooks on marketing and financial analysis (Keown, et al., 2001; Kotler and Armstrong,
2003); local business school professors conducted the training sessions. Each student received
training on one of the three topics: (1) marketing environment analysis, (2) market segmentation
analysis, and (3) financial statement analysis. After training, all students took 2 competency
tests, test 1 on the topic of lecture they attended on experiment day and test 2 on the other two
topics of lecture that they did not attend on experiment day, but may have been exposed to
during their business education. We drew the competency test questions directly from the
instructors’ manuals of the textbooks (Keown, et al., 2001; Kotler and Armstrong, 2003). Each
topic consisted of 20 five-choice questions. Altogether, the students answered 60 competency
questions. Correct responses to these competency questions represented students’ personal
knowledge on task-relevant topics, a control for access to personal memories (chance=20%).

In the afternoon, we employed stratified random assignment to move students from three
training conditions into four information retrieval conditions. We created the conditions with
2x2 experimental manipulations: access/no access to social/non-social sources.

**Manipulation of non-social and social sources (2x2):** We manipulated non-social
sources using reference manuals in all training conditions and two information retrieval
conditions. Reference manuals consisted of relevant chapters of the textbooks (Keown, et al.,
2001; Kotler and Armstrong, 2003). Students in conditions without access to non-social sources
– Condition “no-Talk no-Read” (nTnR) and Condition “Talk” (T) – did not have manuals, whereas students with access to non-social sources – Condition “Read” (R) and Condition “Talk Read” (TR) – did have manuals.

We manipulated social sources of information through stratified random assignment of students into cross-functional teams. Members of cross-functional teams were concurrently users of information and social sources of information to each other. Students had access to social sources when they worked with their teammates; i.e., in Condition “Talk” and Condition “Talk Read”. Students had no access to social sources when they did not work with their teammates; i.e., in Condition “no-Talk no-Read” and Condition “Read”. Figure 5 describes the formation of cross-functional teams.

To summarize, in Condition “no-Talk no-Read”, students were not aware of teammates who attended training on different topics and performed tasks without any information aid other than what they had in their heads and personal notes. In Condition “Read”, students were not aware of teammates who attended training on different topics and performed tasks with the aid of manuals on all three training topics. In Condition “Talk”, students worked with teammates who attended training on different topics and performed tasks without any information aid other than what they had in their heads and personal notes. In Condition “Talk Read”, students worked together with teammates who attended training on different topics and performed tasks with the aid of manuals on all three training topics. Figure 6 describes these conditions.

*** Figure 5, Figure 6, Figure 7, and Figure 8 about here***

**Control of task complexity and time pressure**: Students in all conditions evaluated the same four business plans under the same time constraint of one hour per plan. We selected the business plans from real-life compilation (Jacksack, 1998)³. We employed stratified random
assignment and Latin-square block design to control the levels of complexity from plan 1 to plan 4 by increasing the number of pages and number of choices presented in the problems. With pages, plan 1, 2, 3, and 4 consisted of 20, 23, 29, and 31 pages, respectively. With choices, plan 1 and 2 consisted of two-choice problems and plan 3 and 4 consisted of five-choice problems.

We generated 2 sets of problems for the business plan analysis task. The first set asked questions about plan 1 (two-choice) and plan 3 (five-choice). The second set asked questions about plan 2 (two-choice) and plan 4 (five-choice). Each set consisted of 30 questions about marketing environment, market segmentation, and financial statement analysis. Altogether, two sets of business plan problems consisted of 60 distinct questions, 20 questions about marketing environment analysis, 20 about market segmentation analysis, and 20 about financial statement analysis. These questions were based on 60 competency questions that students answered earlier. Figure 7 illustrates competency and business plan questions on three topics.

By manipulating number of choices in the problems generated for each business plan and number of pages per business plan, we increased the level of complexity among 4 business plans by order from plan 1 to plan 4. By number of choices, plan 1 and plan 2 were less complex than plan 3 and plan 4. By number of pages, plan 1 was less complex than plan 2, and plan 3 was less complex than plan 4. Altogether, plan 1 consisted of 20 pages and 30 two-choice problems, plan 2 consisted of 23 pages and 30 two-choice problems, plan 3 consisted of 29 pages and 30 five-choice problems, and plan 4 consisted of 31 pages and 30 five-choice problems.

On the whole, students solved 120 business plan problems linked to 60 competency questions that measured their personal task-relevant knowledge. Correct responses to these 120 business plan problems represented students’ task performance (overall chance=35%).

**Stratified random assignment, Latin Square block design, and repeated measures:**
This study accounts for possible measurement errors, such as individual differences, learning-by-doing, self-selection, boredom, and exhaustion, by using stratified random assignment, Latin Square block design, and repeated measurement procedures (Pedhazur and Schmelkin, 1991). We combined stratified random assignment and Latin Square block design in a three-step process. First, we randomly assigned students into 3 training conditions. Second, after training, we randomly assigned students into 4 information retrieval conditions ("no-Talk no-Read", "Read", "Talk", and "Talk Read") where they stayed throughout the experiment. At the same time, we also carefully grouped students attending different lectures into cross-functional teams. Third, within each condition, we randomly assigned students into 4 sub-groups by the Latin Square block design: sub-group 1, 2, 3, and 4 conducted tasks by sequence of plan 1-2-3-4, 2-3-4-1, 3-4-1-2, and 4-1-2-3, respectively.

We developed an Excel program that randomly generated 300 unique ID numbers with coded instructions to carry out these procedures. We pre-printed these unique ID numbers on blank name tags and distributed to students at registration (in blocks of 30 ID numbers at a time). Experiment proctors relied on these ID numbers to direct students into designated training and information retrieval conditions and administer the business plan tasks by designated sequences. Figure 8 illustrates unique ID numbers of the first 5 students.

We employed repeated measures by rewarding students for their correct responses to 60 competency questions (chance=60x20%=12 correct answers; mean=30.2 correct answers; sd=7.2) and 120 business plan evaluation questions (chance=(60x50%)+(60x20%)=42 correct answers; mean=68 correct answers; sd=17.7). After each business plan, all students reported their efforts and task perceptions. Moreover, those with access to social sources also reported their coordination, credibility, and specialization (4 repeated measures; Likert-scale from 1 to 7).
Repeated measures allow for precision in measurements of personal knowledge, task performance and other subjective evaluations. As suggested by Pedhazur & Schmelkin (1991:83), “repeated measurements of an object enable the physical scientist to assess the precision with which it is measured”. However, repeated measures can be problematic in socio-behavioral sciences because the very act of measurement can change the people being measured (Pedhazur and Schmelkin, 1991). This research heeds these warnings and carefully combines repeated measures, stratified random assignment, and Latin Square Block design of the 4 business plans in the measurements of personal knowledge, task performance, and other subjective evaluations. Moreover, we recognize changes inevitably occur over time and incorporate them in our multi-level statistical analysis.

RESULTS AND ANALYSIS

Model specification & variable description

We employ a generalized linear mixed model (GLMM), also known as a multi-level generalized linear model, to analyze data of 246 students answering questions about 4 business plans with each business plan consisting of 30 questions (n=29,520 individual-plan-question). To test H1 and H2, we analyze data at the question-level (within-subject differences) and individual-level (between-subject differences) (Hox, 2002; Hanley, et al., 2003; Rabe-Hesketh, Skrondal, and Pickles, 2004, 2005). We use full maximum likelihood methods to estimate Equation 1.

\[
\begin{align*}
\pi_{q_i} &= \text{logistic} (\alpha + \beta_K K_{q_i} + \beta_M M_i + \beta_R R_i + \beta_T T_i + \beta_{TR} R_i T_i + \beta_{KR} K_{q_i} R_i + \beta_{KT} K_{q_i} T_i + \beta_{KTR} K_{q_i} R_i T_i + e_i) \\

\pi &\sim \text{Binomial} (n_{q_i}, \mu)
\end{align*}
\]

We dummy-code all variables. Subscript \(q\) indicates analysis of the variables at the
Organizational memory question-level and subscript $i$ at the individual-level. The dependent variable $Y_{qi}$ denotes students’ task performance at the question-level (i.e., whether individual $i$ has the correct solution to question $q$). \(^4\)

Predictor variables include problem-level, student-level, and cross-level variables. $K$ represents a problem-level variable. It denotes the student’s personal task-relevant knowledge of the business plan problem.

$R$, $T$, $TR$, and $M$ represent student-level variables. $R$ and $T$ denote Condition “Read” and Condition “Talk”, respectively. $TR$ denotes a two-way interaction between Condition “Talk” and Condition “Read”. $M$ denotes “Male”.

$KR$, $KT$, and $KTR$ represent cross-level variables. $KR$ and $KT$ denote two-way interactions between the student’s task-relevant knowledge of the business plan problem and the experimental conditions – Condition “Read” and Condition “Talk”, respectively. $KTR$ denotes a three-way interaction between the student’s task-relevant knowledge of the business plan problem and a combination of both experimental conditions – Condition “Read” and Condition “Talk”. Table 1 describes the summary statistics and correlations for the variables.

*** Table 1 about here ***

**Hypothesis tests**

We estimate Equation 1 using the “xtlogit” procedure in Stata 8 (Das, Poole, and Bada, 2004). We employ the method recommended by Tuma and Hannan (1984) and Long and Freese (2001) to interpret the regression coefficients of the full model (Model 8). Table 2 & Table 3 summarize the regression coefficients of the nested models in regular and exponential form. Table 4 provides chi-square tests of coefficients.

*** Table 2, Table 3, & Table 4 about here ***
Confirming basic intuition, we find the likelihood of correct solution increases with access to personal memories and external memory aids (via social and non-social sources). With personal memories, having task-relevant knowledge ($\beta_k$) more than doubles the odds of arriving at the right solution ($\beta_k= e^{2.18}$, $p<.01$). With external memory aids, having access to non-social sources ($\beta_R$) increases the likelihood of getting the right solution by 34% ($\beta_R= e^{1.34}$, $p<.01$), whereas having access to social sources ($\beta_T$) increases the likelihood of getting the right solution by 211% ($\beta_T= e^{3.11}$, $p<.01$).

The results then support both hypotheses. H1 suggests users benefit from social sources ($\beta_T$) more than from non-social sources ($\beta_R$). We conduct a coefficient comparison test (whether $\beta_T = \beta_R$), and find social sources ($\beta_T= e^{3.11}$, $p<0.01$) to have a significantly greater effect on performance than non-social sources ($\beta_R= e^{1.34}$, $p<.01$. Test 1: $\beta_T = \beta_R$, $\chi^2=94.27$, $p=0.000$). In other words, although people with access to the relevant manuals perform approximately 34% better than those without, they also perform approximately 77% worse than those with access to members of cross-functional teams (Test 1: $\beta_T = \beta_R$, $\chi^2=94.27$, $p=0.000$. $\beta_T-\beta_R= e^{3.11}-e^{1.34}=e^{1.77}$).

H2 expects the decline in task performance benefits from access to non-social sources to be greater than the decline in task performance benefits from access to non-social sources when users have access to both sources. We test this hypothesis in four steps. First, we determine if there is a decline in performance benefits from access to either social or non-social sources when users have access to both (whether $\beta_{TR}=0$). Second, we determine if having access to only social sources is significantly different from having access to both sources (whether $\beta_T = \beta_R+\beta_T+\beta_{TR}$). Third, we determine if having access to only non-social sources is significantly different from having access to both sources (whether $\beta_R = \beta_R+\beta_T+\beta_{TR}$). Fourth, we examine the magnitudes of the coefficients to determine the extent of the decline in the performance benefits from access to 

25
social and non-social sources.

Three coefficient comparison tests provide results that support H2. The first test shows a significant negative interaction between Condition “Talk” and Condition “Read” ($\beta_{TR}=e^{0.76}$, p<.01), indicating a decline of 24% in the performance benefits from access to either social or non-social sources when users have access to both sources. The second test shows no significant difference between the benefits from access to social sources and the benefits from access to both sources (Test 2: $\beta_T = \beta_T + \beta_R + \beta_{TR}; \chi^2=0.04, p=0.83$). The third test shows a significant difference between the benefits from access to non-social sources and the benefits from access to both sources (Test 3: $\beta_R = \beta_T + \beta_R + \beta_{TR}; \chi^2=82.46, p=0.00$). Since the tests indicate a significant negative interaction, no significant difference in the benefits from access to social sources, and a significant difference in the benefits from access to non-social sources, we attribute all 24% decline in benefits reported by the interaction coefficient ($\beta_{TR}=e^{0.76}$, p<.01) to non-social sources. This represents an extreme case of users ignoring non-social sources completely when they have access to both social and non-social sources.

We use exploratory analysis to extend understanding of these results. We find significance for the two-way interaction between social and non-social sources ($\beta_{TR}=e^{0.76}$, p<.01) for H2 in the full model (Model 8). This model includes a three way interaction (KTR) of having knowledge (K), access to social sources (T), and access to non-social sources (R), which is not significant ($\beta_{KTR}=e^{0.14}$, p=.10). In combination, a significant two-way interaction ($\beta_{TR}=e^{0.76}$, p<.01) and a non-significant three-way interaction ($\beta_{KTR}=e^{0.14}$, p=.10) suggest the 24% decline in the performance benefits from access to non-social sources occurring only in the absence of personal knowledge (TR), not in the presence of personal knowledge (KTR). In other words, people with access to both social and non-social sources will ignore reference manuals.
only when they do not have requisite knowledge of the problem (TR). The same result does not hold for people with requisite knowledge of the problem (KTR).

We also conduct exploratory analyses of the performance impact of personal knowledge in different information retrieval conditions. In particular, we compare two cross-level interaction terms: KR and KT. KR describes the effect of personal knowledge with access to non-social sources. KT describes the effect of personal knowledge with access to social sources. Both interaction terms are negative ($\beta_{KR}=e^{0.81}$, $p<.01$ and $\beta_{KT}=e^{0.60}$, $p<.01$), which mean that the benefits from access to personal knowledge and other sources of information substitute for each other (similar to social sources substituting for non-social sources in H2). Most interestingly, a coefficient comparison test of the two terms (Test 4: $\beta_{KR}=\beta_{KT}$, $\chi^2=19.99$, $p=0.000$) shows the aggregate reduction in benefits is greater when personal knowledge is complemented by social sources ($\beta_{KT}=e^{0.60}$, $p<.01$, a 40% attenuation) than by non-social sources ($\beta_{KR}=e^{0.81}$, $p<.01$, a 19% attenuation). Hence, with access to both requisite knowledge of the problem and other people who likely have requisite knowledge of the problem, the combined benefits decline by about 40%. In contrast, with access to both requisite knowledge of the problem and relevant manuals, the combined benefits decline by only 19%.

**DISCUSSION**

This paper has two main research objectives. First, we develop an integrative conceptual framework of organizational memory, using the supply-side construct of risk-based storage and demand-side construct of social retrieval. Second, we test the performance impact of organizational memory, using the demand-side construct of social retrieval.

Our results confirm basic insights about organizational memory and extend the insights into new arenas. Five experimental results stand out. First and perhaps most intuitively, better
task performance arises from both greater personal knowledge and access to external memory aids via social sources and non-social sources. Second, social sources and non-social sources have substantially different effect sizes: having access to people who likely have relevant information in their personal possession is more effective than having access to manuals with the relevant information. Third, in the absence of personal knowledge, users do not utilize all information available from social and non-social sources: the aggregate task performance benefits from combined access to both sources are less than the sum of the benefits from separate accesses to social and non-social sources. Fourth, given a decline in the aggregate task performance benefits, the benefits from social sources decline less than the benefits from non-social sources when users have access to both sources: indeed, our experiment finds an extreme case of users ignoring non-social sources completely. Fifth, the task performance benefits of personal knowledge decline with access to both social and non-social sources of knowledge: users’ personal knowledge can substitute for others’ personal knowledge, but not for manuals; i.e., I must have some requisite knowledge in order to benefit from having manuals, but I must not have some requisite knowledge in order to benefit from having access to other people.

These results shed light on issues we described in the introduction: (1) people can learn from their organizations’ past, yet they frequently suffer from loss of organizational memory, and (2) firms invest in knowledge management systems, yet employees underutilize them.

Concerning the first point, our conceptual framework identifies occasions of memory loss within the firm – when employees who have unique control of unique information leave the firm. We also specify the probability of memory loss linked to employee turnover – only information in the high-risk archives is likely to be lost when employees leave the firm; other information in the low-risk archives, retrievable from both social and non-social sources, is not likely to be lost.
when employees leave the firm. However, given the strong preference for social sources, the loss of a social contact can be very important. Moreover, even if the information could be accessed from non-social means, it may not be – especially when there is a lack of personal knowledge necessary to extract the benefits of information available via non-social sources.

Concerning the second point, our empirical test demonstrates returns on firms’ investment in non-social sources of information (reference manuals improved task performance by 34%). Although we expect a greater improvement with knowledge management systems, our results with reference manuals can explain why firms continue to invest in non-social sources even when studies show employees tend to underutilize them – because users benefit from non-social sources (34% more than when they have no access to any external memory aid).

The results also answer a follow-up question – why do employees underutilize non-social sources when non-social sources can assist task performance? In normal organizational settings, users often have options between social and non-social sources of information within the organization. On the one hand, non-social sources generate a 34% improvement in performance benefits when compare having access to relevant manuals and no access to any external memory aid. On the other hand, non-social sources generate a 77% decline in performance benefits when compare having access to relevant manuals and access to people who likely have the relevant information. These findings have implications for researchers and managers.

Implications for researchers

By extension, this analysis has implications for explaining two ambiguous empirical findings on the effects of employee turnover and firms’ investment in knowledge management systems in existing organizational memory literatures. The first ambiguity is that the literatures are not clear on the effects of employee turnover; some studies show firms are negatively
affected by employee turnover whereas other studies show firms are not affected (Argote, 1999). We discuss the implications of our results using the supply-side and demand-side views of organizational memory.

From the supply side, employee turnover does not necessarily equate with loss of access to information – firms only lose unique information in control of unique employees who leave the firm (high-risk archives). Hence, the effect of employee turnover on performance can potentially be moderated by whether the relevant information held by the departing employee exists in the high-risk or low-risk archives. We expect a negative effect if the information exists only in the high-risk archives, and no effect if the information exists in the low-risk archives, or readily available in the external archives. For example, a departure of a highly skilled specialist hurts the operation of the firm only if his skills are so unique the firm cannot replace him with another person internally (low-risk archives) or externally (external archives). But if the person is a key node in a social network, and thus a way of getting to the information that is held in external archives or with another employee, the loss may be important.

From the demand side, users prefer and benefit from social sources more than from non-social sources; hence employee turnover may cause remaining employees to believe that their performance will suffer. Thus, we expect researchers’ choices of performance measures to moderate the effect of employee turnover. In particular, we expect subjective measures to associate with a negative effect, whereas objective measures to associate with other effects driven primarily by supply-side factors discussed above.

The second ambiguity is that the literatures are not clear on the performance impact of firms’ investments in knowledge management systems (Alavi and Leidner, 1999; Lim, Richardson, and Roberts, 2004). In particular, it is not clear why firms continue to make these
investments even when employees tend to underutilize these resources (Markus and Keil, 1994; Carr, 2003; Dedrick, Gurbaxani, and Kraemer, 2003). We provide supply-side and demand-side explanations for firms’ investments and discuss a potential problem for research in this area.

Firms can benefit from investments in KMS for both supply-side and demand-side reasons. From the supply side, information stored in KMS is not likely to be lost when employees leave the firm (low-risk archives). From the demand side, access to non-social sources has greater benefits for task performance than no access. Nonetheless, these positive aspects suggest a potential problem of self-selection bias in research – IT managers and IT consultants with vested interests will likely find evidence supporting investments in KMS. In particular, we expect positive findings in studies employing subjective performance measures linked to supply-side factors or studies comparing performance of users having access to KMS to those without access to any external memory aid.

Implications for managers

Our results might not surprise some users of organizational memory, because studies show people commonly prefer social sources to non-social sources of information (Bystrom and Järvelin, 1995; Bystrom, 2002). However, they are highly relevant for shaping incentives to invest in different retrieval mechanisms. Two important questions arise concerning the tradeoffs associated with investments in social sources and non-social sources. First, social sources are more susceptible to loss due to employee turnover, but they are also more effective than non-social sources; what can managers do to reduce the risk of memory loss associated with social sources? Second, non-social sources are less susceptible to loss due to employee turnover, but they are also less effective than social sources; what can managers do to improve the performance impact of non-social sources. We propose some answers to these questions.
The first challenge for managers is to reduce the risk of memory loss associated with the social sources of organizational memory. Managers can do this with supply-side and demand-side solutions. The supply-side solution involves investing in knowledge management systems, effectively making information available from people (social sources) also available from computers (non-social sources). The demand-side solution involves information sharing among employees, effectively turning unique information available from unique employees (high-risk archives) into shared information available from multiple employees (low-risk archives).

In practice, the supply-side solution – investing in the non-social sources – has been a common approach; firms have invested in millions of dollars to capture organizational memory in under-utilized knowledge management systems (Markus and Keil, 1994; Carr, 2003; Dedrick, Gurbaxani, and Kraemer, 2003). This brings us to the demand-side solution, which we believe has been under-emphasized. The risk of memory loss due to employee turnover associated with social sources may well outweigh the benefits.

This study provides information about the relative benefits from access to social and non-social sources of organizational memory. We identify ways to reduce the risk of memory loss associated with social sources, in that non-codified and dispersed information that exists in multiple locations is not highly susceptible to loss during employee turnover (Figure 1, Figure 2 and Figure 3 describing the sources, archives, and structure of organizational memory). Specifically, we suggest that managers can benefit from investing in low risk archives that make up social sources. They can do this through a system of apprenticeship or discussion groups, in which people share information without having to undertake codification and centralization.

The second challenge for managers is to improve the performance impact of non-social sources to rival that of social sources. Managers can do this by acquiring advanced technology
to augment the performance impact of non-social sources at two levels. At the macro level, technology provides categorical search by bringing information from dispersed locations to the users. For example, computer databases such as ProQuest can bring required articles to users’ desktops. However, users still have to read through them to find relevant information. At the micro level, technology provides full-text search by facilitating information processing and enabling users to sieve through available information more effectively. For example, computer search engines such as Google Desktop, Microsoft’s “find”, and Acrobat’s “search” can help users to conduct micro-search of keywords within documents.

We manipulate non-social sources in the form of reference manuals that are readily available to the users. This approach indicates that the use of technology at the macro level will not affect our results. However, the use of technology at the micro level can potentially improve the performance impact of non-social sources. Specifically, users of non-social sources can benefit from technology that simulates an interactive cueing process similar to that occurring among social sources of information. This cueing process can mimic social sources in providing opportunities for transactive memory and mechanistic coordination. The extent of this improvement – whether non-social sources can rival that of social sources in performance impact – remains open for future investigations.

Limitations and future research directions

These findings generate a number of questions for future research. First, it would be useful to examine negative aspects of OM, such as the potential for trapping organizations in suboptimal past activities.

Second, little is known about the underlying human factors that influence access to information available from social sources. The transactive memory literature suggests
coordination, credibility, and specialization moderate memory retrieval among individuals in group. Nonetheless, it is not clear if better performance arises from greater coordination, credibility, and specialization.

Third, organizations have different incentive structures for users and sources. Some firms reward users and sources equally, whereas other firms do not. Future investigations are needed to advance understanding on whether social sources will generate greater benefits than non-social sources if users and sources do not share similar goals and incentives.

Finally, it is not clear when the use of computer technology might augment the performance benefits from access to non-social sources to the point that they would rival the benefits from access to social sources. With increasingly advanced search technology, the benefits from access to non-social sources through the use of a computer will likely be greater than those without; nonetheless, the tacit and organizationally embedded nature of much relevant knowledge suggests that social sources will continue to be highly relevant sources of organizational memory.

ENDNOTES

1 Organizational memory may also have a negative impact on performance, such as through using outdated information, but such negative impact is beyond the scope of the study.

2 At the time of the experiment, the official exchange rate was approximately VND15,000 = US$1. However, the value of compensation was much higher than indicated by the exchange rate. In 2002, the average annual income of Vietnamese professionals in Ho Chi Minh City was approximately VND14 million (~US$930) (World Bank, 2005). The sum of the average performance-based payment of VND48,000 (~US$3) and the time-based payment of VND100,000 (~US$7) is VND 148,000 (~US$10) representing more than a half week’s pay for a young professional. According to school officials, students normally pay rent of approximately VND150,000 (~US$10) per month for a twin-share room at the university.

3 Four business plans selected from Jacksack (1998) include: Bob’s Big Pencils (BBP or plan 1), African Adventure Tours (AAT or plan 2), Jumpin’ Java Cybercafé (JJC or plan 3) and Computer Solutions Inc (CSI or plan 4).

4 We have four measures of task performance and personal knowledge: subjects’ correct response, incorrect response, blank response, and earnings. These measures vary by subjects’ attitude toward risk. Results are similar for the performance-based payment and correct response measures. We interpret the coefficients of the correct response measure.
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APPENDICES

Figure 1: Demand-side view of organizational memory: Retrieval of information from social and non-social sources

The demand-side construct isolates sources of information by whether human interaction is required during retrieval. Social sources differ from non-social sources by whether users can retrieve stored information from self v. other, and if from other, by whether information is both codified and centralized (i.e., users have options of retrieving information from non-social sources) or otherwise (i.e., users can only retrieve information from social sources).
Figure 2: Supply-side view of organizational memory: Storage of information in high-risk and low-risk archives

The supply-side construct considers the probability of information loss when employees leave the organization. Two factors influence the probability of information loss, particularly loss that occurs when knowledgeable people leave the organization. The first concerns whether individuals hold information of unique content. The second concerns whether individuals have unique control over the access of information.

High-risk archives contain information that has a high probability of loss if people leave the organization. The information can be retrieved only by its own archivists. The information can exist in any form (codified, non-codified, centralized, or dispersed) provided that its content is unique, and unique individuals control its access.

Low-risk archives contain information that has a low probability of loss, even if knowledgeable personnel leave the organization. The information can be retrieved by multiple users, including non-archivists. The information can exist in any form (codified, non-codified, centralized, or dispersed) provided that it exists in multiple locations (e.g., multiple copies of reference manuals and knowledge held by multiple people). In addition, the information can also exist in a single location provided that is both codified and centralized, such as a knowledge management system.
Figure 3: Social retrieval and risk-based storage framework of organizational memory

<table>
<thead>
<tr>
<th>Low-risk archives (content or control of access is not unique)</th>
<th>High-risk archives (content &amp; control of access are unique)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Social sources</strong> (retrieval requires human interactions)</td>
<td><strong>Social sources</strong> (retrieval requires human interactions)</td>
</tr>
<tr>
<td>- Both non-codified &amp; codified info</td>
<td>- Both non-codified &amp; codified info</td>
</tr>
<tr>
<td>- In dispersed &amp; central locations</td>
<td>- In dispersed locations</td>
</tr>
<tr>
<td>- Either content or control of access is not unique</td>
<td>- Both content &amp; control of access are unique</td>
</tr>
<tr>
<td>- Retrieval requires human interactions</td>
<td>- Retrieval requires human interactions</td>
</tr>
<tr>
<td>Example: Common ideas</td>
<td>Example: Personal ideas</td>
</tr>
<tr>
<td><strong>Non-social sources</strong> (retrieval does not require human interactions)</td>
<td><strong>Non-social sources</strong> (retrieval does not require human interactions)</td>
</tr>
<tr>
<td>- Only codified info</td>
<td>- Only codified info</td>
</tr>
<tr>
<td>- In central locations</td>
<td>- In central locations</td>
</tr>
<tr>
<td>- Either content or control of access is not unique</td>
<td>- Both content &amp; control of access are unique</td>
</tr>
<tr>
<td>- Retrieval does not require human interactions</td>
<td>- Retrieval does not require human interactions</td>
</tr>
<tr>
<td>Example: Common references</td>
<td>Example: Personal websites</td>
</tr>
</tbody>
</table>

Figure 4: Schedule of 11-hour experiment

In the afternoon, students spent approximately 15 minutes for each task evaluation and 15 minutes for coffee break following each evaluation. Altogether, students answered from 287 to 359 questions, including 15 demographic questions, 60 competency questions, 120 business plan questions, and either 92, 116, 148, or 164 subjective evaluation questions depending on their assigned organizational memory conditions.

<table>
<thead>
<tr>
<th>8:00 am</th>
<th>1:00 pm</th>
<th>9:00 am</th>
<th>2:00 pm</th>
<th>10:00 am</th>
<th>2:30 pm</th>
<th>10:10 am</th>
<th>3:30 pm</th>
<th>10:40 am</th>
<th>4:00 pm</th>
<th>11:00 am</th>
<th>5:00 pm</th>
<th>11:50 am</th>
<th>5:30 pm</th>
<th>Noon</th>
<th>6:30 pm</th>
<th>6:45 pm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Registration &amp; briefing</td>
<td>Work on 1st business plan</td>
<td>Attend lecture</td>
<td>Evaluate 1st business plan</td>
<td>Evaluate lecture</td>
<td>Work on 2nd business plan</td>
<td>Work on competency test 1</td>
<td>Evaluate 2nd business plan</td>
<td>Evaluate competency test 1</td>
<td>Work on 3rd business plan</td>
<td>Work on competency test 2</td>
<td>Evaluate 3rd business plan</td>
<td>Evaluate competency test 2</td>
<td>Work on 4th business plan</td>
<td>Lunch</td>
<td>Evaluate 4th business plan</td>
<td>Debriefing &amp; payment by time</td>
</tr>
</tbody>
</table>
Figure 5: Cross-functional team formation

Social sources were manipulated by stratified random assignment of 246 business students into 82 cross-functional teams and 4 information retrieval conditions. Each team consists of 3 students having attended separate training in financial statement, market segmentation, and marketing environment analysis (e.g., s1, s2, s3). Students in Condition no-Talk no-Read worked alone without any external memory aid. Students in Condition Read worked alone but consulted reference manuals. Students in Condition Talk consulted cross-functional team members. Students in Condition Talk-Read consulted both reference manuals and cross-functional team members.

![Diagram of team formation]

Figure 6: Random assignment of subjects into 4 experimental conditions

<table>
<thead>
<tr>
<th></th>
<th>Non-social sources available (Read)</th>
<th>Non-social sources not available (No Read)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social sources available (Talk)</td>
<td>Condition Talk Read</td>
<td>Condition Talk</td>
</tr>
<tr>
<td>Social sources not available (No Talk)</td>
<td>Condition Read</td>
<td>Condition no Talk no Read</td>
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</table>
Figure 7: Sample competency and business plan questions

<table>
<thead>
<tr>
<th>CONCEPTUAL QUESTIONS</th>
<th>PLAN QUESTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Measure of personal knowledge</strong></td>
<td><strong>Measure of task performance</strong></td>
</tr>
<tr>
<td>A higher ________ reflects the firm’s ability to manage receivables effectively.</td>
<td>In 1998, the accounts receivable turnover ratio of AAT’s competitor is 90. This indicates AAT’s management of accounts receivable is ____ than its competitor.</td>
</tr>
<tr>
<td>A. Accounts receivable turnover ratio</td>
<td>A. Better</td>
</tr>
<tr>
<td>B. Current ratio</td>
<td>B. Worse</td>
</tr>
<tr>
<td>C. Debt ratio</td>
<td></td>
</tr>
<tr>
<td>D. Acid-test ratio</td>
<td></td>
</tr>
<tr>
<td>E. None of the above</td>
<td></td>
</tr>
<tr>
<td><strong>Financial statement</strong></td>
<td></td>
</tr>
<tr>
<td>When introducing new products in an existing market or old products in a new market, a firm with limiting resources should pursue an undifferentiated or concentrated marketing strategy supported by ______.</td>
<td>AAT has a better chance of success if it pursues a concentrated marketing strategy supported by ______.</td>
</tr>
<tr>
<td>A. Advertising many products at a time.</td>
<td>A. Advertising of one packaged tour to one group of individual and family travelers.</td>
</tr>
<tr>
<td>B. Advertising only one product at a time.</td>
<td>B. Advertising of many packaged tours to many groups of travelers.</td>
</tr>
<tr>
<td>C. Advertising in many markets at a time.</td>
<td></td>
</tr>
<tr>
<td>D. Advertising in only one market at a time.</td>
<td></td>
</tr>
<tr>
<td>E. None of the above</td>
<td></td>
</tr>
<tr>
<td><strong>Market segmentation</strong></td>
<td></td>
</tr>
<tr>
<td>Recently you read a marketing research report that mentioned ___ has utter fluency and comfort with computer, digital, and internet technology.</td>
<td>Considering JJC’s strategic location near high school and college campuses, the majority of JJC customers will be ______.</td>
</tr>
<tr>
<td>A. Generation X</td>
<td>A. Baby boomers</td>
</tr>
<tr>
<td>B. Generation Y</td>
<td>B. Generation Z</td>
</tr>
<tr>
<td>C. Generation Y</td>
<td>C. Generation X</td>
</tr>
<tr>
<td>D. Baby boomers</td>
<td>D. Generation X</td>
</tr>
<tr>
<td>E. None of the above</td>
<td>E. None of the above</td>
</tr>
<tr>
<td><strong>Marketing environment</strong></td>
<td></td>
</tr>
<tr>
<td>We developed an Excel program to randomly generate 300 unique ID numbers pre-printed on blank name tags and distributed to students at registration. These unique ID numbers provided procedures for random assignment of students into different training and information retrieval conditions, different task sequences by the Latin square block design, and different cross-functional teams. The letters in the ID codes correspond to Vietnamese terms in order to help local proctors direct registered students to designated experiment rooms and administer business plan tasks by designated sequences. Keys to the codes are:</td>
<td></td>
</tr>
<tr>
<td>L = Lecture room number (from 1 to 6)</td>
<td></td>
</tr>
<tr>
<td>TH = Information retrieval condition (from 1 to 4)</td>
<td></td>
</tr>
<tr>
<td>P = Experiment room number (from 1 to 40)</td>
<td></td>
</tr>
<tr>
<td>H = Task sequence number (from 1 to 4)</td>
<td></td>
</tr>
<tr>
<td>N = Cross-functional team number (from 1 to 100)</td>
<td></td>
</tr>
<tr>
<td>SV = Student’s ID number (from 1 to 246)</td>
<td></td>
</tr>
</tbody>
</table>

Figure 8: Sample ID numbers given to first 5 students during registration

| L2 - TH3 - P8 - H4 - N48 - SV1 |
| L1 - TH1 - P2 - H4 - N12 - SV2 |
| L4 - TH3 - P5 - H1 - N33 - SV3 |
| L3 - TH1 - P2 - H4 - N16 - SV4 |
| L4 - TH3 - P8 - H4 - N48 - SV5 |
### Table 1: Correlation table and summary statistics

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<th>8</th>
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</table>
Table 2: Statistical results from generalized linear mixed model (GLMM) with coefficients reported in regular form

See Table 4 for tests of coefficients providing support for H1 and H2

<table>
<thead>
<tr>
<th>Regular</th>
<th>model1</th>
<th>model2</th>
<th>model3</th>
<th>model4</th>
<th>model5</th>
<th>model6</th>
<th>model7</th>
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<tbody>
<tr>
<td>Know ($\beta_K$)</td>
<td>0.44**</td>
<td>0.43**</td>
<td>0.45**</td>
<td>0.45**</td>
<td>0.45**</td>
<td>0.50**</td>
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<td>0.78**</td>
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<td></td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.04)</td>
<td>(0.04)</td>
<td>(0.05)</td>
</tr>
<tr>
<td>Male ($\beta_M$)</td>
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<td>0.16*</td>
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<td>(0.07)</td>
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<td>(0.09)</td>
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<td>Talk x Read ($\beta_{TR}$)</td>
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<td>-0.27*</td>
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<tr>
<td></td>
<td>(0.13)</td>
<td>(0.13)</td>
<td>(0.13)</td>
<td>(0.14)</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Know x Read ($\beta_{KR}$)</td>
<td>-0.11*</td>
<td>-0.13**</td>
<td>-0.21**</td>
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<td>(0.07)</td>
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</tr>
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<td>-0.51**</td>
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<td>-0.62**</td>
<td>-0.64**</td>
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<td>(0.06)</td>
<td>(0.07)</td>
<td>(0.07)</td>
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</tr>
<tr>
<td>Wald Chi-square</td>
<td>302.58</td>
<td>310.07</td>
<td>456.16</td>
<td>456.76</td>
<td>454.45</td>
<td>458.88</td>
<td>539.58</td>
<td>541.65</td>
</tr>
<tr>
<td>LR test: Adjacent</td>
<td>1.51</td>
<td>1.89</td>
<td>1.96</td>
<td>4.39</td>
<td>76.42</td>
<td>76.42</td>
<td>2.04</td>
<td></td>
</tr>
<tr>
<td>LR test: Model 8</td>
<td>207.37</td>
<td>205.86</td>
<td>86.70</td>
<td>84.81</td>
<td>82.85</td>
<td>78.46</td>
<td>2.04</td>
<td></td>
</tr>
<tr>
<td>Observations</td>
<td>29,520</td>
<td>29,520</td>
<td>29,520</td>
<td>29,520</td>
<td>29,520</td>
<td>29,520</td>
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</tr>
<tr>
<td>Number of id</td>
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<td>246</td>
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<td>246</td>
<td>246</td>
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</tr>
</tbody>
</table>

Standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Table 3: Statistical results from generalized linear mixed model (GLMM) with coefficients reported in exponential form

See Table 4 for tests of coefficients providing support for H1 and H2

<table>
<thead>
<tr>
<th>Exponential</th>
<th>model1</th>
<th>model2</th>
<th>model3</th>
<th>model4</th>
<th>model5</th>
<th>model6</th>
<th>model7</th>
<th>model8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Know ($\beta_K$)</td>
<td>1.55**</td>
<td>1.54**</td>
<td>1.56**</td>
<td>1.56**</td>
<td>1.57**</td>
<td>1.65**</td>
<td>2.10**</td>
<td>2.18**</td>
</tr>
<tr>
<td>Male ($\beta_M$)</td>
<td>1.13</td>
<td>1.17*</td>
<td>1.07</td>
<td>1.09</td>
<td>1.08</td>
<td>1.08</td>
<td>1.07</td>
<td>1.07</td>
</tr>
<tr>
<td>Read ($\beta_R$)</td>
<td>0.90</td>
<td>1.09</td>
<td>1.19+</td>
<td>1.26*</td>
<td>1.29**</td>
<td>1.34**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Talk ($\beta_T$)</td>
<td>2.16**</td>
<td>2.18**</td>
<td>2.39**</td>
<td>2.41**</td>
<td>3.00**</td>
<td>3.11**</td>
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<td></td>
</tr>
<tr>
<td>Talk x Read ($\beta_{TR}$)</td>
<td>0.84</td>
<td>0.83</td>
<td>0.82</td>
<td>0.76*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Know x Read ($\beta_{KR}$)</td>
<td>0.90*</td>
<td>0.88**</td>
<td>0.81**</td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Know x Talk ($\beta_{KT}$)</td>
<td>0.64**</td>
<td>0.60**</td>
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<td></td>
</tr>
<tr>
<td>Know x Talk x Read ($\beta_{KTR}$)</td>
<td>1.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Wald Chi-square 302.58 310.07 456.16 456.76 454.45 458.88 539.58 541.65
LR test: Adjacent 1.51 1.89 1.96 4.39 76.42 76.42 2.04
LR test: Model 8 207.37 205.86 86.70 84.81 82.85 78.46 2.04
Observations 29,520 29,520 29,520 29,520 29,520 29,520 29,520 29,520
Number of id 246 246 246 246 246 246 246 246

Standard errors in parentheses
+ significant at 10%; * significant at 5%; ** significant at 1%
Table 4: Chi-square tests of coefficients provide support for H1 and H2

<table>
<thead>
<tr>
<th>Model 8</th>
<th>Chi-square statistics</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test 1</td>
<td>$\beta_T = \beta_R$</td>
<td>92.73</td>
</tr>
<tr>
<td>Test 2</td>
<td>$\beta_T = \beta_T + \beta_R + \beta_{TR}$</td>
<td>0.04</td>
</tr>
<tr>
<td>Test 3</td>
<td>$\beta_R = \beta_T + \beta_R + \beta_{TR}$</td>
<td>82.46</td>
</tr>
<tr>
<td>Test 4</td>
<td>$\beta_{KT} = \beta_{KR}$</td>
<td>19.59</td>
</tr>
</tbody>
</table>

Test 1 provides support for H1 (See Table 3: $\beta_T=e^{3.11}$, $\beta_R=e^{1.34}$, Test 1: $\beta_T>\beta_R$, $\chi^2=92.73$). Information users have greater task performance benefits from access to social sources than from access to non-social sources.

The results also provide support for H2 through a combination of three tests. The first test shows the effect of information retrieval from non-social sources declines with access to social sources (See Table 3: $\beta_{TR}=e^{0.76}$, p<.05). The second test shows no significant difference in the benefits from access to social sources and the benefits from access to both sources (Test 2: $\beta_T = \beta_T + \beta_R + \beta_{TR}$, $\chi^2=0.04$, p=0.83). The third test shows a significant difference in the benefits from access to non-social sources and the benefits from access to both sources (Test 3: $\beta_R = \beta_T + \beta_R + \beta_{TR}$, $\chi^2=82.46$, p=0.00). We then compare the magnitudes of the coefficients for access to social and non-social sources and find support for H2. The benefits from access to non-social sources decline significantly (a 34% gain from $\beta_R=e^{1.34}$ offset by a 24% decline from $\beta_{TR}<e^{0.76}$, supported by Test 3: $\beta_T + \beta_R + \beta_{TR} = \beta_R$, p<.05, $\chi^2=82.46$, p=0.00). This decline is greater than the decline in benefits from access to social sources (a 211% gain from $\beta_T=e^{3.11}$ offset by no significant decline from $\beta_{TR}<e^{0.76}$, supported by Test 2: $\beta_T + \beta_R + \beta_{TR} = \beta_T$, p<.05, $\chi^2=0.04$, p=0.83).

Moreover, we find personal knowledge moderates the task performance benefits from access to social and non-social sources. The results show an aggregate reduction in task performance benefits when personal knowledge is complemented by social sources (See Table 3: $\beta_{KT}=e^{.60}$, p<.01, a 40% attenuation) and by non-social sources (See Table 3: $\beta_{KR}=e^{.81}$, p<.01, a 19% attenuation). Test 4 shows the reduction is greater when personal knowledge is complemented by social sources than when it is complemented by non-social sources (Test 4: $\beta_{KR}=\beta_{KT}$, $\chi^2=19.99$, p=0.000).