Carnegie Mellon
Tepper
SCHOOL OF BUSINESS

DISSERTATION

Submitted in partial fulfillment of the requirements for the degree of

**DOCTOR OF PHILOSOPHY
INDUSTRIAL ADMINISTRATION
(INFORMATION SYSTEMS)**

Titled

"AN EMPIRICAL ASSESSMENT OF KNOWLEDGE MANAGEMENT SYSTEMS"

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AN EMPIRICAL ASSESSMENT OF KNOWLEDGE MANAGEMENT SYSTEMS

Dissertation

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August 2008

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Acknowledgements

I cannot imagine the completion of my dissertation without the support and encouragement of many important people.

I would like to thank Tridas Mukhopadhyay, my dissertation co-chair, who always encouraged me to improve my work and not to be satisfied with the status quo. He has been a great mentor and supporter throughout my five years at Tepper. I thank Bob Kraut, my dissertation co-chair, who has been a key source of knowledge and kept his door open to assist me. He always provided me with very constructive and workable advice. I also thank Rahul Telang and Linda Argote for providing numerous comments and suggestions.

I would like to thank Sandy Slaughter, Dennis Rousseau, and Millie Myers for their advice and encouragement. They were very helpful whenever I need some advice on the areas in which I do not have expertise. I also thank my fellow PhD colleagues. The Tepper staff members have also supported my work in many ways; thank Lawrence, Theresa, and Stephanie. I am also grateful for the continued help and support from the people in the research site of my dissertation: Bob, Russ, Jan, Lisa, David, Mindy, Julie, Kitty, Joan, Alro, Gary, Theresa, Jeff, Bill, Bryan, Sean, David, Dan, Chris, Brian, Christine, and all other senior members who attended my presentation in the company. All these people were very willing to share their experience and spend time for me. I thank my Professors at Yonsei University, Korea and University of Maryland; Professors Sang Un Yun, Ho Geun Lee, Ku Hyuk Kwon, Chul Eung Kim, and Hassan Ibrahim. Nothing could start without their strong recommendation several years ago. Professor Sang Un Yun must deserve special thanks for having been my mentor for years. Maybe the beginning of my journey for PhD was the undergraduate exchange program; I thank Professors Bon Il Ku and Heung Soo Park.

Thank Seok Yoon for her patience and never-ending encouragements. It would have been very difficult to survive the PhD program without her sweet and lovely voice. I am very much indebted to my parents in Korea. Their prayers, waiting, unconditional love, and faith in me helped me overcome all difficulties and challenges. Most importantly, I thank God for having sent these important people to me.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Abstract

Today knowledge is viewed as a more important production factor than traditional resources of capital, labor, and land. To effectively manage firms' knowledge assets with the aid of advanced technology, many companies have deployed KMS (Knowledge Management Systems). The organizations with IT-enabled knowledge management face two fundamental questions. First, how will knowledge management efforts with technologies pay off with what measurable outcomes? Second, if KMS pay off, how can the organization assimilate the KMS better? In my dissertation I identify three common forms of KMS, repository, business intelligence, expert directory KMS, and study the outcomes and drivers of usage for each category. I collected rich panel data from a retail grocery chain with more than 40,000 employees.

My dissertation consists of three studies. Study 1 investigates the contingent impact of KMS usage as a production factor on the group level performance measured by department-level weekly sales in a retail grocery chain. Study 2 examines how and why KMS in business environments influence individual knowledge workers. Study 3 examines what contextual factors specific to different types of KMS influence their usage at the weekly level. My dissertation makes important contributions to the literature by providing a systematic approach to assess the contingent value of KMS and promote the usage of different forms of KMS based on objective measurements of both KMS usage and performance. I not only study whether the implementation of KMS helps an organization manage knowledge as organizational assets or not, but also investigate why a specific type of KMS and knowledge is more effective for certain knowledge workers and how to target them to promote the use of KMS depending on their task and individual characteristics.

Chapter 1

Introduction

Since the term “knowledge worker” was coined in late 1950s, a majority of the workforce in North America is viewed as knowledge workers today (Zuckerman 1994). Knowledge is viewed as more important than traditional resources of capital, labor, and land (Hansen et al. 1999; Romer 1990). Knowledge is often considered an important asset that creates sustainable competitive advantage against competitors (Grant 1996; Kogut and Zander 1992; Teece et al. 1997). To effectively manage firms’ knowledge assets with the aid of advanced technology, many companies have deployed knowledge management systems (KMS). KMS are designed to facilitate all activities related to knowledge creation, knowledge storage, knowledge transfer, and knowledge application. Firms’ knowledge management efforts enabled by IT (information technologies) take many different forms and may include a repository of electronic documents, data warehouse, subject matter expert directory, and collaborative tools such as groupware and discussion forums.

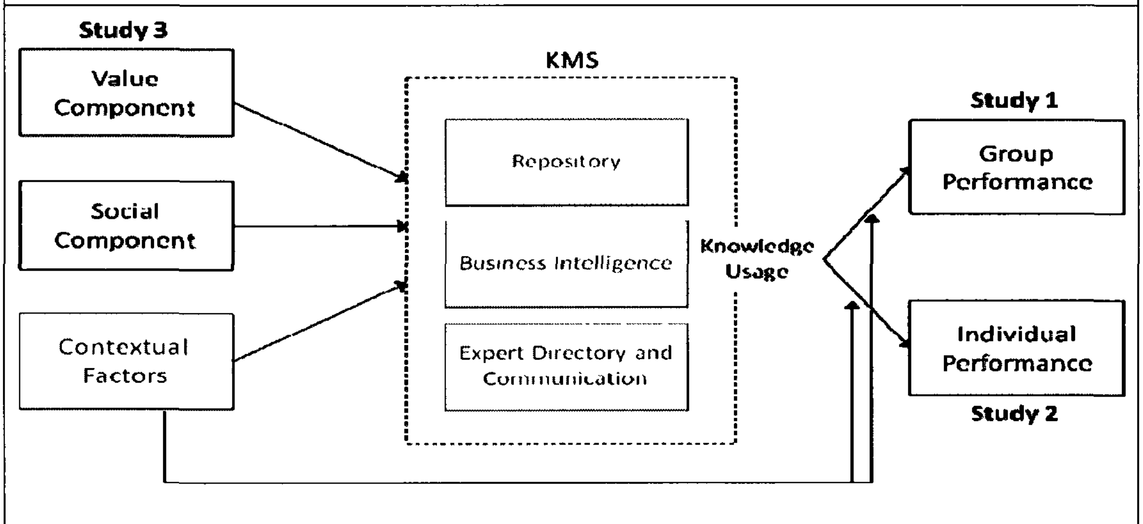
The organizations with IT-enabled knowledge management face two fundamental questions: will the KMS really pay off, and if so, how can the organization assimilate the KMS better? In fact, quantifying the value of information systems and identifying the drivers of systems adoption have been two core research questions in the IS literature. The first stream is represented by the business value of IT literature and the second stream is represented by the studies based on TAM (Technology Acceptance Model), TRA (Theory of Reasoned Action), and IS success model. In the context of KMS, prior studies show the benefit of computer-aided knowledge management practices (Haas and Hansen 2005; Tanriverdi 2005) and the antecedents to the use of KMS (Kankanhalli et al. 2005; Kulkarni et al. 2006; Lee and Choi 2003).

Nevertheless, the prior studies that examine the outcome of KMS have several limitations in understanding the performance impact and the usage drivers of KMS. Some limitations appear commonly in the traditional IT value research and the systems adoption research, while the other limitations rose by not incorporating factors specific to knowledge management. First, despite the existence of different forms of KMS, previous studies tend to focus on a repository of codified knowledge and do not consider possible interactions of a repository KMS with other types of KMS (e.g., data warehouse, expert directory, etc.) and with existing social networks as alternate sources of knowledge. Especially in the context of KMS, the value of sourcing knowledge from KMS will be determined by whether the user can obtain comparable knowledge from other sources or not. The IS literature has not much studied the issue of interaction between different computer assets in creating business value (with a few exceptions such as Davamanirajan et al. (2006)). Second, prior studies have attempted to measure the outcomes of KMS at various levels, but heavily relied on self-reported KMS usage and outcome measures, which may be biased (Straub et al. 1995). Since knowledge itself has an attribute of personal belief (Nonaka 1994), it may not be appropriate to measure the performance impact of KMS by self-reported belief. As a result, the benefits of KMS could not be measured in objective ways (Alavi 2000). The third limitation with prior studies is that the performance is measured only once. While the measurements of KMS use and the performance can be conducted with a certain time lag, it does not completely tease out the possibility of reversed causality. The fourth limitation is that prior studies do not sufficiently consider the contingent value of KMS. It is very important to understand to whom and under what conditions KMS creates greater value to better design and implement different forms of KMS that best suits a firm's needs. Lastly, most studies have focused on the distinction between codified and tacit knowledge (e.g., Haas and Hansen (2005)) or procedural and declarative knowledge (e.g., Arnold et al. (2006)) so far. However, there exist many other important dimensions that have important managerial implications in KM (Knowledge Management) practice.

In reference to the second fundamental question by firms, the IS literature is replete with studies of why individuals adopt information systems including possible factors that influence employees' usage behaviors. However, most studies do not fully answer the following questions to provide a complete picture of employees' KMS usage behaviors.

- Why do knowledge workers choose to source knowledge from different forms of KMS?
- What KMS-specific factors are relevant to the use of KMS?
- How is the usage of different forms of KMS interrelated? For example, when two applications can be used for similar purposes, "residual demand" may lead to more usage of the other application as in the Internet search engines (Telang et al. 2004).
- How do the usage behaviors of knowledge workers change over time? The existing models on the use of IT systems have relied on static methods, so they do not effectively model the dynamics in usage and outcomes over time.

Figure 1-1. Dissertation Overview



My dissertation attempts to overcome the limitations of previous studies and provides new insights into knowledge management practices in several ways. First, I consider three common forms of KMS – repository, business intelligence, and expert directory KMS – and examine how they interact with each other in improving the individual and group performance. I study why multiple KMS within an organization may be complementary or substitutive. Furthermore, I study how the motivations to source knowledge from different types of KMS may differ. I also examine how the usage of one form of KMS may influence that of other forms of KMS in the subsequent period. Second, I use very detailed and objective measures of performance. With a rich panel dataset collected from a retail grocery chain, I address many issues that have not been studied by the prior research. I use both the HR performance appraisal data on knowledge workers as a measure of the individual level performance and weekly sales of store departments as a measure of the group-level performance. All usage variables are system-recorded to avoid any possible bias of self-reporting. Third, I analyze the panel data with an econometric model to consider the dynamic nature of the use and outcomes of KMS. The contingent value of KMS use can be more rigorously studied with the econometric model as well. Fourth, I consider various contextual factors specific to different forms of KMS such as one's social capital, actual use of frequently interacting co-workers, geographical distance, environmental turbulence, task information and knowledge intensity, and so on. I aim to study how these factors motivate users to source knowledge from different forms of KMS, and how they moderate the impact of KMS use on the performance. For example, I find that the positive impact of KMS use is greater when the user is situated with little access to social networks and physical documents. In addition, the positive impact of KMS use is greater under less dynamic business environments and greater geographic dispersion. Fifth, I distinguish between different types of knowledge by introducing two dimensions of knowledge: knowledge life span and knowledge granularity. The life span of knowledge considers the rate at which knowledge degrades. The granularity of knowledge refers to the depth and details of knowledge. With the two dimensions, I consider the varying level of marginal value and cost of utilizing knowledge from external sources dependent on the business conditions to understand the optimal consumption strategy of knowledge. Figure 1-1 outlines my dissertation.

In sum, knowledge management is considered an organization-wide effort with a great promise. Our study develops a systematic way to measure the impact of technology-enabled knowledge management on individual knowledge workers across a whole gradient of an organization beyond self-reported perceived performance. I seek to better understand 1) why knowledge workers source knowledge from different types of KMS with different incentives and 2) why certain knowledge workers benefit more or less from different types of KMS. This dissertation will provide the firms interested in leveraging the intellectual assets with a full picture of the usage and outcomes of multiple KMS.

Chapter 2

STUDY 1: Assessing the Differential Impact of Knowledge Use on Group Performance

2.1. Introduction

A majority of the workforce in North America is viewed as knowledge workers today (Zuckerman 1994). Knowledge is now viewed as more important than traditional resources of capital, labor, and land (Hansen 1999; Romer 1990). Knowledge is often considered an important asset that creates sustainable competitive advantage against competitors (Grant 1996; Kogut and Zander 1992; Teece et al. 1997). To effectively manage firms' knowledge assets with the aid of advanced technology, many companies have deployed knowledge management systems (KMS). KMS are designed to facilitate all activities related to knowledge creation, knowledge storage, knowledge transfer, and knowledge application. Firms' knowledge management efforts enabled by IT (information technologies) take many different forms and may include a repository of electronic documents, data warehouse, subject matter expert directory and collaborative tools such as groupware and discussion forums.

One fundamental question faced by the organizations with IT-enabled knowledge management is whether KMS pay off or not. If we view the inflow of knowledge from KMS as a factor of production (e.g. Romer 1990), we would expect it to have a positive quantifiable impact on performance. Although it may be possible to quantify the impact of KMS, simply knowing that there is any measurable impact does not add many insights for managers into how to actually implement or improve KMS to maximize their returns on investments,

In fact, quantifying the value of information systems has been a core research question in the IS literature. In the context of KMS, prior studies have attempted to measure the benefit of computer-aided knowledge management practices (e.g., Haas and Hansen 2005, Tanriverdi 2005). Nevertheless, these studies on the outcomes of KMS have several limitations. First, previous studies tend to focus on a repository of codified knowledge only, and do not consider other sources of computer-based knowledge (e.g., data warehouse, expert directory, collaborative KMS) or existing social networks as alternate sources of knowledge. It is important to understand to whom and under what conditions KMS creates greater value in order to better design and implement different forms of KMS. The value of knowledge is determined by the interactions of the types of knowledge, the characteristics of knowledge users, and the business conditions, but such a perspective of contingent value of knowledge is scant in empirical studies. So far, most studies have focused on the distinction between codified and tacit knowledge (e.g., Haas and Hansen 2005) or procedural and declarative knowledge (e.g., Arnold et al. 2006) although there exist many other important dimensions that have important managerial implications in KM practice. Methodologically, prior studies have heavily relied on self-reported measures. The benefits of KMS have been little studied using objective measures (Alavi 2000). Another limitation with prior studies is that the performance outcome is often measured only once. Since the impact of KMS use on performance may manifest with a certain time lag, a one-time measurement may not accurately capture the effect. Second, prior studies do not sufficiently consider the contingent value of KMS.

Our study attempts to overcome these limitations and provides new insights into knowledge management practices in several ways. First, we consider different sources of knowledge such as knowledge repository, data warehouse, experts and social networks, and examine how they may interact with each other in improving performance outcomes. We study why multiple sources of knowledge within an organization may be complementary or substitutive. Second, we use detailed and objective measures of performance. With a rich panel dataset collected from a retail grocery chain, we study why the use of KMS contributes to enhanced group-level performance. We use store department level performance data such as sales and customer satisfaction. All usage data are system-recorded, and are free of any possible bias from self-reports (Straub et al. 1995). We also measure what information and knowledge are actually used. Third, we analyze the panel data with a Cobb-Douglas production function to quantify the impact of knowledge use over time. For example, we examine the impact of knowledge use on weekly sales of 364 departments over 146 weeks in a retail grocery chain. Lastly, we consider various contextual factors such as social capital of a knowledge work group, geographical dispersion, and environmental business dynamics. We find that the positive impact of KMS use on sales as the group performance measure is greater when a group is endowed with fewer alternative sources of information and knowledge (in terms of social capital and physical documents), or the external business environments are less dynamic, or knowledge workers are more geographically dispersed. We also find that the use of knowledge from repository KMS and data warehouse produce substitutive outcomes on the group performance level. We further distinguish different types of knowledge and consider two dimensions of knowledge: knowledge life span and knowledge granularity. The life span of knowledge considers the rate at which knowledge degrades. The granularity of knowledge refers to the depth and details of knowledge. With the two dimensions, we take the varying level of marginal value and cost of utilizing knowledge from external sources dependent on the business conditions into our account to understand the optimal consumption strategy of knowledge. With analytical models and empirical tests, we find that as the level of business dynamics increases, it is more beneficial for knowledge work groups to increase the proportion of shorter life-span knowledge and fine-grained knowledge in knowledge consumption.

Overall, our research contributes to enhanced understanding of the differential value of knowledge obtained from KMS contingent on the mix of the type of knowledge, group conditions, and external business environments. Knowledge management activities are costly and call for organizational support as a firm strategy (O'Dell and Grayson 1998). As a firm's understanding of the differential value of knowledge improves, its knowledge strategy also has to shift from mass creation or distribution of knowledge to targeting each business group to maximize organizational returns. In this paper, we offer the first step towards such a targeted knowledge strategy.

The balance of this paper is organized as follows. Section 2.2 presents a review of prior literature. Section 2.3 outlines our research model. Section 2.4 discusses our research method, and Section 2.5 presents the results of the study. Section 2.6 discusses the implications of the study, and the last section presents our concluding remarks.

2.2. Literature Review

This study draws on the knowledge management literature and the IT business value literature. Alavi (2000), Alavi and Leidner (2001), and Schultze and Leidner (2002) discuss how KMS is positioned in the IS literature. One stream of research assumes that using KMS facilitates knowledge management and would create business value. For example, the studies such as Boh (2004), Gray and Durcikova (2005), Kankanhalli et al. (2005), Wasko and Faraj (2005), and Markus (2001) include KMS as a part of research model and examine why people use a repository or contribute their knowledge to a knowledge repository. Hass and Hansen (2005, 2007), Feng et al. (2004), and Sabherwal and Sabherwal (2005) examine the impact of KMS on firms and user groups. Especially, the studies like Haas and Hansen (2005, 2007) began to differentiate the effects of personalized advice and electronic documents in the sales proposal development process. Another stream of research attempts to identify factors including technology that facilitate knowledge management processes such as knowledge creation, transfer, and retention (Gray and Meister 2004; Ko et al. 2005; Kwan and Cheung 2006; Lee and Choi 2003) and how improved knowledge management processes create value (Becerra-Fernandez and Sabherwal 2001; Gold et al. 2001; Lee and Choi 2003). In fact, the two views are not conflicting and they complement each other in studying IT-enabled knowledge management. Our study is close to the first stream of knowledge management studies in the IS that examines the outcomes of using different forms of KMS.

Quantifying the value of IT investments on a firm's performance has been one of the core research questions in the domain of IS (Ashworth et al. 2004; Brynjolfsson and Hitt 1996; Davamanirajan et al. 2006; Mukhopadhyay and Kekre 2002; Mukhopadhyay et al. 1995; Mukhopadhyay et al. 1997a). The recent trend is that the actual use of systems should be used to better explain variations in performance at the firm level (Devaraj and Kohli 2003) and at the individual level (Aral et al. 2006). On the other hand, Burton-Jones and Straub (2006) argue that IT use should capture the extent to which a specific user employs the system to carry out a particular task. How to measure IT usage at the fine level and how to measure its impact continue to be a core issue in the IS domain. Our study extends the trend by measuring the actual usage and considering the different types of knowledge usage.

2.3. Research Model and Hypotheses

Common Forms of Knowledge

A common view of knowledge is based on the hierarchy of data, information, and knowledge. According to this view, data is raw numbers and facts, and information is processed data, and knowledge is authenticated information (Dretske 1981; Machlup 1983). Thus information is the "commodity capable of yielding knowledge," and knowledge is "a high value form of information that is ready to apply to decisions and actions." (Davenport and Prusak 1998). Alternatively, knowledge may be viewed as an object, access to information, a process of applying expertise, and so on (Alavi and Leidner 2001). One lesson from the prior literature is that knowledge is a multidimensional construct with more complex characteristics than those of information (Kulkarni et al. 2006; Nonaka 1994). As two widely acknowledged dimensions of knowledge, tacit knowledge refers to knowledge that is unarticulated, rooted in actions and experience, and situated in context, while explicit knowledge refers to knowledge that is articulated in some symbolic form (Nonaka 1994; Polanyi 1962, 1967).

Knowledge management is a process of facilitating knowledge creation, knowledge storage, knowledge transfer, and knowledge application within an organization. Since information is consumed to generate new knowledge and knowledge itself is recombined to generate new knowledge (Kogut and Zander 1992), knowledge management activities should range from providing a knowledge worker with any factual information to be combined with one's prior knowledge to facilitating transfer of personalized "tacit" knowledge through socialization (Nonaka 1994; Polanyi 1962, 1967). In this respect, it is difficult to distinguish any information systems that provide a knowledge worker with highly customized actionable information from any commonly cited forms of KMS such as a repository of codified knowledge (Alavi and Leidner 2001). Since some nuances may be lost during codification and the cognitive capability of every knowledge worker is not identical, it may be more useful for a certain knowledge worker to receive well-processed and presented information rather than to receive other people's interpretation of the same information. Thus, we adopt a relatively broad view of knowledge and KMS. We take the view of knowledge as high value actionable information for decision-making and immediate reactions to tasks. Any information systems that potentially contribute to creation, storage, transfer, and application of actionable information and knowledge are considered a type of KMS in this paper. We present a brief definition of each type below.

Electronic Knowledge Repository An electronic knowledge repository model is one of the most common forms of KMS implemented by firms. A knowledge repository stores explicit knowledge (Nonaka 1994; Polanyi 1962, 1967) codified by other employees within the organization. The codified knowledge stock in a repository includes corporate policies, best practices and procedures, suggested improvements by other employees, training materials, and so on. A repository can be used to distribute knowledge to more employees who would otherwise never have access to it. Although it is relatively easy to deploy a repository, many studies have shown organizational and social barriers to maintain a "working" repository and other potential problems. For example, a repository may not contain high quality knowledge without proper incentives or may be filled with garbage even under monetary incentives (Garud and Kumaraswamy 2005).

Data warehouse Employees in organizations access information from various computer application systems from accounting, and inventory control to payroll systems. Often, data warehouses combine such information over a long period of time, and act as a source of business intelligence. Data mining tools are used to assist one's decision making, and facilitate the generation of new knowledge and insights. Given the vital role of data warehouse as business intelligence in organizational decision-making, we also include it in our analysis. Data warehouses are often considered a repository of corporate data, and classified within the same category as a document repository (Hahn and Subramani 2000).

Expert Directory model In an expert directory KMS model, a company creates and maintains a list of subject matter experts to map internal expertise (Alavi and Leidner 2001). While this yellow page of experts (Hahn and Subramani 2000) may be linked with experts' email accounts to transfer explicit knowledge only via emails, the expert directory KMS is likely to trigger new discussions via other media such as telephone or other collaborative tools. It provides an opportunity to develop a shared understanding of context and social relationship, which may enable an employee to transfer more sophisticated and complex knowledge that is even "tacit."

Collaboration tools to coordinate knowledge transfer process between more than two persons are often classified as another type of KMS (Alavi and Leidner 2001). In this study, we focus on the three common forms of KMS stated above because collaborative tools are not in much use at our research site.

Impact of KMS Usage on Group Performance

Prior studies have theorized that the use of electronic repositories is positively associated with the performance at the group and firm level (Feng et al. 2004; Haas and Hansen 2005; Sabherwal and Sabherwal 2005). Wixom and Watson (2001) show that the perceived data quality of data warehouse is positively associated with perceived benefits of data warehouse at the firm level. Knowing expertise location and developing ways by which expertise can be coordinated improves performance (Faraj and Sproull 2000). Thus, it is arguably reasonable to hypothesize that the use of repository, data warehouse, and expert directory KMS is positively associated with the performance at the group level.

A process is defined as a structured, measured set of activities designed to produce a specified output for a particular customer or market and may be broken down into multiple sub-processes (Davenport 1993). How does knowledge function as inputs for the increased output in a production process? When a production process acquires and capitalizes appropriate knowledge to add value to the product, knowledge inputs become a critical driver of the output level (cf. Massey et al. 2002). For example, in the traditional manufacturing process, knowledge can be accumulated through repetitive production or it can be transferred from other sources (Argote et al. 1990). In more competitive and dynamic environments, the inflow of information and knowledge on supply of materials and product demand can improve the management of sales and inventory. In the service sector such as the retail industry, stores have limited space to display and feature products while maintaining sufficient product variety. Retail stores make multiple decisions on product portfolio, pricing, advertising, temporary price reduction, and product display, which requires information and knowledge on the supply and demand of multitudes of products. Such decisions can be facilitated by better information and knowledge learned in the past. Employees need better training, which involves knowledge transfer from other employees or knowledge inputs from other sources like printed manuals. In addition to simply being better informed in the production process, knowledge may also facilitate innovation and can be used to create new knowledge. If KMS can provide a work group with useful knowledge to make better decisions and facilitate employee learning, the usage of KMS is likely to be associated with improved process output. Thus, we propose our baseline hypothesis with regard to the KMS impact on the group performance in a knowledge intensive process.[1]

Hypothesis 1: The higher usage of KMS is positively associated with the higher performance of a knowledge work group.

Contingent Impact of KMS Usage: Opportunity and Misfit Cost

The potential benefit of using KMS varies across groups and the use of KMS involves search and transfer costs (Huber and Daft 1987; Uzzi 1997). Since utilizing and applying knowledge in KMS incurs significant opportunity costs due to the time spent on searching and knowledge transfer, using computer-based KMS may even diminish performance when comparable knowledge already resides within the group (Haas and Hansen 2005). While Hass and Hansen (2005) consider the value of knowledge from KMS in comparison to accumulated stock of knowledge and expertise within a group, we turn to the opportunity cost in terms of the potential quality and quantity of knowledge inflows from existing external sources. Knowledge can be obtained from multiple sources and a knowledge work group has a choice from which source to gain relevant knowledge. In this sense, there exist several "competing" knowledge sources for employees' choice. To the extent that knowledge obtained from KMS is unique and easily utilized compared to that from other sources, the relative opportunity cost becomes smaller and the value of KMS utilization is greater. We identify three moderators affecting the relative size of opportunity cost that stand out based on the literature: alternative social and physical sources of information and knowledge, geographical dispersion, and the usage of other types of KMS. While the opportunity cost determines the relative value of knowledge from KMS, the misfit between needed

[1] We use the term "baseline" in the sense that the direct impact of KMS may not be a new hypothesis. However, this hypothesis will set a ground to examine other factors that moderate this relationship.

knowledge and actual knowledge available from KMS reduces the absolute value of knowledge When the misfit is present, the same amount of knowledge utilized will have a smaller impact on performance We describe below why the misfit becomes greater under the higher level of business dynamics below

Alternatives Sources of Information and Knowledge Knowledge sourcing is a learning behavior employed by individuals in an organization (Gray and Meister 2004), and employees can learn either from own experiences or from the experiences of others (Levitt and March 1988) The traditional sources of knowledge other than KMS have been other employees or other codified documents [2] Interactions with other employees such as supervisors and colleagues within an organization enable the members of knowledge work group to obtain appropriate knowledge An organization may also publish policies, best practices, standard operating procedures, training materials, internal reports, and manuals in physical documents and distribute them to be used by employees Codified documents are important sources of explicit knowledge and are utilized as inputs to create either tacit or explicit knowledge through the internalization and combination modes (Nonaka 1994)

When a knowledge work group is endowed with rich alternate sources of information and knowledge, the marginal benefit of using KMS is not as large compared to other groups with fewer alternate sources of information and knowledge Due to the cost of sourcing knowledge from KMS compared to seeking similar information and knowledge from alternate sources, using KMS under more alternative knowledge sources may even reduce the performance of a work group Since social network enables transfer of even tacit knowledge, replacing social sources of knowledge with KMS may run the risk of poor performance Relying on traditional sources may result in better outcomes unless KMS is sufficiently easy to use or provides the best information

[2] For example, Gray and Mesiter (2004) identifies three types of knowledge sourcing dyadic, group, and published knowledge sourcing Notice that the first two forms rely on person(s) while the last form relies on codified document as a channel for knowledge transfer

and knowledge. Our interview with one executive, who was not a frequent KMS user, illustrates this point: "If I need more information, it is their job (those who report to the executive) to get the information for me". For the executive, using KMS may not be as helpful as it is for other employees who do not have any support personnel to obtain and collect information and knowledge from other places. By not spending time on learning how to use the system and searching knowledge needed, he can focus on more strategic issues such as longer-term planning and decision-making.

Hypothesis 2: The performance impact of KMS usage is greater for knowledge work groups with limited alternate sources of knowledge.

Geographical Dispersion It is harder for geographically dispersed employees to even know what information and knowledge are available within an organization. Even when they know what knowledge may be out there, it is difficult for geographically dispersed employees to access knowledge that is available to others because geographical distance degrades relationships and reduces group interactions (Kiesler and Cummings 2002). Geographical distance reduces the chances of interpersonal interactions and is also likely to inhibit transfer of tacit knowledge through socialization. A narrow and distant interface makes learning and knowledge sharing very difficult (Inkpen and Dinur 1998). Geographical distance is also often associated with less access to formal knowledge transfer channels such as training. [3] The use of KMS enables a remotely located work group to overcome the communication deficiency by improving the ability to search for knowledge available in other parts of an organization. Therefore, the value of KMS is greater for the geographically dispersed knowledge workers.

Hypothesis 3: The performance impact of KMS usage is greater for a knowledge work group with a greater degree of geographical dispersion.

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[3] For instance, driving hundreds of miles to the headquarters for training itself is a big challenge for the store personnel in our research site.

KMS Substitutability Assets or activities are mutually complementary (substitutive) if the levels of any subset of the activities are increased, the marginal return to the other subset rises (falls) (Milgrom and Roberts 1990; Stieglitz and Heine 2007). The topic of complementarity between activity choices has received much attention in the organization, economics, management, and IS literatures (Milgrom and Roberts 1990, 1995; Siggelkow 2002; Stieglitz and Heine 2007; Zhu 2004). Similar to the case of alternative sources of information and knowledge, the performance impact of obtaining knowledge from any specific KMS is determined by the degree to which any equivalent knowledge can be acquired from alternate KMS in the organization. At the information level, it is possible that two pieces of information are complementary such that knowing only one of them is of little value. However, since every piece of knowledge in KMS has its stand-alone value, the two different types of KMS at the source level are likely to be substitutive. The typology of explicit and tacit knowledge is also useful in understanding the complementarity and substitutability of sourcing knowledge from different types of KMS as well. The knowledge from both repository KMS and data warehouse shares one important characteristic: knowledge from both sources is highly codified and explicit. Using knowledge from the repository KMS and data warehouse are likely to produce substitutive outcomes because they are not only explicit knowledge, they also overlap in content. However, since the expert directory KMS can be used to transfer more tacit components of knowledge and the answer from an expert can be customized to one's needs, the substitutability is not obvious. Expert directory KMS may become complementary if it leads to a high degree of tacit knowledge transfer. For example, Haas and Hansen (2007) argued that personal advice and codified documents are not complete substitutes for each other because both have different performance outcomes. In this sense, it would be desired for companies to implement both expert directory KMS and codification-based KMS (Alavi 2000). Since this complementarity is not guaranteed, we only hypothesize the substitutability between data warehouse and repository KMS.

Hypothesis 4: The performance impact of repository KMS usage decreases under higher level of data warehouse usage and vice versa.

Environmental Business Dynamics Environmental turbulence, dynamism, and instability refer to the extent to which one's environment is predictable or not (Baum and Wally 2003). In an unstable environment, the need for quicker response increases (Nayyar and Bantel 1994). For example, the literatures on dynamic capabilities (Eisenhardt and Martin 2000; Teece et al. 1997) and innovation speed (Kessler and Chakrabarti 1996) have stressed the speed of responding to changing environments as a key to success for organizations. Thus, timely acquisition of knowledge becomes more critical under turbulent environments. The clockspeed literature (e.g., Mendelson and Pillai 1998) has studied the organizational response to the increased environmental dynamics and argues that more use of communication technology enables an organization to improve information flow and better respond to the changes. Such dynamics is expected to reduce a firm's performance (Baum and Wally 2003).

Dynamic environments require more information and knowledge by their nature (Mendelson and Pillai 1998). To the contrary, search and misfit cost of knowledge is also greater under more turbulent environments. Increased dynamics demands creation of more rapidly changing and situation-specific new knowledge (Eisenhardt and Martin 2000), but KMS as a generalized source of knowledge becomes harder to provide context-specific solutions. In general, codified knowledge allows a knowledge work group to address relatively straightforward issues and a simplified and generalized component of knowledge in the repository KMS is less likely to be rich enough for specific environments (Haas and Hansen 2005). Thus, a repository KMS is less likely to be helpful under highly turbulent environments. For example, the reuse of codified knowledge fits better when firms produce standardized products rather than customized products (Hansen et al. 1999) since knowledge from data warehouse and repository KMS is focused more on dissemination of widely applicable knowledge than on customizing it to individual's specific needs. Even data warehouse has its limitation unless it is updated real-time and provide a point solution with algorithms written for the specific dynamic environment. Even for the expert directory KMS, the subject matter experts may not know about the specifics of users under highly dynamic environments. For example, even experts in perishable departments cannot obtain exact information about the users because much information in perishable departments is collected by physically examining freshness, color, and taste of products.

***Hypothesis** 5*: The performance impact of KMS usage is smaller for a knowledge group under more dynamic environments.

Optimal Balance between Different Types of Knowledge

The contingency theory (Lawrence and Lorsch 1967; Luthans and Stewart 1977) argues that system performance is determined by the interaction of independent situations and resources. Therefore, organizational design has to correspond to the external environments. We find our theoretical base from the streams of research in the "industry clockspeed" or environmental dynamics that focus on business dynamics (Mendelson and Pillai 1998, 1999). Dynamic environments are information-rich by nature (Mendelson and Pillai 1998) and thus demand larger volume of information and knowledge that need to be updated quickly for decision-making. Due to the bounded rationality and limited information processing capacity of decision makers, consuming too much or too detailed information and knowledge leads to information overload and may even hurt performance (Cyert and March 1963; March and Simon 1958). Decision makers have to choose the appropriate set of information that is useful but manageable. That is, dynamics affects the optimal set of information and knowledge by changing the relative value and cost of information and knowledge. The dynamics influences performance at the group level but every group does not face the same dynamics. The industry-level clockspeed does not capture the group-specific dynamics. For example, Mendelson and Pillai (1998) developed a measure of industry clockspeed: change in input prices, product life cycle, and product-line freshness, but such dynamics should be defined at the group level.

Life Span of Knowledge Burton-Jones and Straub (2006) have suggested that system usage should take a type of tasks into account. It implies that a set of knowledge from KMS may fit better with tasks in perishables (i.e., more dynamic environments) than with those in non-perishables. We focus on one important dimension of knowledge: life span of knowledge. Like a product whose value degrades over time, the value of knowledge degrades as well (Birkinshaw and Sheehan 2002). Each piece of knowledge has an effective life span, beyond which it needs to be revised or discarded (Dennis and Vessey 2005). One of the important characteristics of short life span knowledge is that its value degrades sharply while the value of long life span knowledge degrades more gracefully. As short life span knowledge is by nature more frequently updated, it tends to be more up-to-date. To the contrary, codified knowledge with long life span tends to stay in KMS for a long time. Dynamic environments demand more up-to-date information and knowledge, and thus short life span knowledge fits well with dynamic environments. However, short life span knowledge is not appreciated under stable environments as much. For users under stable environments, obtaining knowledge that lasts longer is more beneficial because long life span knowledge can take effect for a long period of time, if other things being equal. In fact, existing knowledge may even hurt if managers overly generalize from their past experience (Argote 1999) especially under dynamic environments. Thus, we expect that the proportion of short life span knowledge neutralize the negative effect of dynamic environments on performance. Mathematical consideration of the hypothesis is presented in Appendix-A.

Hypothesis 6: The more a knowledge group uses short life span knowledge rather than long life span knowledge, the smaller the negative impact of dynamics on performance becomes.

Information and Knowledge Granularity Information and knowledge granularity refers to the depth and details of information and knowledge. Again, identifying, transferring, and applying external knowledge is costly and managers have limited attention due to bounded rationality As the granularity of information and knowledge increases, the cost of learning such information and knowledge is also likely to increase due to the complexity and information and knowledge overload Therefore, although fine-grained information and knowledge may be available for access, knowledge workers do not always appreciate it For example, a manager in a grocery chain does not always look for a report that details hour-by-hour sales per item when a report to show daily sales per category of products gives her sufficient information and insights However, as the level of business dynamics increases, consuming information and knowledge with fine granularity becomes more useful than it used to be As noted above, an increase in dynamics requires managers to create more rapidly changing and situation-specific new knowledge (Eisenhardt and Martin 2000)

***Hypothesis** 7* The more a knowledge group uses fine-grained knowledge rather than coarse-grained knowledge, the smaller the negative impact of dynamics on performance becomes

2.4. Research Method

Data Collection

We collected our data from Ace Grocery (a pseudonym), a grocery chain with more than 200 stores nationwide and around 40,000 employees in total Each store has around ten business departments such as grocery, meat, seafood, deli, produce, and so on The chain has run retail grocery business for over 50 years Providing managers in stores with information and knowledge in a timely manner is critical in the retail grocery industry Improvement and innovation in one store can be applied by other stores as well It also realized that important knowledge is lost when senior employees leave the company To effectively manage knowledge scattered within the organization, Ace Grocery initiated a knowledge management system project and deployed KnowLink (a pseudonym) over several years Although the main component of KnowLink is a repository of documents on business plans designed by HQs, it also contains procedures, policies, training materials, suggestions for improvements by other employees, and so on KnowLink includes other tools such as inquiries to experts, data warehouse and data warehouse in order to supply relevant information and knowledge to the right person in the organization in various ways whenever he or she needs

Measurements and Operationalization

Knowledge Sourcing from KMS Measuring the use of information systems has been discussed a lot in the IS literature We obtained a weekly level system-recorded usage of KMS (KMS^{j}_{iT}) as follows

- Repository Use The total number of documents used by a work group per week
- Data warehouse Use The total number of customized reports used by a work group per week More than 200 report types were used at least once by our sample departments during the sample time period
- Expert KMS Use The total number of inquires by the work group per week

We aggregated the weekly-level usage to derive the usage of each type within the past 13 week time period (i e , a quarter) [4] We selected the cumulative usage with a sliding time window to account for two factors First, the effect of knowledge learned manifests over a period of time

[4] The 13-week window is appropriate for the study for several reasons It matches the business cycle of the research site, where seasonal factors are important For example, a customer satisfaction survey is conducted by the company every quarter Since the shortest review cycle set for the codified document in the repository is around 3 months, it is reasonable to believe that viewing a codified document may be good for at least 3 months Many reports in the business intelligence systems provide quarterly-level aggregated reports Thus, it is reasonable to believe that the minimum length of period to aggregate the KMS usage needs to be 13 weeks In fact, extending the aggregation length beyond 13 weeks tended to make the effect of KMS usage on sales performance more and more significant In this regard, our 13-week aggregation is at least a conservative estimate

Second, knowledge depreciates as well and expires after a while. We use the superscripts $j \in \{R, B, X\}$ to indicate repository, data warehouse, and expert KMS, respectively.

Every piece of document in the company's repository is postmarked with the date of creation, last review date for the validity of knowledge, and next review date. Therefore, the gap between the next and the last review date can be viewed as the life span of knowledge. We operationalized the use of short life span knowledge by the number of viewed documents that have a review cycle shorter than 6 months in the past quarter ($KMSS_{iT}^{R}$). Thus, the proportion of short-life span knowledge is operationalized by $KMSL_{iT}^{R} / KMS_{iT}^{R}$. When KMS_{iT}^{R} is zero, the ratio variable was coded as 0.5 to indicate that it is neutral.

The measure of the granularity of information and knowledge was derived from the use of data warehouse. We consider two dimensions to capture the granularity of information: time and cross-sectional dimensions. In the time dimension, two out of 205 reports available provide hour-by-hour sales-related information while other reports provide information at the more aggregate level such as by day, week, month, quarter, or year. In the cross-sectional dimension, 20 reports are designed to provide item-by-item information while other reports provide more aggregated information at the level of product category, department, store, region, or the entire chain. We counted the number of hour-level reports viewed by department i ($KMSH_{iT}^{D}$) and the number of item-level reports viewed by department i within the past four weeks ($KMSI_{iT}^{D}$). [5] Then, we derived the proportion of the number of hour-level reports viewed out of the total number of reports viewed ($KMSH_{iT}^{D} / KMS_{iT}^{D}$) and the proportion of the number of item-level

[5] We needed to choose a shorter time window because store department managers use finer grained knowledge primarily to develop action plans for up-coming business weeks. The company's HQs starts distributing its weekly advertising plans four weeks before the actual business week, and this time is when the managers start to plan for the up-coming business weeks in details with fine-grained knowledge.

reports viewed out of the total number of reports viewed ($KMSI_{iT}^{D}$ / KMS_{iT}^{D}). When KMS_{iT}^{D} is zero, the ratio variables were coded as 0.5 to indicate that it is neutral. The two ratio variables were then averaged to derive a single variable for the general level of knowledge granularity ($KGRN_{iT}$).

Knowledge work group performance and Controls The store department-level performance is measured by weekly department sales. We view weekly sales as a measure of productivity-based performance because increased inputs such as hours worked by store clerks result in increased sales at the store level. Since the weekly department sales are influenced by temporal characteristics, we introduced two control variables. We included a dummy variable to account for seasonal peaks in sales during major holiday weeks. 12 out of 52 weeks in a year were identified as special weeks by the company (e.g., Christmas, Thanksgiving, Halloween, Labor Day, etc) and coded as one for our analysis ($SPWK$). To account for a possible change due to temporal trend, a variable that was coded as 0, 1, and 2 for year 2004, 2005, and 2006, respectively, was added ($TRND$).

Business Dynamics Mendelson and Pillai (1998) have developed an aggregate measure of industry clockspeed that consists of three dimensions: change in input prices, product life cycle, and product-line freshness. Since our samples are from a single company, every group in the company is likely to face the same level of industry dynamics and thus we need a specific measure of business dynamics faced by store departments in the retail industry. Through our interviews and discussions with its employees including store managers, we identified three varying important sources of business dynamics across different store departments in the retail grocery chain: store competition, product perishability, and task information and knowledge intensity. First, the level of competition influences the business dynamics at the store level. Competition is an important determinant of the group-level dynamics in earlier studies (e.g., Haas and Hansen 2005). The competition data came from the strategic planning department in the company and each store is classified into either high or low competition store (0 = low and 1 = high). Second, as the two of the three industry-level clockspeed drivers are related to products, product characteristics are important sources of business dynamics in the store department as well. The departments handling perishable products must constantly exercise better planning to prevent throw-away, which makes their task environments highly unpredictable. Perishable departments (e.g., bakery, meat, seafood, and floral) were coded as 1. Competition and product characteristics are often measured to capture the dynamics in survey-based studies as well (e.g., Baum and Wally 2003). Beyond the two important sources of dynamics, some store departments are inherently situated under highly dynamic environments created by the volume and volatility of information and knowledge. If we adopt the information-processing view of the firm (Cyert and March 1963; March and Simon 1958; Simon 1973; Tushman and Nadler 1978) that views the organization as an information-processing system that assimilate information from the external environment, match it with information and knowledge that were accumulated within the organization, and act on it, group tasks are basically a series of information processing and task-related dynamics originate from the task-specific intensity of information and knowledge. For example, some departments may need much more information because of unique and rapidly changing needs of customers in the trade area. Based on Schroder et al. (1967), we view 1) volume of information and knowledge needed and 2) rate of change in needed information and knowledge as two sub-dimensions of task information and knowledge intensity. We developed the survey measures for the intensity of information and knowledge (Appendix 2-B) that were filled out by store department managers. Then, a store department was coded as one if the aggregate task information and knowledge intensity is higher than the median, and zero, otherwise. The three components serve as the formative sub-constructs that lead to the variation in the degree of business dynamics. In contrast to reflective constructs that are caused by the latent variable, formative constructs cause the latent variable. "While it may occur, formative indicators need not be correlated nor have high internal consistency such as Cronbach's alpha" (Chin 1998) . Thus, the latent variable is an additive index of sub-dimensions. We took the average of the three such that our measure of business dynamics takes one of the four possible values: 0, 0.33, 0.66, and 1.

Other KMS-Specific Contingencies The distance between the corporate headquarters and the location of users was calculated using MapQuest.com. The driving distance in miles was coded for our analysis. To account for alternative sources of information and knowledge for each department, we used survey-based measures. We used four items to measure alternate *social* sources of information and knowledge and two items to measure alternative *physical* sources of information and knowledge. We then aggregated the two alternative sources of information. The items used and Cronbach's alpha for the two alternative sources are summarized in table 1.

Econometric Model Specification

We employ a Cobb-Douglas production function framework that has been widely used in IT business value literature (Brynjolfsson and Hitt 1996; Mukhopadhyay et al. 1997b). We formulate that the sales of a store department i at week T is determined by its labor inputs ($LHRS$) and a set of knowledge inputs (KMS). The generation of sales in a store department can be viewed as a production process for two reasons. First, the sales process involves value-adding activities by utilizing labor inputs from receiving products to replenishing store shelves. Second, store employees literally cook or make products such as foods to be sold. Knowledge inputs are also required to make timely decisions on order placements, store display, and temporary price reductions. For example, data warehouse provides knowledge on what has sold well in the department and other departments in similar stores, and helps make informed decisions on what portfolio of products should be carried in a particular week. Employees can review historical sales and infer seasonal trends by interpreting knowledge from the data warehouse. The repository KMS provides additional knowledge on what new products may be available, what new trends are observed, and what new procedures and practices are suggested to improve sales. The expert directory KMS in the retail environment can also help department managers solve business problems or learn about new vendors to order products from. The weekly sales ($SALE$) of store department i at week T can be specified as

$$\begin{aligned} Log(SALE_{iT}) = {} & v_i + \beta_0 + \beta_1 \cdot Log(LHRS_{iT}) + \beta_2 \cdot Log(KMS_{iT}^{j}) + \beta_3 \cdot Z_i + \beta_4 \cdot R_{iT} \\ & + \beta_5 \cdot Log(KMS_{iT}^{j}) \cdot Z_i + \beta_6 \cdot DYN_i \cdot R_{iT} + \beta_7 \cdot Log(KMS_{iT}^{j}) \cdot Log(KMS_{iT}^{-j}) \\ & + \beta_8 \cdot SPWK_T + \beta_9 \cdot TRND_T + \varepsilon_{iT}. \end{aligned}$$

v_i is a constant term specific to a department i. Z_i is a vector of time-invariant factors. In our model, Z_i includes the distance from the headquarters, alternative sources of information and knowledge, the level of environmental dynamics, and control variables such as department manager's tenure in the company and in her position. R_{iT} is a set of the ratio variables such as knowledge granularity and the proportion of short life-span knowledge. DYN_i is a variable for business dynamics. We also control for seasonality and temporal trend with $SPWK_T$ and $TRND_T$ as explained in the data section. ε_{iT} is the idiosyncratic component of the error term. KMS_{iT}^{-j} indicates the use of KMS that is not of type j. We will set the error terms serially correlated as AR (1) process.

We will consider a model with either fixed or random effects. The limitation of using a fixed effects model is that it cannot estimate any effects of time-invariant factors. Since we need to estimate β_3, the coefficient for the time invariant factors, in order to estimate the coefficient for any moderating effects precisely (Baron and Kenny 1986), we will present a random effects model with AR(1) as our main model. However, the random effects model also makes a potentially restrictive assumption that the unobservable heterogeneity is uncorrelated with the included regressors. Perceiving that any single model does not satisfy all of our estimation requirements, our approach is to compare the estimation results with different model specifications and show that there is no fundamental difference across the models.

2.5. Results

The descriptive statistics are presented in Table 2-1. Note that the outcome and KMS usage variables have been masked (multiplied by a positive number) to protect the confidential nature of the data. All numeric variables were standardized during our analysis.

Table 2-1. Descriptive Statistics

Variable	*N*	*Mean*	*Std Dev*
Log of Weekly Sales	39,858	10.3180	1.3929
Log of Labor Hours	39,858	5.5717	0.7613
Log of Repository KMS Use	39,858	2.4801	1.2861
Log of Data Warehouse Use	39,858	5.1595	1.7058
Log of Expert KMS Use	39,858	0.0313	0.1622
Log of Repository KMS Use by Co-workers	22,046	2.6124	1 0797
Log of Data warehouse Use by Co-workers	22,046	3 8623	1.6411
Log of Expert KMS Use by Co-workers	22,046	0.0138	0.0703
Aggregate Alternative Sources	38,252	5.5768	0.9278
Log Distance from HQs	39,858	4.2619	0.9939
Environmental Dynamics	38,690	0.5962	0.2608
Knowledge Granularity	39,858	0.1305	0.1735
Proportion of Short Life-span Knowledge	39,858	0.0942	0.1853
Tenure in Company	37,376	4.4766	1.0567
Tenure in Position	37,084	3.5906	1.1929
Special Week	39,858	0.2192	0.4137
Trend	39,858	1.0137	0.8023

Table 2-2 shows our estimation results for the direct effects of knowledge use from the three types of KMS on the sales output. The first column is the result with our random effects model. We confirm that all three KMS usage variables are significant at $\alpha = 0.01$. The estimates are $\beta_{BI} = 0.0054$, $\beta_{Repository} = 0.0078$, and $\beta_{Expert} = 0.0026$. The coefficients can be interpreted as the output elasticity of each factor that represents the percentage increases in the sales output by a small percentage increase in input at a time. That is, one percent increase in the repository use is likely to lead to 0.0054 percent increase in weekly sales. Since the median weekly sales in the given samples is around 28,000 dollars, a unit percent increase in the usage of repository, data warehouse, and expert directory KMS altogether corresponds to a company-wide increase in annual sales by 830,000 dollars if we assume that there are 200 stores and each store has around 10 departments. [6] Considering the low margin in the retail grocery chain, this number is rather surprising. It is interesting that the output elasticity of labor inputs is much greater than that of knowledge inputs (β_{Labor} = 0.1960). Although the contribution of knowledge to production is substantial, the value-adding process in the retail grocery chain is still labor-intensive. The R^2 statistics in the Table 2-2 was calculated as the squared correlations between the predicted value and the observed value of the dependent variable (i.e., $Corr(\hat{Y}_{it}, Y_{it})^2$). [7]

The second model in Table 2-2 is obtained when we consider the time-series nature of the panel data. The estimated autocorrelation coefficient (ρ) is around 0.59, which is not trivial although testing the null hypothesis of ρ = 0 involves extremely complicated distributions to derive a cutoff point (STATA 2003). Nevertheless, we do observe any dramatic change in the nature of the estimates by specifying the autoregressive error components. The next two models estimated are the fixed effect model without and with the autoregressive error components, respectively. The fifth and sixth columns are our estimation results with 2SLS with different sets of instrumental variables (IV) to address the possible endogeneity. As the choice of instruments is not an easy issue, we tried two sets of variables as our instruments. The fifth model uses the lagged independent variables as instruments and the sixth model uses the KMS usage by co-

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[6] \$ 28,000 * (0.018+0.0078+0.0026) % * 200 (stores) * 10 (departments) * 52 weeks ≈ \$ 830,000. The number of stores and the number of departments per store are similar to the actual numbers from the research site.

[7] The reported R^2 does not have all the properties of the OLS R^2 . (STATA 2003, p.194). For example, it is not equal to the fraction of the variance in the observed value explained by the predicted value.

workers outside the group as instruments.[8] We observe that the estimated coefficients are larger than those in the previous models in general. Therefore, although the estimation results form the fixed and random effects models might have been influenced by the possible endogeneity due to simultaneity, they are likely to be conservative. [9]

Table 2-2. Estimation of Knowledge Input Elasticity

	Random Effect Model	Random Effects Model - AR(1)	Fixed Effect Model	Fixed Effect Model - AR(1)	Fixed Effect Model - 2SLS (1)	Fixed Effect Model - 2SLS (2)
Intercept	-0 0166 (0 0330)	-0 0158 (0 0242)	-0 0166 *** (0 0007)	-0 0142 *** (0 0005)	-0 0169 *** (0 0007)	-0 0119 *** (0 0010)
Log of Labor Hours	0 1960 *** (0 0023)	0 1868 *** (0 0027)	0 1932 *** (0 0023)	0 1820 *** (0 0027)	0 1934 *** (0 0023)	0 3496 *** (0 0047)
Log of Repository KMS Use	0 0054 *** (0 0010)	0 0102 *** (0 0017)	0 0053 *** (0 0010)	0 0096 *** (0 0018)	0 0049 *** (0 0010)	0 0102 *** (0 0015)
Log of Data Warehouse Use	0.0078 *** (0 0014)	0 0078 *** (0 0024)	0 0080 *** (0 0013)	0 0067 *** (0 0024)	0 0080 *** (0 0013)	0 0152 *** (0 0019)
Log of Expert KMS Use	0 0026 *** (0 0007)	0 0020 * (0 0012)	0 0026 *** (0 0007)	0 0019 (0 0012)	0 0024 *** (0 0007)	0 0040 *** (0 0010)
Special Week	0 0756 *** (0 0016)	0 0689 *** (0 0010)	0 0756 *** (0 0016)	0 0689 *** (0 0010)	0 0756 *** (0 0016)	0 3496 *** (0 0047)

[8] As popular instruments in the literature (Greene 2002, p.79), the first set of instruments is the lagged usage variable (e.g., Dewan and Kraemer 2000). That is, the sum of KMS usage between 14 weeks and 26 weeks before week T was used as our instruments in the fifth model. Since it is not the case that the store department starts planning on 13 weeks before the upcoming business, using the lagged independent variable as instruments is reasonable. The second set of instruments is the KMS usage by co-workers outside the group as instruments. The usage by co- workers involved two-step processes. We first asked the department managers to identify up to six employees in corporate headquarters (excluding temporary employees and contractors) with whom they frequently interact in order to accomplish their job. Then we averaged the level of actual usage by those co-workers over the 13 week period. The rationale for using the co-workers' usage is that department manager's usage is influenced by their co-workers usage while their co-workers usage is not directly correlated with the group's performance. However, since only around 70 percent of the managers in our samples identified at least one co-worker, the sixth model has fewer observations.

[9] Another set of instruments that we have considered plausible was the usage by other department managers in the same store. However, we did not find the sufficient level of correlations between the managers in the same store ($r < 0.1$).

Trend	0 0341 *** (0 0007)	0 0267 *** (0 0013)	0 0341 *** (0 0007)	0 0249 *** (0 0013)	0 0340 *** (0 0007)	0 0747 *** (0 0022)
R^2	0 5508	0 5482	0 5499	0 5501	0 5511	0 5452

Significant at 1 % ***, 5 % **, and 10% *. The numbers in parentheses are standard errors.

We further examine the robustness of the model by analyzing how the change in the knowledge inputs led to the change in the sales output level over a relatively long period of time. Table 2-3 supports that the groups with increased knowledge usage could improve their sales over the two-year time period. [10] Only the difference in logged data warehouse usage was not significant. Figure 2-2 plots the difference in logged sales over the two-year time period against the difference in the logged repository use by each group, which indicates linear relationship between the two variables.

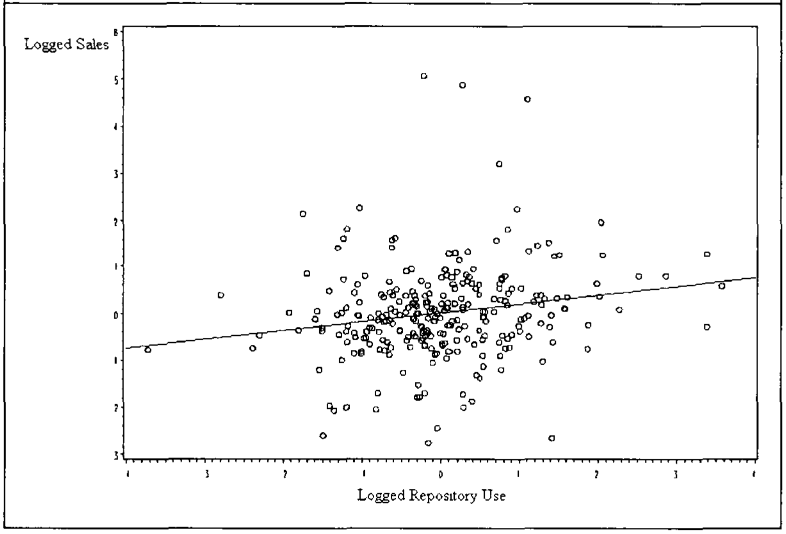
Table 2-3. Performance Change over 2 Years

Variable	Estimate
Intercept	0 0000 (0 04951)
Diff ın Logged Labor Hours	0 52753 *** (0 04992)
Dıff. ın Logged Data Warehouse Use	-0 01553 (0 05217)
Diff ın Logged Repository Use	0 16841 *** (0 05212)
Dıff ın Logged Expert KMS Use	0 12588 ** (0 05024)
R^2	0 3407

Significant at 1 % ***, 5 % **, and 10% *. The numbers ın parentheses are standard errors.

[10] Out of 146 weeks in our samples, we selected two years (104 weeks) to examine this difference-in-dıfference model to minimize any possible effect of seasonality.

Figure 2-1. Plot of Yearly Sales and Repository Use



Overall, we confirm that Hypothesis 1 is strongly supported. The patterns are preserved across different model specifications and we conclude that the knowledge input results are robust against autocorrelation and endogeneity. The Hausman test rejects the null hypothesis that the coefficients from the random effects and the fixed effects model are the same ($\chi^2 = 270.74$, d.f. = 6). However, we did not observe any fundamental difference in the significance level and the size of coefficients between the fixed and the random effects specification. Furthermore, the fixed effects model cannot estimate the coefficients for any time-invariant moderator although inclusion of the two direct effect terms is considered important in evaluating the moderating effects in the literature (Baron and Kenny 1986). Therefore, we present the random effects model with the first order autoregressive error component for the subsequent tests of the moderating effects. We confirmed that using fixed effects did not change the nature of the results in the moderating effects model as well. We will compare the results from the different specifications in the full model with all the variables at the end of this section. Before we estimate the full model with all the variables, we will estimate the influence of including each moderator separately to minimize the effect of multicollinearity by including too many interaction terms. Moreover, it is difficult to obtain efficient estimates because the correlation between the repository usage and the data warehouse usage is already present in the model ($r = 0.47$), otherwise.

Table 2-4 presents our estimation results on the contingent factors of knowledge elasticity using the random effects model with autoregressive error terms. We find that all coefficients for the interaction terms between KMS usage and alternative sources of information and knowledge are in the expected direction, and the two of them are statistically significant as in the first column. The insignificant moderating effect for the repository may be because the repository has been much used to publish and distribute unique information and knowledge in the company. That is, although the users may have good alternative sources of information and knowledge, this moderating effect is unlikely to be significant if they can obtain much knowledge that is otherwise impossible to obtain from their existing sources in a timely manner. The results support that the output elasticity of KMS knowledge use is greater in general when a store department manager is endowed with fewer alternative sources in terms of social network and physical documents.

The second column supports that the output elasticity of KMS is greater for knowledge work groups that are geographically dispersed (Hypothesis 3). We find that all coefficients for the interaction terms are in the expected direction, but the two of the three are significant. We argued earlier that the impact of KMS on output is greater when a user is experiencing communication deficiency due to geographical distance from important sources of knowledge, which is corporate headquarters in our case. The reason why the coefficient for the interaction between expert directory KMS usage and geographical distance is not significant may be that expert directory KMS has created an opportunity to locate expertise and obtain even tacit knowledge in the company. Such opportunities are not necessarily restricted by geographical dislocation.

The third column in Table 2-4 shows that the knowledge inputs from different types of KMS substitute the effect of other types of KMS (Hypothesis 4). It suggests that the data warehouse and repository KMS are substitutive as a reservoir of codified explicit knowledge, and overlap in knowledge from both sources may exist. We did not propose any hypothesis on the interaction between other types of KMS above, and the coefficients for the two other interaction variables are insignificant as expected. We believe that the insignificant coefficients for the interaction between expert directory KMS and other types of KMS may pertain to the specifics of the company. We observed that a manager initially submits an inquiry and more rich communications are triggered for detailed discussions. Therefore, the degree of substitution between the expert KMS and other codified knowledge-based systems is likely to be much smaller. Despite the value of expert directory KMS in transferring more sophisticated knowledge, it is not completely complementary because there are some cases where the transfer ends up with simple answers to the inquiries as well. In addition, we found that some financial reports are available in the repository while the similar reports can be also retrieved from data warehouse. We further discuss this result in the discussion section.

The fourth column in Table 2-4 tests Hypothesis 5 on the interaction between KMS usage and environmental dynamics. It supports that the output elasticity of KMS use is greater when external environment is less dynamic. The signs for all three coefficients for interaction terms are in the expected direction again. Only the interaction between repository KMS and external dynamics is not significant. We argued earlier that the KMS effect becomes smaller under higher business dynamics because of the increased misfit between the needed knowledge and the actual knowledge obtained from KMS. We find that the misfit is present even in the expert directory KMS that can be better customized to meet the users' needs. To the contrary, the misfit does not make the repository less useful in our case. The misfit in repository may be already high to the extent that any additional misfit captured by our measure of business dynamics does not contribute to a decrease in the usefulness of knowledge in repository. An alternative explanation is that the company has well adjusted its knowledge in repository such that the negative impact of misfit can be minimized and knowledge is equally useful for those with potentially high misfit

Table 2-4. Contingent Effects of Knowledge Use

Variable	Alternative Sources	Distance	Knowledge Substitution	Environmental Dynamics
Intercept	-0 0160 (0 0255)	-0 0162 (0 0258)	-0 0129 (0 0259)	-0 0139 (0 0250)
Log of Labor Hours	0 1859 *** (0 0028)	0 1841 *** (0 0028)	0 1844 *** (0 0028)	0 1859 *** (0 0028)
Log of Repository KMS Use	0 0103 *** (0 0018)	0 0107 *** (0 0018)	0 0102 *** (0 0018)	0 0104 *** (0 0018)
Log of Data Warehouse Use	0 0062 ** (0 0026)	0 0068 *** (0 0026)	0 0010 (0 0029)	0 0038 (0 0027)
Log of Expert KMS Use	0 0027 ** (0 0012)	0 0022 * (0 0012)	0 0017 (0 0014)	0 0016 (0 0012)
Repository Use * Alternative Sources	0 0005 (0 0019)			
Data Warehouse Use * Alternative Sources	-0 0113 *** (0 0027)			
Expert KMS Use * Alternative Sources	-0 0025 ** (0 0012)			
Repository Use * Distance		0 0059 *** (0 0018)		
Data Warehouse Use * Distance		0 0061 ** (0 0028)		
Expert KMS Use * Distance		-0 0004 (0 0012)		
Repository Use * Data Warehouse Use			-0 0081 *** (0 0016)	
Data Warehouse Use * Expert KMS Use			-0 0008 (0 0014)	
Expert KMS Use * Repository Use			0 0007 (0 0017)	
Repository Use * Environmental Dynamics				-0 0028 (0 0018)
Data Warehouse Use * Environmental Dynamics				-0 0113 *** (0 0025)
Expert KMS Use * Environmental Dynamics				-0 0023 * (0 0012)
Alternative Sources	-0 0491 * (0 0276)	-0 0491 * (0 0279)	-0 0497 * (0 0280)	-0 0488 * (0 0271)
Environmental Dynamics	-0 2141 *** (0 0266)	-0 2150 *** (0 0270)	-0 2145 *** (0 0270)	-0 2152 *** (0 0262)
Log Distance from HQs	0 0230 (0 0263)	0 0222 (0 0267)	0 0226 (0 0267)	0 0240 (0 0259)
Tenure in Company	0 2336 *** (0 0325)	0 2351 *** (0 0330)	0 2346 *** (0 0330)	0 2329 *** (0 0320)
Tenure in Position	0 0530 (0 0330)	0 0522 (0 0334)	0 0527 (0 0335)	0 0523 (0 0325)
Special Week	0 0676 *** (0 0010)	0 0677 *** (0 0010)	0 0677 *** (0 0010)	0 0677 *** (0 0010)

Trend	0 0267 *** (0 0014)	0 0268 *** (0 0014)	0 0263 *** (0 0014)	0 0267 *** (0 0014)
R^2	0 3970	0 3990	0 3983	0 3986

Significant at 1 % ***, 5 % **, and 10% * The numbers in parentheses are standard errors

Table 2-5 presents our estimation results on the choice of the different types of knowledge by its life-span and granularity contingent on business dynamics using the random effects model with autoregressive error terms. The two columns test Hypothesis 6. The estimated coefficient for the interaction term between environmental dynamics and the proportion of short-life span knowledge is positive and significant as expected (β = 0.0054, p-value < 0.01). We confirm that it is optimal to increase the proportion of short life-span knowledge as the level of environmental dynamics increases. The estimated direct effect of the higher dynamics is negative and significant (β = - 0.2239, p-value < 0.01). We test Hypothesis 7 on information and knowledge granularity in the next column. The model shows that an increase in the granularity of information and knowledge under higher environmental dynamics significantly reduces the negative effect of environmental dynamics on performance (β = - 0.2251, p-value < 0.01). The level of environmental dynamics is negatively associated with the weekly sales in the two columns again.

Table 2-5. Knowledge Allocation Results

Variable	Life-span	Granularity
Intercept	-0 0159 (0 0259)	-0 0157 (0 0255)
Log of Labor Hours	0 1849 *** (0 0028)	0 1851 *** (0 0028)
Log of Repository KMS Use	0 0096 *** (0 0020)	0 0103 *** (0 0018)
Log of Data Warehouse Use	0 0076 *** (0 0026)	0 0076 *** (0 0027)
Log of Expert KMS Use	0 0021 * (0 0012)	0 0022 * (0 0012)
Environmental Dynamics * Proportion of Short Life-span Knowledge	0 0052 *** (0 0012)	
Environmental Dynamics * Knowledge Granularity		0 0051 *** (0 0013)

Proportion of Short Life-span Knowledge	-0 0009 (0 0014)	
Knowledge Granularity		0 0021 (0 0014)
Alternative Sources	0 0491 * (0 0280)	-0 0487 * (0 0276)
Environmental Dynamics	-0 2150 *** (0 0271)	-0 2145 *** (0 0267)
Log Distance from HQs	0 0234 (0 0268)	0 0236 (0 0264)
Tenure in Company	0 2349 *** (0 0331)	0 2347 *** (0 0326)
Tenure in Position	0 0520 (0 0336)	0 0522 (0 0331)
Special Week	0 0677 *** (0 0010)	0 0677 *** (0 0010)
Trend	0 0264 *** (0 0014)	0 0267 *** (0 0014)
R^2	0 4003	0 3988

Significant at 1 % ***, 5 % **, and 10% * The numbers in parentheses are standard errors

Table 2-6 presents our estimation results on the full model with all variables for the four possible combinations of fixed vs random effects and with- vs without autoregressive error terms First, all four columns show similar results across different specifications Second, although some variables become insignificant due to the increased multicollinearity, the overall patterns are preserved in the full model in comparison with the previous separate estimations

Table 2-6. Contingent Impact and Allocation Results

Variable	Random Effect Model	Random Effect Model with AR(1)	Fixed Effect Model	Fixed Effect Model with AR(1)
Intercept	0 0092 (0 0318)	-0 0097 (0 0242)	-0 0144 *** (0 0010)	-0 0165 *** (0 0007)
Log of Labor Hours	0 1954 *** (0 0025)	0 1859 *** (0 0028)	0 1927 *** (0 0025)	0 1701 *** (0 0027)
Log of Repository KMS Use	0 0050 *** (0 0012)	0 0100 *** (0 0020)	0 0050 *** (0 0012)	0 0093 *** (0 0019)
Log of Date Warehouse Use	-0 0007 (0 0017)	-0 0006 (0 0030)	0 0006 (0 0017)	-0 0003 (0 0029)
Log of Expert KMS Use	0 0027 *** (0 0009)	0 0020 (0 0014)	0 0027 *** (0 0009)	0 0023 (0 0014)
Repository Use * Alternative Sources	0 0000 (0 0012)	0 0014 (0 0020)	-0 0001 (0 0012)	0 0014 (0 0019)

Date Warehouse Use * Alternative Sources	-0 0078 *** (0 0016)	-0 0071 ** (0 0028)	-0 0077 *** (0 0016)	-0 0049 * (0 0027)
Expert KMS Use * Alternative Sources	-0 0040 *** (0 0007)	-0 0026 ** (0 0012)	-0 0040 *** (0 0007)	-0 0028 ** (0 0012)
Repository Use * Environmental Dynamics	0 0014 (0 0012)	-0 0004 (0 0020)	0 0016 (0 0012)	0 0003 (0 0020)
Date Warehouse Use * Environmental Dynamics	-0 0087 *** (0 0015)	-0 0068 ** (0 0027)	-0 0087 *** (0 0015)	-0 0063 ** (0 0027)
Expert KMS Use * Environmental Dynamics	-0 0024 *** (0 0008)	-0 0018 (0 0014)	-0 0024 *** (0 0008)	-0 0017 (0 0013)
Repository Use * Distance	0 0066 *** (0 0011)	0 0059 *** (0 0018)	0 0066 *** (0 0011)	0 0057 *** (0 0017)
Date Warehouse Use * Distance	0 0049 *** (0 0016)	0 0047 (0 0029)	0 0051 *** (0 0016)	0 0046 (0 0028)
Expert KMS Use * Distance	0 0002 (0 0008)	0 0001 (0 0013)	0 0002 (0 0008)	-0 0003 (0 0013)
Repository Use * Date Warehouse Use	-0 0062 *** (0 0010)	-0 0060 *** (0 0017)	-0 0063 *** (0 0010)	-0 0061 *** (0 0016)
Date Warehouse Use * Expert KMS Use	-0 0011 (0 0010)	-0 0001 (0 0015)	-0 0011 (0 0010)	-0 0001 (0 0015)
Expert KMS Use * Repository Use	0 0009 (0 0011)	0 0005 (0 0017)	0 0009 (0 0011)	0 0003 (0 0016)
Environmental Dynamics * Knowledge Granularity	0 0046 *** (0 0010)	0 0036 *** (0 0014)	0 0047 *** (0 0010)	0 0033 ** (0 0014)
Environmental Dynamics * Proportion of Short Life-span Knowledge	0 0065 *** (0 0008)	0 0041 *** (0 0013)	0 0065 *** (0 0008)	0 0035 *** (0 0013)
Environmental Dynamics	-0 2154 *** (0 0332)	-0 2157 *** (0 0253)		
Knowledge Granularity	0 0031 *** (0 0010)	0 0025 * (0 0014)	0 0031 *** (0 0010)	0 0021 (0 0013)
Proportion of Short Life-span Knowledge	0 0002 (0 0010)	0 0001 (0 0014)	0 0003 (0 0010)	0 0008 (0 0014)
Aggregate Alternative Sources	-0 0481 (0 0344)	-0 0488 * (0 0262)		
Log Distance from HQs	0 0237 (0 0329)	0 0231 (0 0250)		
Tenure in Company	0 2309 *** (0 0406)	0 2322 *** (0 0309)		
Tenure in Position	0 0518 (0 0412)	0 0533 * (0 0314)		
Special Week	0 0741 *** (0 0016)	0 0677 *** (0 0010)	0 0742 *** (0 0016)	0 0676 *** (0 0010)
Trend	0 0349 *** (0 0007)	0 0266 *** (0 0014)	0 0349 *** (0 0007)	0 0245 *** (0 0013)
R^2	0 4040	0 4073	0 5101	0 5222

Significant at 1 % ***, 5 % **, and 10% * The numbers in parentheses are standard errors

2.6. Discussion

In fact, there have been good reasons to believe that the value of knowledge management with codified knowledge may be neither quantifiable nor substantial (e.g., Gilmour 2003). Employees may resist contributing their knowledge or release only the part of it (Gilmour 2003; Kankanhalli et al. 2005). Due to the search and transfer cost of both codified and personal knowledge, the use of knowledge from external sources may even hurt performance if a user is already experienced or the environment is more competitive (Haas and Hansen 2005). A recipient's lack of the "absorptive capacity" (Cohen and Levinthal 1990) may limit the knowledge transfer process (Szulanski 1996). A recipient may end up misunderstanding knowledge or applying it even when she is situated in different context due to limited cognitive processing capability (Alavi and Leidner 2001; Poston and Speier 2005). The value of knowledge in a repository depreciates as well (Dennis and Vessey 2005).

Our work finds that knowledge management with a codified approach result in positive outcomes in a knowledge intensive process that can be quantifiable with an econometric method. The knowledge obtained from KMS, as we theorize, did contribute to the increased weekly sales and thus could be viewed as a production factor in the era of knowledge. The output elasticity of knowledge, however, differed depending on the characteristics of the knowledge workers and the group. The elasticity is greater when the group is endowed with fewer alternative sources of information and knowledge or suffers from geographical dispersion. The environmental dynamics decreases the value of knowledge from external sources because the applicability of knowledge created by other individuals whose environments are different from that of the user becomes lower under the higher level of environmental dynamics. Considering the factors specific to one's own environments and creating own knowledge become more important under dynamic environments.

Interestingly, although different types of KMS may complement each other in finding necessary knowledge, the performance outcomes are not complementary. For data warehouse and repository KMS as sources of codified knowledge, the usage of the two is likely to be substitutive in creating value especially when their contents overlap. This result may appear to be contradictory to Haas and Hansen (2007) which claimed that personal advice and codified documents are not substitutes because each of the two has distinct performance outcomes. However, the substitutive effect in our theory takes place when knowledge inputs from different sources are used to improve a single performance outcome measure. In our results, the repository has the largest output elasticity. Since Data warehouse in the research site provides much information and knowledge about sales and product movements, an out-of-stock rate may be one of alternative performance outcomes. Due to increased concerns about health and safety, more customers ask managers about the products and nutrition. Since the expert directory KMS in the research company often help department managers handle unexpected cases initiated by customers, one possible outcome measure of the expert directory KMS is customer satisfaction. Therefore, while implementing multiple types of KMS will help knowledge workers to juggle diverse performance outcomes, they substitute the value of each other within a single performance outcome.

We also theorized and tested the notion of optimal balance between different types of knowledge depending on the level of business dynamics faced by a knowledge work group. As the level of business dynamics increases, it is beneficial to increase the proportion of short-life span knowledge and fine-grained knowledge. Overall, our study shows that knowledge obtained from KMS as external sources pays off but the size of returns is influenced by the mix of the type of knowledge, group conditions, and external business environments.

One alternative explanation for the positive direct impact of knowledge on performance may be that they are not causal but correlated. For example, there may exist a common factor such as the smartness of department managers that lead to variations of knowledge and performance in our model We believe that we can reject this possibility through the multiple methods we used in the paper First, our two-year analysis in Table 2-3 shows that a variation in one department's usage is actually leading to a variation in performance over time, which cannot be necessarily true unless such a common factor changes over time as well However, we believe that such a factor as smartness is unlikely to change much over time In addition, our 2SLS analysis in Table 2-2 also shows that endogeneity is not problematic Second, if such a factor as smartness is relevant, there is no reason that our moderating effects are significant Third, since the KMS usage is voluntary in the research site, there is no strong incentive for managers to use KMS unless they are helpful As KMS are very task-oriented systems, there is no intrinsic motivation for time-pressured managers to use KMS Lastly, from our in-site observations in the site, we identified many qualitative reasons to believe that using KMS is actually helping managers make better informed decisions in stores as in the following examples

Department managers make various decisions that influence the group level performance On a daily basis, managers decide on how much to produce and initiate daily price reductions At least on a weekly basis, they have to decide on what portfolio of products should be carried, how much to order, how the products should be displayed to sell more, and how much labor hours will be needed In the longer term, they have to make many management-related decisions on employee training, store sanitation, new equipment and tools, communication with customers, store managers and headquarters, etc The efficiency and effectiveness of the decisions altogether determine departmental sales

Codified knowledge in repository KMS enables a manager to develop a better understanding of business, obtain training materials, find best practices that have worked for other departments, and learn about what new products are available and what products will be advertised The knowledge may be even unique and unavailable from one's traditional knowledge sources, or may help managers obtain it faster than otherwise possible. Even obtaining the same knowledge faster allows more time to plan on the upcoming events and business weeks. Data warehouse can provide managers with more insights into one's own department, and allow them to compare their performance with that of others. It gives more detailed information on what has sold well and what the new trend is to help determine both the quantity and the variety of products to order. Placing products in the right quantity prevents out-of-stock incidences not only in their inventory but also in the store shelves because data warehouse can provide managers with the ideas on what products are moving faster or slower than normal. Fewer incidences of out-of-stock reduce potential lost sales and may increase customer satisfaction. Comparisons of one's own performance with others motivate managers to review past practices and contact the high performers to obtain any further knowledge. The expert directory KMS in the company also allows easier access to experts and save managers' time in identifying experts. With emails, they do not have to wait until both the owner and the recipient of knowledge are available for knowledge transfer. We have also observed that the expert directory KMS is used a lot when customers initiate questions involving process exceptions (e.g., special dietary products). It also provides an opportunity to incorporate customers' opinions and needs. The usage of KMS thus improves a manager's efficiency and effectiveness in terms of important decision-making in both the short and longer term.

2.7. Conclusion

Although our analyses reveal strong supports for our theory, our work is not without limitations. First, we assumed that the social capital of a department manager is a proxy for the social capital at the group level. This assumption can be justified considering the company's business environments. In many grocery stores, the employee turnover rate is very high and most employees managed by department managers have a shorter tenure in the company. The employees with a relatively short tenure have few opportunities to develop one's social capital beyond the boundary of one's store. Furthermore, the most direct source of knowledge for the employees is their department managers. Recognizing the relatively stronger ties between department mangers and other employees managed by them, we believe that the social capital of a department manager is a good proxy for the social capital at the store department level.

Second, the generalizability of our results to other contexts may be limited. The employees in the research site may have two major differences that should be considered when the results are to be applied to other settings. First, the employees in the retail industry suffer geographical dispersion to a greater extent compared to those in other industries. Second, the tenure of department managers in the organization is longer and many of them rely more on their traditional social network. Many store employees are locally employed and the senior people were not familiar with computers in the early days of KMS deployment.

The last limitation of our research is that we did not include the collaborative KMS. The collaborative KMS has a greater potential to transfer even a tacit component of knowledge. However, it may take many diverse forms and may use a very different set of technologies. For example, the use of Web forum and Web conferencing may not share a lot of things in common. The company site also has started to deploy the collaborative KMS, but we did not observe a sufficient level of adoption at the time of our research.

Notwithstanding the limitations, we make important contributions both in theory and methodology. Overall, the study enhances our understanding of how and why different forms of KMS enable a firm to effectively manage knowledge assets to improve the performance of knowledge work groups. Our study shows that the knowledge inputs from KMS increased the output level in a knowledge intensive process in a similar way to traditional production processes. Knowledge can be viewed as a new type of production factor and the size of its return is affected by the group characteristics (e.g., social networks and physical documents available, and geographical distance from headquarters), external environments, and technology characteristics (i.e., use of other types of KMS) The use of different types of knowledge needs to be adjusted depending on the external environments to maximize returns Our research provides a systematic approach to study the contingent value of KMS with objective measurements of both usage and outcomes.

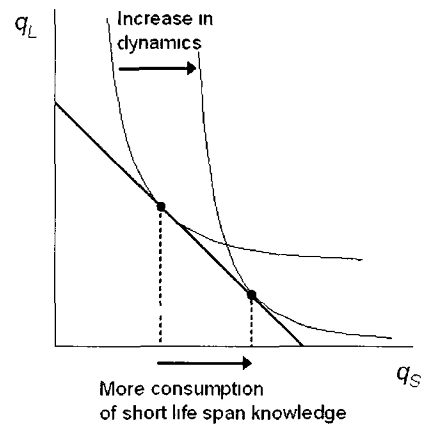
Appendix 2-A. Mathematical Proof

Suppose there are two types of knowledge: short life span knowledge and long life span knowledge. Let $V(q_S, q_L)$ denote the total value by consuming short and long life span knowledge as much as q_S and q_L, respectively. We assume that V is an additive function of value of consuming each type of knowledge such that $V(q_S, q_L) = V_S(q_S) + V_L(q_L)$. We assume that i type knowledge degrades at δ_i where $i \in \{S, L\}$. The subscript S and L denote short and long life span knowledge, respectively. Supposing that the unit value of i type knowledge is a_i, the present value of consuming i type knowledge as much as q_i becomes $V_i = a_i \cdot [q_i + \delta_i \cdot q_i + \delta_i^2 \cdot q_i + \cdots] = a_i \cdot [q_i / (1 - \delta_i)]$. We assume that consuming i type knowledge incurs cognitive cost of c_i and a group has limited attention A. Therefore, the consumption of both types of knowledge needs to be subject to $c_S \cdot q_S + c_L \cdot q_L \le A$. The optimal allocation between different types of knowledge becomes the consumer choice problem in the traditional microeconomic theory. In microeconomics, it is well known that the optimal combination between two goods satisfies $MRS_{SL} = V_S'(q_S) / V_L'(q_L) = c_S / c_L$. Notice that any change in A does not influence the optimal ratio between q_L and q_S as long as the preference is homothetic. Now we let the depreciation rate δ_i is influenced by the external dynamics of d. We assume that $0 > \delta_S'(d) \ge \delta_L'(d)$ such that long life span knowledge depreciates at the same or at a faster rate than short life span knowledge does as environmental dynamics increase.[11] It

[11] This assumption is consistent with the popular methods used to reduce the value of assets over time in accounting and financial economics. For example, in the straight line depreciation method, where the value of asset depreciates by the same fixed amount every year over the life span of asset, an increase in the life span of asset shortens the speed of depreciation. In the accelerated depreciation method, where the value of asset depreciates at the fixed rate such that assets are more useful when they are newer, an increase in the life span of asset does not change the speed of depreciation. In both cases, $0 > \delta_S'(d) \ge \delta_L'(d)$ is satisfied.

can be easily shown that $\partial MRS_{SL}(d)/\partial d > 0$, which implies that the slope of an indifference curve becomes steeper and q_S/q_L needs to be increased as below That is, as the level of business dynamics increases, it is optimal to increase the proportion of short life span knowledge Figure 2-1 illustrates this shift in the optimal allocation of knowledge

Figure 2-2.Change in the slope of an Indifference Curve as Dynamics Increase



Suppose that there are only two types of information and knowledge one with fine granularity and the other with coarse granularity as in the analytical example for the knowledge life-span above The marginal values of consumption for each of the two are denoted a_F and a_C, respectively From the discussions above, an increase in business dynamics is likely to lead to an increase in a_F a_C may decrease or increase but at the slower rate than a_F Therefore, an increase in business dynamics will make it optimal to increase the portion of fine-grained knowledge compared to coarse granularity in a similar way to Figure 2-1

Proof) $MRS(d) = a_S\left[\frac{1}{1-\delta_S(d)}\right] \Big/ a_L\left[\frac{1}{1-\delta_L(d)}\right] = \frac{a_S}{a_L}\,\frac{1-\delta_L(d)}{1-\delta_S(d)}$

$$\frac{\partial MRS(d)}{\partial d} = \frac{a_S}{a_L}\,\frac{-[1-\delta_S(d)]\delta_L'(d) + [1-\delta_L(d)]\delta_S'(d)}{[1-\delta_S(d)]^2}$$

$$= \frac{a_S\left[\{1-\delta_L(d)\}\delta_S'(d)-\{1-\delta_S(d)\}\delta_L'(d)\right]}{a_L\left[1-\delta_S(d)\right]^2}$$

If $\delta_S'(d) \geq \delta_L'(d)$,

$$\{1-\delta_L(d)\}\delta_S'(d)-\{1-\delta_S(d)\}\delta_L'(d) \geq \{1-\delta_L(d)\}\delta_L'(d)-\{1-\delta_S(d)\}\delta_L'(d)$$

$$=\left[\delta_S(d)-\delta_L(d)\right]\delta_L'(d) > 0\,.$$

Appendix 2-B. Survey Measures

ALTERNATIVE SOURCES OF INFORMATION AND KNOWLEDGE

1 Alternative Social Sources of Information & Knowledge (alpha = 0 768)

- My supervisor often provides useful information and advice that I need to do my work
- My colleagues are accessible for information and advice that I need to do my work
- I know many employees outside my own department from whom I can get information and advice for doing my work
- The people whom I work with provide me with useful information and advice

2 Alternative Physical Sources of Information & Knowledge (alpha = 0 865)

- I get a lot of the information that I need to do my work in printed reports and documents
- The printed reports and documents I get are useful for my work

TASK INFORMATION AND KNOWLEDGE INTENSITY [12]

1 Information & Knowledge Intensity - Volume (Alpha = 0 882)

- I need to keep up with a lot of information to do my work
- It is important for me to bring together information from many sources in my job
- I have to compare many alternatives to make work-related decisions
- My job requires me to stay on top of a variety of information

2 Information & Knowledge Intensity - Volume (Alpha = 0 754)

- The information I need to do my work changes a lot week to week
- I have to pay attention to changes in information related to my work
- If I can respond quickly to changes in information, I can do my job better
- I have to make new decisions each week, because the environment changes quickly

[12] Developed based on Schroder et al (1967) and Campbell (1988)

Chapter 3

STUDY 2: A STUDY OF CONTINGENT KMS IMPACTS ON INDIVIDUAL KNOWLEDGE WORKER PERFORMANCE

3.1. Introduction

The knowledge-based view of the firm considers knowledge as the single most important resource. Since it is hard to imitate and socially complex, it is claimed that knowledge can confer sustainable competitive advantage against competitors (Grant 1996; Kogut and Zander 1992). As an effort to manage firm's own knowledge assets more effectively with the power of information technologies that allow easier codification, collection, distribution, and transfer of knowledge than ever before, many firms have implemented KMS (Knowledge Management System). Such efforts aim to establish "internal benchmarking" to make the best use of what one part of the firm has already known but many other parts are not aware of yet (O'Dell and Grayson 1998). KMS takes many forms and there is no agreed-upon boundary of KMS as knowledge itself is a multifaceted concept with multilayered meanings (Nonaka 1994). In a very limited scope, a central repository of best practices shared among employees is one common form of KMS. In a broader sense, technology-assisted knowledge management activities range from a repository of various contents including expert solutions, work-related documents, tips, and opinions to data warehouse, corporate intranet, expert directory, groupware, data mining tools, electronic bulletin boards, discussion forums, expert systems, etc (Alavi and Leidner 2001; Ruggle 1998).

Researchers have claimed that one's access to knowledge through one's social network leads to superior performance and power (Brass 1984; Raider and Krackhardt 2001). This may imply potential "knowledge divide" determined by the quality of access to knowledge. Can IT-enabled knowledge management practices help a firm manage the potential knowledge divide? The underlying assumption in a firm's KMS efforts is that knowledge management with advanced technology will improve the quality of work by disseminating existing knowledge and supporting creation of new knowledge However, the performance impact of KMS on individual knowledge worker is not as well understood as the impact of IT (Information Technologies) as a general purpose technology at the firm level (Barua et al 1995, Brynjolfsson 1996, Brynjolfsson and Hitt 1996) or at the process level (Ashworth et al 2004, Davamanirajan et al 2006, Mukhopadhyay and Mangal 1997, Mukhopadhyay et al 1997b)

There are many challenges involved with IT-enabled knowledge management For example, employees may not want to contribute and selectively release what they know (Gilmour 2003, Kankanhalli et al 2005) More important organizational knowledge may be tacit and may be hard to codify even in the presence of intentions to share (Goodman and Darr 1998, O'Dell and Grayson 1998) Employees listed as experts may receive too many inquires and may become overwhelmed (Ackerman 1998, Hansen et al 1999) KMS may bias employees to adopt existing solutions rather than search for or develop new solutions that may be more effective in the longer term (Hahn and Subramani 2000) Due to the search and transfer cost of both codified and personal knowledge, application of knowledge from external sources may even hurt performance if a user is highly experienced or the environment is very competitive (Haas and Hansen 2005) A recipient's lack of "absorptive capacity" (Cohen and Levinthal 1990) also limits the knowledge transfer process (Szulanski 1996) A recipient may end up misunderstanding knowledge or applying it even when she is situated in a different context due to limited cognitive processing capability (Alavi and Leidner 2001, Poston and Speier 2005) The value of knowledge in a repository may even depreciate and stop being useful (Dennis and Vessey 2005) In addition to estimating the direct performance impact of knowledge usage from KMS, another important question is under what conditions the impact of KMS, if any, may be greater This contingency impact of KMS is particularly important because understanding the moderators will help managers allocate their resources more effectively around knowledge workers.

The challenges reveal that it is not completely understood why and under what conditions KMS either improve or hurt the performance of knowledge workers. In this paper, our goal is to examine how and why the introduction of KMS into an organization in which employees compete for scarce resources and cooperate with each other affects the individual worker performance. We first test the underlying assumption of the positive performance impact of individual KMS usage and examine the situational factors that influence the size of the impact. We find a significant positive impact of KMS usage in a longitudinal setting. Such performance impact of knowledge seeking from KMS is greater when an employee is endowed with little social capital from which to obtain knowledge as an alternative source. This finding is important in that KMS can help employees overcome "knowledge divide" within a company that we define as the performance gap between those with access to rich knowledge sources and the others without them. From a firm's perspective, it may have to design its KMS to meet the demand for knowledge by those with limited social capital. The knowledge divide can be better understood with our analysis on the impact of group-wide KMS usage on the individual relative performance. Since employees' performance cannot always be evaluated by absolute performance criteria, they are likely to be compared with other employees as internal competitors when evaluated. We find that the aggregate usage by other employees within the same business group as internal competitors decreases the relative individual performance and slows the rate of one's improvement in relative performance by using KMS. This implies that successful implementation of KMS may bring more dramatic changes to an organization than initially expected. Our findings suggest that employees already with superior alternative knowledge sources to those of internal competitors may be most resistant to the adoption of KMS. As other employees also use KMS, their competitive position within an organization will be weakened while their additional benefits by adopting KMS are smaller. If these employees have to play important knowledge roles in a KMS project, it is likely to be less successful without proper rewards.

We also find that the impact of KMS is greater when it is used in an exploratory manner. According to a survey by the ePolicy Institute and the American Management Association (AMA 2005), more than 50 percent of firms monitor employees' technology usage to a certain degree despite privacy concerns about common monitoring practices (WSJ 2007). Firms often rely on such metrics as the number of document hits to examine whether employees are actually sourcing knowledge from KMS after implementation. If the differential effect of knowledge usage patterns on performance is understood, managers will be able to guide their employees in an appropriate manner beyond watching only the number of document hits. We further find the impact of KMS usage on knowledge workers is mediated by intermediate performance in a knowledge-intensive process. This finding reveals how KMS improves the overall work performance of knowledge workers. That is, individual worker benefit from the improved performance in knowledge-intensive processes by sourcing knowledge from external sources and but not by any means.

Our extensive research makes at least three contributions to the literature. Our research sheds light on how and under what conditions KMS enables knowledge workers to improve their performance under what conditions by overcoming the possible knowledge divide and how such impacts should be measured and quantified depending on the types of knowledge workers. Managers need to understand the differential effects of KMS on their employees and allocate resources to maximize their returns on KMS investments. Second, our study is one of the first attempts to investigate the possible negative influence of KMS on the individuals who are left behind in accessing new knowledge sources despite its positive influence on the organization as a whole. Our findings suggest that KMS, successfully implemented, may result in any unexpected outcomes by fundamentally changing the way employees obtain knowledge and compete for internal resources. This finding highlights why individual-level studies are worth distinct attention from group-level studies in evaluating the performance impact of KMS. Third, we collected archival data on both KMS usage and performance, which has been scarce in the literature. In many studies measuring the individual level impact of IT, researchers have used self-reported subjective measures of both usage and performance thus attracting criticism due to possible biases and incomparability across subjects (Pentland 1989; Straub et al. 1995). We hope that our research can motivate others to conduct more fine-grained research at the employee level with objective data.

3.2. Knowledge and Knowledge Management Systems

A common view of knowledge is based on the hierarchy of data, information, and knowledge. According to this view, data are raw numbers and facts, and information is processed data, and knowledge is authenticated information(Dretske 1981; Machlup 1983). Thus information is the "commodity capable of yielding knowledge," and knowledge is "a high value form of information that is ready to apply to decisions and actions." (Davenport and Prusak 1998). Alternatively, knowledge may be viewed as an object, access to information, or a process of applying expertise (Alavi and Leidner 2001). One of the lessons from the prior literature is that knowledge is a multidimensional construct with complex characteristics (Kulkarni et al. 2006; Nonaka 1994). As two widely acknowledged dimensions of knowledge, tacit knowledge refers to knowledge that is unarticulated, rooted in actions and experience, and situated in context, while explicit knowledge refers to knowledge that is articulated in some symbolic form (Nonaka 1994; Polanyi 1962, 1967).

Knowledge management is a process of facilitating knowledge creation, knowledge storage, knowledge transfer, and knowledge application within an organization. Since information is consumed to generate new knowledge and knowledge is recombined to generate new knowledge (Kogut and Zander 1992), knowledge management activities should range from providing a knowledge worker with factual information to be combined with her prior knowledge to facilitating transfer of personal "tacit" knowledge through socialization (Nonaka 1994; Polanyi 1962, 1967). In this respect, it is difficult to distinguish any information system that provides a knowledge worker with highly customized actionable information from any commonly cited forms of KMS such as a repository of codified knowledge (Alavi and Leidner 2001). Since some nuances may be lost during codification and the task environments and cognitive capability of every knowledge worker are different, it may be more useful for a knowledge worker to receive customized information rather than to receive other people's interpretation of the same information. We adopt a relatively broad view of knowledge and KMS. We take the view of knowledge as high value actionable information for decision-making and immediate reactions to tasks. Any information systems that potentially contribute to creation, storage, transfer, and application of actionable information and knowledge are considered a type of KMS in this paper.

In this paper, we consider multiple sources of information and knowledge. We focus on three common types of KMS that are popular in many industries: knowledge repository, data warehouse, and expert directory and communication. We will use more examples from the retail grocery industry, which is our research context. A document repository is one of the most common forms of KMS adopted by firms. A repository stores explicit knowledge (Nonaka 1994; Polanyi 1962, 1967) codified by other employees within the organization. The codified knowledge stock in a repository ranges from corporate policies, best practices and procedures (O'Dell and Grayson 1998) to suggested improvements by other employees. The strength of a repository compared to other forms of KMS is the ease with which it can be deployed because technically it only requires a central database. If well-managed, it can be used to distribute internal knowledge to employees who would otherwise never have access to it. However, many studies document organizational barriers to deploying a "working" repository and many problems associated with this effort. For example, store bakery managers in a retail grocery chain can have access to such materials as nutritional information, how to train new bakers, how to keep sanitation and food safety, availability of new products, and new cake suggestion for holidays made by colleges in the form of electronic documents

Employees in organizations also access information from various computer application systems from accounting, and inventory control to payroll systems Often, a data warehouse combines such information over a long period of time, and acts as a source of business intelligence Data mining tools are used to assist one's decision making, and facilitate the generation of new knowledge and insights Given the vital role of business intelligence in organizational decision-making, we also include business intelligence explicitly as one type of KMS Business intelligence systems such as data warehouses are often considered a repository of corporate data (Hahn and Subramani 2000) by producing highly tailored actionable information for managers For example, the manager in the bakery department may face a question of how many cakes to be baked every morning As the freshness is key in her business, she does not want to bake too many cakes in the morning but does not want to bake too few, either She can check the recent trend in sales per item while considering other seasonal specific factors by viewing the sales per item during the same period last year using data warehouse applications

With the expert directory KMS, a company creates and maintains a list of subject matter experts to provide internal expertise (Alavi and Leidner 2001) While this yellow page of experts (Hahn and Subramani 2000) may be linked with experts' email accounts to transfer explicit knowledge only via emails, it is likely to trigger new discussions via other media such as telephone or other collaborative tools It also provides an opportunity to develop a shared understanding of the context and social relationship that may result in the transfer of more sophisticated and complex knowledge that may even be "tacit " Faraj and Sproull (2000) suggest that knowledge coordination consists of three processes knowing expertise location, recognizing the need for expertise, and bringing expertise to bear on such needs A corporate directory of expertise facilitates these processes by providing a list of experts often with a channel to contact the experts. For instance, the bakery manager may want to find the procedures on ordering a new product that was asked by her customer but do not know where to find it. Such an unexpected and unroutinized inquiry may be answered by her subject matter experts although the customer may not receive an immediate response back.

Notice that the first two types of KMS are efficient methods to store and distribute codified knowledge throughout the organization while the expert directory KMS is focused on matching and communication. The expert directory KMS recognizes that knowledge generation and knowledge application are fundamentally social processes that take place most efficiently through direct interactions and communications among members of communities (Alavi 2000). The need for cognitive processing is likely to be highest for business intelligence, but business intelligence is likely to face the lowest organizational barrier related to sharing knowledge between people.

3.3. Theory and Hypotheses

Long-Term Impact of KMS on Individual Knowledge Workers It has been theorized that the use of KMS is likely to positively influence performance at the individual, group, and firm level (Feng et al. 2004; Haas and Hansen 2005; Sabherwal and Sabherwal 2005). The quality of data warehouse is found to be positively associated with perceived benefits of data warehouse at the firm level (Wixom and Watson 2001). Knowing expertise location and developing the ways by which expertise can be coordinated have also been found to improve the performance of employees (Faraj and Sproull 2000). The quality of knowledge in a repository has been found to be positively associated with user satisfaction (Kulkarni et al. 2006).

Nevertheless, there exist a number of challenges related to each type of KMS as discussed above and it is important to understand how the challenges can be mitigated over time. The first issue is the value of knowledge from KMS if the codification process significantly reduces the quality of knowledge or if the commitment of experts is low to the extent that expert consultation is of little worth When the use of KMS is voluntary, it is likely to be used as a complement to one's existing sources of knowledge The advantage of data warehouse and repository KMS is that they can be used even without participation of others in the organization Data warehouse can process a large volume of information, which is otherwise impossible for users to match As we have observed in our research site, KMS does not prevent a user from contacting the author of knowledge In fact, it can help a user identify the expert on the subject and even contact her for clarification The expert directory KMS may take too much time and resource from an expert, but the expert can be given incentives for high quality person-to-person knowledge transfer as is practiced at Bain (Hansen et al 1999) Therefore, despite the possibility of some degradation of the quality of knowledge available from KMS, it can still create substantial value for the users

The second issue is whether the search and transfer cost overwhelms the benefit, which is quite important for data warehouse and repository KMS Again, a user can directly contact an author for assistance or other designated knowledge administrators The individual-level absorptive capability to recognize the value and adopt new knowledge is likely to develop as employees are exposed to a variety of knowledge From prior experience of applying knowledge to one's own context, the ability to selectively apply relevant knowledge is also likely to improve over time The search cost due to the structure and interface of KMS will become lower as employees use KMS over time because system usage has a sequential effect on the ease of system use (Kim and Malhotra 2005)

In the longer term, users will gain additional benefits of KMS It is a common finding in several research streams including decision making, interpretation systems, sense making, and information processing that individual's cognitive structures in terms of replication, adaptation, and innovation can change (Gray and Meister 2004) after communicating with others through emails (Constant et al 1996), peer networks (Sparrowe et al 2001), and project teams (Hansen

1999). Knowledge acquisition itself changes the way knowledge is exploited. Consistent knowledge sourcing behaviors alone have a positive impact on one's cognitive capability besides the direct benefit of applied knowledge.

We take an example of department manager in a retail grocery chain to understand how knowledge obtained from KMS contributes to enhanced performance. Department managers make various decisions that influence the group level performance. On a daily basis, managers decide on how much to produce and initiate daily price reductions. At least on a weekly basis, they have to decide on what portfolio of products should be carried, how much to order, how the products should be displayed to sell more, and how much labor hours will be needed. In the longer term, they have to make many management-related decisions on employee training, store sanitation, new equipment and tools, communication with customers, store managers and headquarters, etc. The efficiency and effectiveness of the decisions altogether determine departmental sales.

Codified knowledge in repository KMS enables a manager to develop a better understanding of business, obtain training materials, find best practices that have worked for other departments, and learn about what new products are available and what products will be advertised. The knowledge may be even unique and unavailable from one's traditional knowledge sources, or may help managers obtain it faster than otherwise possible. Even obtaining the same knowledge faster allows more time to plan on the upcoming events and business weeks. Business intelligence can provide managers with more insights into one's own department, and allow them to compare their performance with that of others. It gives more detailed information on what has sold well and what the new trend is to help determine both the quantity and the variety of products to order. Placing products in the right quantity prevents out-of-stock incidences not only in their inventory but also in the store shelves because business intelligence can provide managers with the ideas on what products are moving faster or slower than normal. Fewer incidences of out-of-stock reduce potential lost sales and may increase customer satisfaction. Comparisons of one's own performance with others motivate managers to review past practices and contact the high performers to obtain any further knowledge. The expert directory KMS in the company also allows easier access to experts and save managers' time in identifying experts. With emails, they do not have to wait until both the owner and the recipient of knowledge are available for knowledge transfer. We have also observed that the expert directory KMS is used a lot when customers initiate questions involving process exceptions (e.g., special dietary products). It also provides an opportunity to incorporate customers' opinions and needs. The usage of KMS thus improves a manager's efficiency and effectiveness in terms of important decision-making in both the short and longer term.

Taken together, although any negative outcome from the use of KMS may be conceivable in the short-term in a specific task, in the longer term, the cumulative use of KMS is likely to positively influence one's overall work performance in a voluntary setting. As long as knowledge acquisition from KMS is voluntary, employees can adjust and balance between the benefit and cost of KMS usage over time such that knowledge acquisition has a positive impact on their performance. Since the development of such capabilities relies much on the repeated use of KMS over time, a user not only performs better than others by using KMS, but also can keep improving one's performance by increased use of KMS. We argue that while knowledge from KMS may initially have limited value and demand a significant amount of learning cost, the challenges can be overcome by good practices of knowledge management and by recurring usage over time.

Hypothesis 1: A knowledge worker with a greater level of KMS usage exhibits a higher overall work performance.

Hypothesis 2 An increase in knowledge use from KMS leads to an increase in the overall work performance over time

Performance Impact Mediation Although the use of KMS helps a knowledge worker improve her overall work performance and perform better than other knowledge workers in the longer term, it has not been fully understood how and why such an impact takes place and whether there is any measurable mediator to uncover it [13] We take a one more step into the mechanism and argue that KMS is used in a way to assist a knowledge worker to perform better in a knowledge intensive process, which constitutes the overall work performance That is, if a process includes knowledge component, acquiring and capitalizing appropriate knowledge during the process becomes critical in determining the performance level From an incentive point of view, a knowledge worker is also likely to use KMS in a way to improve the process-level performance in the short term if the process-level performance contributes to her longer term overall work performance This mediation effect will become greater when the intermediate performance is already known to employees and more directly observable within an organization The mediation effect rules out the possibility that the use of KMS influences individual performance through different paths For instance, one may argue that the use of KMS affects individual performance when it is considered desired behaviors within an organization The mediation effect has another important implication in examining the performance impact of KMS on individuals For a firm, it is always helpful to identify the most important knowledge-intensive process and design KMS to support such processes

[13] The idea of a mediating effect is that "the effects of stimuli on behaviors are mediated by various transformation processes internal to the organism" by specifying how or why such effects occur (Baron and Kenny 1986)

Hypothesis 3 The impact of KMS usage on overall work performance is mediated by the process-level performance in a knowledge intensive process

Alternative Sources of Information and Knowledge Employees learn either from their own experiences or from the experiences of others (Levitt and March 1988) Knowledge sourcing is a learning behavior employed by individuals in an organization and involves acquisition of expertise, experience, and opinions from others (Gray and Meister 2004) The traditional external sources of knowledge other than KMS have been other employees or other codified documents [14] Interactions with other employees such as supervisors and colleagues within an organization enable the members of knowledge work group to obtain appropriate knowledge Empirical research on intraorganizational networks accumulated over decades demonstrates that social networks are associated with diverse outcomes (Raider and Krackhardt 2001) [15] More connections with other employees provide a knowledge worker with a chance to obtain a greater amount of knowledge that is both rich and unique While their importance is somewhat limited compared to social capital, information and knowledge can also be obtained from codified physical documents such as policies, best practices, standard operating procedures, training materials, internal reports, and manuals Codified documents are important sources of explicit knowledge and can be utilized as inputs to create either tacit or explicit knowledge through internalization and combination (Nonaka 1994) From the discussions, the employees with

[14] For example, Gray and Mesiter (2004) identifies three types of knowledge sourcing dyadic, group, and published knowledge sourcing Notice that the first two forms rely on person(s) while the last form relies on codified document as a channel for knowledge transfer

[15] For example, social network theory posits that the possession of more ties leads to superior performance and access to more unique information (Granovetter 1973) Centrality, or the extent to which an actor in the network is involved in a network, is associated with better access to resource and information (Freeman 1977) More acquaintances (weak ties) provide access to novel information (Granovetter 1973) A high degree of closeness centrality is positively associated with performance at the group (e g , Hansen 2002) Social capital leads to higher compensation at the individual level (Myerson 1994) Social networks can become structural sources of individual power (Brass 1984)

superior knowledge sources in terms of social capital and codified physical documents will have more opportunities to learn and innovate themselves compared to other employees within an organization. The discussions lead to the possible existence of knowledge divide as the performance gap between those with access to rich knowledge sources and the others without them.

If a knowledge worker has access to a lot of information and knowledge from the two alternative sources (either social or physical), the marginal benefit of using KMS is unlikely to be large especially unless knowledge from KMS is very unique. Due to the cost of sourcing knowledge from KMS compared to seeking similar information and knowledge from alternate sources, using KMS under more alternative knowledge sources may even reduce the performance of a work group (cf. Haas and Hansen (2005)). Since social network enables transfer of even tacit knowledge, replacing social sources of knowledge with KMS may run the risk of poor performance. Relying on traditional sources may result in better outcomes unless KMS is sufficiently easy to use or provides the best information and knowledge. Our interview with one executive, who was not a frequent KMS user, illustrates this point: "If I need more information, it is their job (those who report to the executive) to get the information for me". For the executive, using KMS may not be as helpful as it is for other employees who do not have any support personnel to obtain and collect information and knowledge from other places. By not spending time on learning how to use the system and searching knowledge needed, he can focus on more strategic issues such as longer-term planning and decision-making. Since repository KMS and data warehouse are targeted toward distribution of codified knowledge to a broader audience, the misfit due to the lack of customized knowledge and knowledge transfer cost may be higher for those with rich alternative sources. On the other hand, those employees with poor social capital or little access to codified documents can be equipped with an additional source of knowledge through a KMS Thus, the quality of alternative sources such as social networks or physical documents moderates the impact of sourcing knowledge from KMS

Hypothesis 4 The performance impact of KMS usage is greater when a knowledge worker is endowed with fewer alternative social sources of information and knowledge

Hypothesis 5 The performance impact of KMS usage is greater when a knowledge worker is endowed with fewer alternative physical sources of information and knowledge

KMS Usage by Potential Internal Competitors Ideally, an organization is formed to attain common organizational goals In reality, however, people maintain mixed-motive or competitive relationships with their own group members for limited resources and power within an organization The process of generating, transferring, and applying knowledge is also influenced by this complex relationship For example, knowledge seeking behaviors can be influenced in the presence of internal rivalry within an organization (Menon et al 2006) While the acquisition of knowledge related to work help a knowledge worker improve own performance, other workers with similar roles have access to KMS as a universal source of knowledge Therefore, the improvement in the absolute performance due to the KMS usage may not contribute to an increase in the relative performance if all other workers could further improve their absolute performance [16] A knowledge worker's relative performance can be better understood by referring to firms' competitive performance in the industry A firm's innovation or resources may enable it to improve its own productivity (i e , absolute performance), but it does not necessarily help it enjoy a better competitive position (i e , relative performance) if its competitor can have access to the same innovation and imitate the resources (Grant 1996, Wernerfelt 1984) Similarly, competitor's innovation or valuable resources may lead to a firm's

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[16] There are two types of performance rating formats relative and absolute rating formats (Cascio 1991) While the individuals are compared against other employees in relative performance format, ones are compared against absolute standards in absolute performance format (Roch et al 2007)

poor competitive position in the industry if it cannot duplicate them While a firm's own innovation helps achieve a better competitive position in the industry through lower cost or differentiation, such competitive advantages will disappear when the innovation is employed by its competitors and becomes a competitive necessity (D'Aveni 1994) These discussions are also in accordance with the role of information technologies in achieving sustainable competitive advantages (Carr 2003, Clemons and Row 1991, Mata et al 1995) Taken together, the usage of KMS by other employees as internal competitors within an organization not only decrease one's relative performance but also slows the rate at which one improves her relative performance

These two phenomena can be easily understood with the following simple analytical framework (See Appendix for Proof) We can extend our thinking beyond this two-worker case and make the following hypotheses

Hypothesis 6 The usage of KMS by other employees in the same business group as internal competitors decreases the relative individual performance

Hypothesis 7 The performance impact of KMS usage on individual performance is smaller under greater usage of KMS by other employees in the same business group as internal competitors

Exploration and Exploitation Knowledge stored in KMS can be retrieved by individuals, but individuals involved in knowledge searching and utilization may exhibit different behaviors In the studies of organizational learning, two types of actions have been discussed exploitation and exploration (March 1991) Exploration refers to pursuing new opportunities while exploitation refers to a refinement of old certainties Both exploitation and exploration are important for organizations but they also present significant trade-offs While returns from exploration are less certain, and may not materialize in the short term, in the long term exploitation without exploration is likely to lead to suboptimal stable equilibrium (March 1991) This concept has also been adapted to system usage For example, Subramani (2004) has examined the benefits of exploitative and exploratory use of supply chain management systems at the organization level System usage can also be classified as exploration and exploitation at the individual level Burton-Jones and Straub (2006) studied the impact of exploitative system usage on short-term task performance While exploitation is associated with a greater impact of system usage on the short-term performance in specific tasks, the increased level of exploration makes a knowledge worker find innovative ways of accomplishing tasks and thus excel other knowledge workers The benefit of exploration is greater in the case of KMS compared to other system usage because KMS is designed to help employees find an improved way of doing work rather than to support specific routinized and repetitive tasks Exploration requires more experimentation and thus requires more unique information and knowledge We thus hypothesize that the longer term performance of a knowledge worker is likely to be greater when KMS is used in a more exploratory way

Hypothesis 8 The impact of KMS usage on the overall work performance of knowledge workers is greater when KMS is used on a more exploratory purpose

3.4. Data and Methods

Data and Measurements

Research Site and Samples We collected our data from Ace Grocery (a pseudonym), a grocery chain in the United States with more than 200 stores nationwide and around 40,000 employees in total A fraction of the stores is independently owned While the independent stores receive products from corporate distribution centers and a great deal of guidance and information from the Headquarters (HQ), they are less subject to corporate policies To effectively manage organizational knowledge distributed across the organization, Ace Grocery initiated a knowledge management system project and deployed KnowLink (a pseudonym) over several years

The main component of KnowLink is a repository of documents on business plans designed by the HQ including advertising and merchandising plans, product information, procedures, corporate policies, training materials, and suggested practices developed by other employees. Although individual employees can contribute their own knowledge, it is in a more hierarchical format such that most electronic documents are created and maintained by the experts in the headquarters to ensure the quality of documents. KnowLink also includes other tools such as collaboration applications, inquiries to experts, and a data warehouse in order to feed important information and knowledge to the knowledge workers in the organization. The systems assist knowledge workers with various roles in the company in making important decisions ranging from short-term operational decisions to long-term planning. In particular, the data warehouse provides useful and rapidly updated operational and financial information that can be customized to store managers' information needs, functioning as business intelligence. For example, a bakery manager in stores can view item-by-item sales at the hourly level from the data warehouse application to determine how many cakes should be baked at the different time of the day. The seasonal variation and time trend can be also considered by checking more aggregate-level reports. She can also check her loss due to the wasted materials, through-away products, and inefficient allocation of labor hours.

Every user in the company is assigned to one of the user groups that represent their business departments by its KMS support group. For example, a user group like "Merch - Bakery HQ" signals that she works for a bakery merchandising group at headquarters. The company has designated subject matter experts for every business group. Once an inquiry is submitted by an employee, it is forwarded to both the knowledge management support group and her subject matter experts. Although the response time may vary dependent on the difficulty of an inquiry and the availability of expects, the support group ensures that every inquiry is responded by her subject matter expects. In order to obtain a full understanding of how knowledge is utilized at the research site, the authors were allowed to attend both formal and informal information sessions, and observe work environments, and conduct interviews for several months.

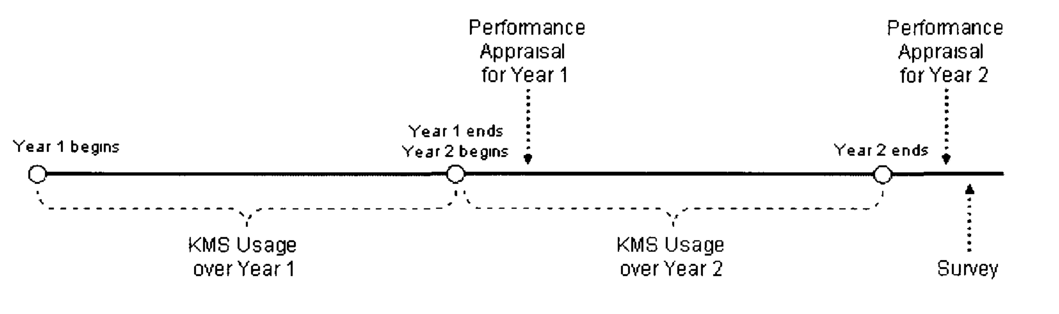
A survey to measure individual characteristics of knowledge workers was designed and initially emailed to 2,000 employees reflecting a broad range of knowledge workers in the company from employees at headquarters to those at distribution centers, store support field groups, and store managers (Table 3-1) [17] To ensure face and content validity of survey items, four iterative procedures were conducted (1) a review of the instruments by faculty experts from different fields, (2) a pretest with university staff to confirm the readability of questionnaire, (3) item-by-item discussion sessions with a head of knowledge strategy group, KnowLink training managers, and KnowLink administrators, and (4) a pilot test with 37 Ace Grocery employees We reworded the items in a way that every employee can easily understand all the questions The third process included two formal sessions with Ace Grocery management and KnowLink specialists For each session at least three Ace Grocery employees attended to share opinions and correct the terms that may not be familiar to store personnel In addition to the two formal sessions, the authors and Ace Grocery employees had several informal discussions before the main survey We obtained 1,232 responses, 24 emails were returned due to employee turnover (response rate = 1,232/1,976 = 63 2 %) Figure 3-1 sketches the timeline of this study

[17] 2,000 employees represent about 40 percent of all active KnowLink users who can be claimed as knowledge workers in the company Through formal and informal information sessions, we and the company agreed that stratified sampling would be desirable in order to take the diverse spectrum of knowledge workers into our consideration The groups in Table 3-1 represent six main business areas that are frequently used to characterize different types of businesses in the company

Table 3-1. Respondents by Business Area

Business Areas	Number of Respondents	Response Rate
Headquarters	392	72.4%
Store managers (Corporate)	1,054	58.4%
Store managers (Independent)	222	40.1%
Warehouse employees	102	72.5%
Field managers	50	76.0%
Subject matter experts	154	85.1%
Total	1,974	62.4%

Figure 3-1. Timeline of the Study



KMS Usage Measures Instead of self-reported measurement of use, we used a system-recorded usage of KMS as follows

- Repository Use (*KMSR*) The total number of documents viewed by an employee each year
- Data warehouse Use (*KMSA*) At Ace Grocery, a user can customize historical data to her needs at the specified aggregation level and for the given time period The total number of customized reports was counted for each year
- Expert directory KMS Use (*KMSX*) The total number of inquires submitted by users to designated subject matter experts each year

We defined the following aggregate KMS usage variable to examine the overall effect of knowledge sourcing from KMS by an individual i in year T

$$KMS_{iT} = KMSR_{iT} + KMSA_{iT} + KMSX_{iT}$$

Thus, we implicitly assume that using each type of KMS can be viewed as one incidence of knowledge acquisition activity by individuals [18] Such an aggregated measure can be more robust and generalizable since all three usage variables are likely to have effects in the same direction (cf Fichman (2001))

From the usage of 2,526 users provided by the research site, we derived the business group usage The employees in the same group may coordinate for a common organizational goal but may also compete with each other for higher relative performance that influences

[18] An alternative to this summative variable is the standardized sum of three standardized usage variables Our results did not change dramatically when we used this alternative standardized sum We preferred the summative measure to the alternative standardized sum because the internal correlations among the three usage variables were not sufficiently high However, the simple aggregation of all three sources may underestimate the effect of the expert directory due to its relatively low frequency in use We discuss this point in the result section in more detail

compensation and other resources. Those in the same group are much likely to share the same performance evaluation scheme. Supposing that N^j workers belong to group j in the given samples, employee i 's overall group use except for herself at t (KMS^j_{-iT}) is measured by

$$KMS^j_{-iT} = \frac{1}{N^j - 1} \cdot \left[\sum_{k \in j, k \neq i} \left(KMSR_{kT} + KMSA_{kT} + KMSX_{kT} \right) \right].$$

To operationalize the degree of exploration in using the repository KMS, we devised the measure below. That is, as a user views a higher variety of documents, the magnitude of *EXPL* becomes greater and approaches one. [19] When no document was viewed by a user, the index was coded as zero.

$$EXPL_{iT} = \frac{Distinct\ Documents\ Viewed_{iT}}{Total\ Number\ of\ Documents\ Viewed_{iT}}$$ [20]

Knowledge worker performance The research site conducts an annual performance appraisal of employees evaluated by their supervisors over various performance criteria. For example, a department manager in a store is evaluated on multiple criteria: financial results, operational performance, customer satisfaction, and department management. Each criterion is given a score between 1.0 (= needs improvement) and 4.0 (=greatly exceeds expectation) with different weight for each criterion. The distribution of total scores is shown in Figure 3-2. While the criteria may be adjusted according to employees' roles, it is consistent across employees with similar roles. The company has a relatively long history of performance appraisal and has established a norm of whether a specific score is considered high or low compared to other

[19] The annual performance appraisal covers the period between July and June in the next year, but our data for the number of distinct documents viewed by individuals covered the period between January and December. Due to this mismatch in the dataset, we calculated the degree of exploration for the calendar year and then averaged the two indices to derive the degree of exploration corresponding to the performance appraisal period.

[20] We discuss the limitation of this measure in the discussion section at length.

employees Since only non-union corporate store personnel and a fraction of part-time employees are subject to this appraisal, the appraisal scores for 605 employees in year 2005 and 2006 could be matched with our survey responses Some of them were not subject to the review in 2005 and thus we observed 531 appraisal scores in year 2005 for the same subjects We confirmed that this performance appraisal score does not represent the absolute performance of employees since supervisors cannot be lenient enough to give good scores to everyone under their supervision To the contrary, supervisors tend to adjust their employees' scores and use an average-performing employee as a reference point [21] To test Hypothesis 3, we selected a sales process in stores not only because the process is very knowledge-intensive to meet the expectations of headquarters but also because it is well-established and well–known performance criterion used in the company The sales process need much information and knowledge to make various decisions on what products to carry, order quantity, store shelf display, a temporary price mark-down, etc A corporate headquarters set a sales goal at the yearly level, and we employed the percentage of actual sales exceeding the prior goal (*PRCS*) as a measure of intermediate performance in a knowledge-intensive process

[21] The fact that our individual performance measure represents the relative performance does not affect our testing for other hypotheses because it is likely to be highly correlated with one's absolute performance Our model also controls for the different groups and the effects by using relative performance will be treated as random errors Furthermore, since any aggregate performance evaluation of knowledge workers with multiple tasks is subject to such human biases by other employees' performance, our measure is practically one of the best ways to evaluate knowledge workers' performance in an objective way

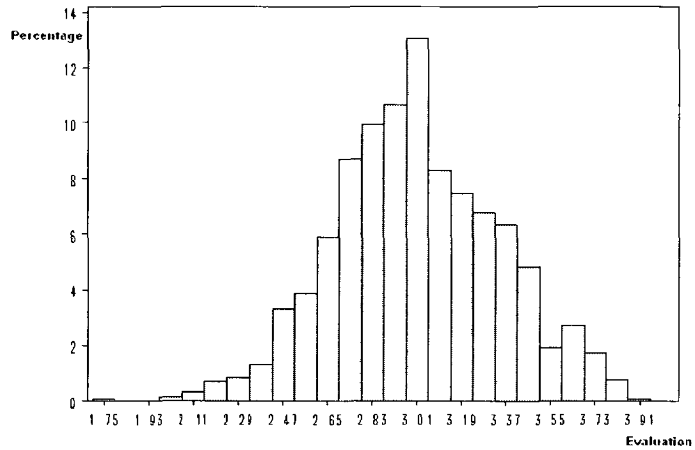


Figure 3-2. Distribution of Appraisal Scores

Alternate Sources of Information and Knowledge We measured the quality of alternate social and physical sources of information and knowledge using a survey. For social alternate sources, we used four items. An employee can obtain useful information and knowledge from her supervisor, colleagues, and subordinates. We asked about the accessibility and quality of knowledge from such sources. We used two items to measure alternate physical sources of information and knowledge. The two constructs were checked for reliability and both had Cronbach's alpha over 0.7, which is the commonly suggested cutoff in the literature. All survey items are shown in the Appendix.

Control Variables In the model, we also included four control variables measured by a survey and one variable derived from archival data. To control for human capitals, we adopted two measures: *KMS user training* (*TRAN*) and *computer skills* (*COMP*). *KMS user training* was measured by the number of KMS training days that an employee received in the past and was pulled from a training record system. *Computer skills* were measured by five items. *Perceived Time Pressure* (*TPRS*) (Peters et al. 1984; Sethi 2000) has been found to be associated with one's performance and was included as a control variable. Two other control variables *Tenure in*

Company ($TCOM$) and *Tenure in Position* ($TPOS$) were also measured through the survey with single items. As noted earlier, it is also important to control for different divisions and departments not only because every business group has different evaluating scheme but also because there may exist business group-wide effects. Thus, we used controls for 73 business user groups that we discussed above, which were based on the user group classification by the company's KMS support group. *Distance* ($DIST$) controls for a knowledge worker's dislocation from the corporate headquarter and was measured by the number miles (in log scale) from headquarters.

Econometric Approach

Hypothesis 1 is tested with the following model

$$EVAL_{iT} = \beta_0 + \beta_1 \cdot GRP_i + \beta_2 \cdot YEAR_T + \beta_3 \cdot KMS_{iT} + \beta_4 \cdot TRAN_{iT} + \beta_5 \cdot Z_i + \varepsilon_{1iT} \qquad (1)$$

where $EVAL_{iT}$ denotes the performance appraisal score of knowledge worker i in year T (2005 and 2006). GRP_i is a set of dummy variables that control for the business group of worker i, $YEAR_T$ is a dummy variable for the year of evaluation ($YEAR_T = 1$ when $T = 2005$). KMS_{iT} is an aggregate usage KMS by worker i over year T. $TRAN_{iT}$ denotes the amount of training received by worker i in year T. Z_i is a vector of other time-invariant control variables. In every model, ε denotes the idiosyncratic component of the error term. We use OLS (Ordinary Least Squares). Hypothesis 2 is tested using

$$\left(EVAL_{iT} - EVAL_{iT-1}\right) = \gamma_0 + \gamma_1 \cdot \left(KMS_{iT} - KMS_{iT-1}\right) + \gamma_2 \cdot \left(TRAN_{iT} - TRAN_{iT-1}\right) + \varepsilon_2 \qquad (2)$$

so that only the increase (decrease) in KMS usage explains the increase (decrease) in the performance. Notice that this equation is the difference between $EVAL_{iT}$ and $EVAL_{iT-1}$ shown in the first model. Since all time-invariant factors are canceled out after taking the difference, we have only time-variant factors in the model. Any time-invariant unobservable heterogeneity can be controlled for in this model since it will be can cancelled by taking the difference between the two time periods in (2).[22] Also notice that γ_0 represents the year level effect. Hypothesis 3 will be tested with

$$EVAL_{iT} = \delta_0 + \delta_1 \cdot GRP_i + \delta_2 \cdot YEAR_T + \delta_3 \cdot KMS_{iT} + \delta_4 \cdot Z_i + \delta_5 \cdot PRCS_{iT} + \varepsilon_{3it} \quad (3)$$

$$PRCS_{iT} = \delta_6 + \delta_7 \cdot GRP_i + \delta_8 \cdot YEAR_T + \delta_9 \cdot KMS_{iT} + \delta_{10} \cdot Z_i + \varepsilon_{4it} \quad (4)$$

We allow ε_{3it} and ε_{4it} to be correlated and use SUR (Seemingly Unrelated Regression) estimation to obtain more efficient estimates for the two equations. Testing Hypothesis 4, 5, 7, and 8 involves inclusion of interaction terms between KMS_{iT} and such interaction terms as $APHY_i$ (alternative physical sources), $ASOC_i$ (alternative social sources), KMS^{J}_{-iT} (usage by other employees in the same business group), and $EXPL_{iT}$ (degree of exploration). We basically extend equation (1), but to avoid the influence of multicollinearity by including multiple interaction terms with the KMS usage variable simultaneously we estimate three separate equations depending on our focus. For example, Hypothesis 4, 5 and 8 are tested with

$$\begin{aligned} EVAL_{iT} = \beta_0 + \beta_1 \cdot GRP_i + \beta_2 \cdot YEAR_T + \beta_3 \cdot KMS_{iT} + \beta_4 \cdot TRAN_{iT} + \beta_5 \cdot Z_i \\ + \beta_6 \cdot KMS_{iT} \cdot ASOC_i + \beta_7 \cdot KMS_{iT} \cdot APHY_i + \varepsilon_{3it}. \end{aligned} \quad (5)$$

When testing Hypothesis 6 and 7, GRP_i is dropped to avoid serious multicollinearity between KMS^{J}_{-iT} and GRP_i. We use OLS estimates to test these hypotheses. For easier interpretation and comparisons of the size of coefficients, all variables were standardized to a mean of zero and standard deviation of one.

[22] For example, factors such as intrinsic motivation may be affecting both sides of the equation. In addition, there may exist "star" employees who simply use KMS more and perform better than others at the same time.

3.5. Results

The descriptive statistics and correlation matrix for the sample are presented in Table 3-2. Note that all variables have been masked (multiplied by a positive number) to protect the confidential nature of the data.

Table 3-2. Sample Descriptive Statistics and Correlations

	N	Mean	Std Dev	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
(1) EVAL	1,136	3 01	0 34													
(2) KMS	1,512	5 88	2 31	-0 17												
(3) EXPL	1,516	0 46	0 24	0 03	0 41											
(4) GKMS	1,516	7 37	1 08	-0 32	0 53	0 09										
(5) PRCS	363	0 01	0 13	0 20	0 37	0 23	0 14									
(6) YEAR	1,516	0 50	0 50	0 01	-0 19	0 01	0 00	-0 17								
(7) DIST	1,516	2 18	2 13	-0 53	0 25	0 13	0 25	-0 10	0 00							
(8) TRAN	1,504	1 42	1 52	-0 03	0 30	0 08	0 28	-0 02	-0 12	0 05						
(9) COMP	1,420	5 94	0 96	0 20	-0 08	-0 08	-0 17	-0 05	0 00	-0 26	-0 09					
(10) TPRS	1,474	4 25	1 50	-0 02	0 09	0 06	0 10	0 00	0 00	-0 09	0 06	-0 12				
(11) ASOC	1,464	5 70	0 98	0 10	0 06	0 00	0 05	0 13	0 00	-0 03	0 07	0 10	-0 07			
(12) APHY	1,466	5 33	1 39	-0 17	0 11	0 00	0 16	0 08	0 00	0 15	0 06	-0 11	-0 01	0 28		
(13) TCOM	1,422	4 37	1 23	0 02	0 36	0 30	0 21	0 23	0 00	0 09	0 26	-0 20	0 04	0 10	0 07	
(14) TPOS	1,416	3 45	1 18	0 07	0 31	0 27	0 17	0 17	0 00	0 12	0 17	-0 22	0 07	-0 01	0 06	0 60

Estimation Results

Table 3-3. Estimation of KMS Impact

Variable	Direct	Moderating Effect			
	Base Model	Alternative Sources	Exploration	Exploration & Alternative Sources	Group Use
Intercept	-0 840 *** (0 118)	-0 850 *** (0 119)	-0 950 *** (0 125)	-0 966 *** (0 126)	0 054 (0 040)
Log of Aggregate KMS Use	0 135 *** (0 041)	0 141 *** (0 042)	0 169 *** (0 045)	0 173 *** (0 045)	0 071 † (0 042)
Log of Aggregate KMS Use * Alternative Social Sources		-0 056 † (0 031)		-0 052 † (0 031)	
Log of Aggregate KMS Use * Alternative Physical Sources		0 024 (0 033)		0 037 (0 034)	
Log of Aggregate KMS Use * Degree of Exploration			0 078 *** (0 029)	0 079 *** (0 03)	
Degree of Exploration			0 066 ** (0 03)	0 066 ** (0 03)	
Log of Aggregate KMS Use * Group-Level KMS Use					-0 104 *** (0 032)
Group-Level KMS Use					-0 241 *** (0 034)
Year 2005	0 050 (0 045)	0 051 (0 045)	0 038 (0 045)	0 039 (0 045)	0 036 (0 052)
Log of Distance from HQs	-0 149 ** (0 064)	-0 152 ** (0 064)	-0 154 ** (0 064)	-0 157 ** (0 064)	-0 415 *** (0 029)
KMS User Training	0 060 ** (0 026)	0 059 ** (0 026)	0 060 ** (0 026)	0 06 ** (0 026)	0 037 (0 027)
Computer Skills	0 010 (0 026)	0 010 (0 026)	0 013 (0 026)	0 013 (0 026)	0 050 † (0 027)
Perceived Time Pressure	-0 064 ** (0 025)	-0 065 ** (0 025)	-0 070 *** (0 025)	-0 072 *** (0 025)	-0 065 ** (0 026)
Alternative Social Sources	0 076 *** (0 025)	0 084 *** (0 025)	0 070 *** (0 025)	0 079 *** (0 025)	0 100 *** (0 027)
Alternative Physical Sources	-0 031 (0 027)	-0 039 (0 027)	-0 029 (0 026)	-0 038 (0 027)	-0 085 *** (0 027)
Tenure in Company	-0 006 (0 035)	0 002 (0 035)	-0 009 (0 035)	-0 001 (0 035)	-0 011 (0 036)
Tenure in Position	0 134 *** (0 032)	0 134 *** (0 032)	0 137 *** (0 032)	0 135 *** (0 032)	0 146 *** (0 034)
Group Controls	Yes	Yes	Yes	Yes	No
N	1 012	1 012	1,012	1,012	1,012
R-Square	55 44%	55 60%	55 87%	56 02%	56 02%
Adj R-Sq	51 40%	51 47%	51 76%	51 83%	51 83%

Significant at 1 % ***, 5 % **, 6 % *, and 10% †

Our estimation results for the direct impact of KMS usage are presented in the first column of Table 3-3 In this base model, the aggregate KMS usage variable (β= 0 14103) is significant at 1 percent level as hypothesized (Hypothesis 1) The model had R-square and adjusted R-square over 50 percent and the residuals showed no obvious pattern indicating a good fit for our econometric model We do not show the coefficients for 73 business group indicator variables in our results to save space VIFs (Variance Inflation Factor) for all variables are lower than the suggested level of 10, indicating no serious multicollinearity problem Interestingly, alternative social sources of information and knowledge have a positive and significant impact on the individual performance It is also interesting to observe that perceived time pressure of employees is negatively associated with performance evaluation KMS training is positively associated with performance even after including KMS usage variables This indicates that user training not only influences knowledge worker performance through usage, but also has a positive direct impact on performance It is possible that user training on KMS may in fact inform employees of why certain knowledge is useful for the conduct of their business It is important to assess how large the coefficients are For easier interpretation, we assume the case where a knowledge worker with KMS usage at the median level (6 47) and the median performance level (3 00) in the samples If other things are equal, the performance level of another worker with the KMS usage at the top 25 percentile level (7 64) corresponds to the performance at the top 42 percentile (3 03) That is, this knowledge worker might be able to excel other 8 percent of colleagues by this hypothetical increase in KMS usage

The next three columns in Table 3-3 test Hypothesis 4 through Hypothesis 8 on the moderating effects The second column includes the interaction terms between the KMS usage and alternative sources of information and knowledge (Hypothesis 4 and Hypothesis 5) We find that the positive impact of aggregate KMS usage on the knowledge worker performance is greater when she is endowed with fewer alternative social sources of information and knowledge, which supports our Hypothesis 4. However, Hypothesis 5 is not supported. In other words, knowledge workers with fewer printed reports or manuals are not benefiting more from their KMS use than those with more physical sources.

The third column in Table 3-3 presents our estimation results of the moderating effect of the degree of exploration (Hypothesis 8). Our implicit assumption in this model is that the degree of exploration derived from repository KMS represents the user's general tendency of using KMS for either exploratory or exploitive purpose. The results support our hypothesis that exploratory use of KMS reinforces the link between KMS usage and individual performance. Although not hypothesized, it is interesting to note that the exploratory use of KMS is positively associated with individual performance. We conclude that a high degree of exploration in using KMS leads to a greater impact of KMS usage on knowledge worker performance and thus Hypothesis 6 is supported. The fourth column then includes the three interaction effects as a full model. We confirm that the estimation results do not change much.

We separately estimated the effects of the group usage (Hypothesis 6 and Hypothesis 7) because we did not include the group-level control variables in this model due to the high correlation between group-level control variables and the group usage. We find that Hypothesis 6 and Hypothesis 7 are strongly supported. That is, the group-wide use of KMS not only decreases the relative individual performance, but also makes it harder for a knowledge worker to improve her own relative performance by utilizing knowledge from KMS. Figure 3-3 illustrates how one's own KMS usage and the group-wide use of KMS determine one's relative performance. The high group KMS usage drags down the performance improvement curve by one's own KMS usage (dotted line). The performance improvement curve under low group usage (dotted line) has a steeper slope than that under high group usage (solid line).

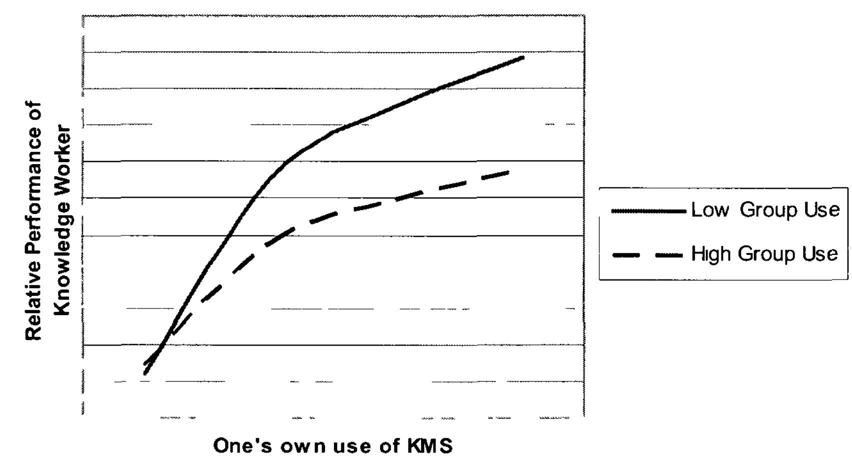


Figure 3-3. Effect of Group-level Use of KMS

Table 3-4 shows that an increase (decrease) in KMS usage level is associated with an increase (decrease) in employee performance (Hypothesis 2). Despite the relatively low R-square level, the model itself is significant at the 5 percent level. The differenced aggregate KMS usage variable is highly significant (β= 0.12546, p-value = 0.015) as expected. We conclude that a knowledge worker can improve her performance by increasing her level of KMS usage over time.

Table 3-4. Result on the Within-User Performance Improvement (N = 500)

Variable	Increment in Evaluation
Intercept	0.061 (0.056)
Differenced Log of KMS Use	0.125 ** (0.051)
Differenced KMS User Training	0.020 (0.038)
R^2	1.3 %
F-Statistics	3.19 **

Significant at 1 % ***, 5 % **, 6 % *, and 10% †

Table 3-5. Result on the Mediation Effect (SUR Estimation)

	Aggregate KMS	
	(a) Financial Perf	(b) Overall Evaluation
Intercept	-0 564 ** (0 249)	-0 752 *** (0.216)
Financial Performance		0 151 *** (0.054)
Log of Aggregate KMS Use	0 897 *** (0 169)	0 057 (0 153)
Year 2005	-0 381 *** (0 097)	0 037 (0 086)
Log of Distance from HQs	-0 008 (0 104)	-0 189 ** (0 09)
KMS User Training	-0 142 ** (0 06)	-0 003 (0 052)
Computer Skills	-0 052 (0 047)	-0 031 (0 041)
Perceived Time Pressure	-0 064 (0 051)	-0 066 (0 044)
Alternative Social Sources	0 085 (0 055)	0 019 (0 048)
Alternative Physical Sources	0 004 (0 066)	0 024 (0 057)
Tenure in Company	-0 020 (0 076)	-0 036 (0 065)
Tenure in Position	0 064 (0 066)	0.204 *** (0 057)
System Weighted R^2	23 18 %	
N	272	

Significant at 1 % ***, 5 % **, 6 % *, and 10% †

Table 3-5 presents our SUR estimation result on the mediation effect by the intermediate performance measure in a knowledge-intensive process (Hypothesis 3). The sample size decreased because this analysis includes only the store personnel with directly observable financial performance measure. Model (a) shows a positive impact of KMS usage on financial performance as the intermediate process-level performance measure, but model (b) shows an insignificant impact of KMS usage on the overall work performance after being explained for the intermediate financial performance measure. Since this result meets the conditions to find a mediating effect (Baron and Kenny (1986) p.1176), we conclude that KMS improves one's work performance by improving the performance in an intermediate knowledge-intensive process. As mediators reveal how and why the causal mechanism works, this finding has two important implications. First, it opens the black-box of how knowledge enables knowledge workers to improve their performance. We show that employees are obtaining the knowledge very specific and relevant to their tasks in the knowledge-intensive process. Second, a firm's role is to identify the major knowledge-intensive process that can be facilitated by timely acquisition of knowledge. This role becomes more important when KMS takes the form of "knowledge hierarchy" (Dennis and Vessey 2005) where knowledge is viewed as organizational resources and centrally managed by the organization.

Robustness Checks

We conducted additional analyses to check for the robustness of our results. First, we checked the residuals from our OLS estimations and no obvious pattern was found. All variables in the analyses have VIF less than 10, which indicates no serious multicollinearity. Although we log-transformed our KMS usage variable, the nature of results were not subject to the transformation. We used the summative measure of all KMS usage incidences across the three different types systems, but our results do not change dramatically when we used the standardized sum of three standardized usage variables. Although we use a single aggregate KMS usage variable in our models, the direct impact of KMS usages are all significant at least at 10 percent significance level if we separately insert the three variables.

3.6. Discussion of Results

Our research aims to rigorously study the impact of KMS on individual knowledge workers within an organization with detailed and objective data. We minimized the possible biases from survey measurements of both cause and effect variables. Our findings have several managerial implications on the role of KMS in an organization. First, different types of KMS do provide a knowledge worker with an opportunity to improve her performance by performing better in a knowledge-intensive process. In our study, we selected the sales process in stores not only because the process is very knowledge-intensive to meet the expectations of headquarters but also because it is a well-established and well-known performance criterion used in the company. In fact, there are many laments on the failed efforts to transfer knowledge with a codification approach (Gilmour 2003) It may not be true that a codification approach does not work simply because the richness and codifiability of knowledge is limited The important task for managers is to identify the knowledge intensive processes that can benefit from the distribution of limited yet timely codified knowledge and to align it with a firm's knowledge strategy and information technology

From our observation in the company, we found that it is very hard to completely separate the effect of one form of KMS from others For example, using a repository KMS may trigger a search into data warehouse to find new patterns If a grocery department manager finds from the repository that a particular item will be advertised in a few weeks, she may examine what the past sales for the item had been She may further investigate what the range of impact of advertisements for similar products had been using business intelligence She will be able to adjust her order quantity to sell more while preventing stockouts for the product The manager can go to the repository KMS and search for additional product information to decide whether it is likely to sell well in her particular store She may also search if the product sells well in other stores of similar size and location If the item had not been carried by any other store before and the manager does not know which vendor to order the new product, she can go to the expert directory KMS to ask for in-depth expertise and procedures This example illustrates that it may be desirable to implement different types of KMS at the same time and they are very well likely to coexist (Alavi 2000)

Second, the lack of social capital can be overcome to some extent as KMS spreads out throughout the organization However, our results do not imply a diminished importance of social capital A good interpretation of our findings is that KMS will help employees with low social capital and those who are less likely to develop it in the short-term In many cases, it is difficult to identify what type of knowledge is even available within an organization, but KMS can at least motivate an employee to seek knowledge from it That is, the "knowledge divide" due to the lack of social capital may be somewhat reduced. A quote from the company's internal document prepared to improve its KMS illustrates this point:

> *X just started at Ace Grocery and is slightly intimidated by the fact that "everybody knows everybody else and has worked here forever." She wants to do her job well but does not want to burden those around her by asking too many questions. She uses KnowLink to learn more about her job and to supplement her lack of institutional knowledge. She needs to learn who's who, what's what and the best way to be successful in her new job.*

It additionally suggests that a company with higher employee turnovers may benefit more from KMS. It is also interesting that the repository KMS was not more beneficial to a knowledge worker with fewer alternate physical sources. We believe that using a repository simply to replace existing printed documents as an electronic substitute may only end up saving paper, printing, and distribution costs rather than stimulating creation of new knowledge within an organization.

Although employees coordinate with their colleagues for better organizational outcomes, they do not necessarily share the common interest in every aspect. Employees work for themselves to maximize their own utility, which is a well-known principal-agent problem in economics. Together with other findings in this paper, those who may be more resistant to KMS in the long term are likely to be the employees already with better alternative knowledge sources compared to their internal competitors. As other employees use KMS more, their relative advantage will go away while their additional benefits by adopting KMS are smaller.

The IS literature has begun to consider system usage as the more important factor that leads to better performance rather than the aggregate IT investment (Devaraj and Kohli 2003). At the individual level, usage needs to be reconceptualized and a more rich usage measures may have to be adopted (Burton-Jones and Straub 2006). Our measurement of the degree of exploration and its moderating effect on KMS impact was made toward considering the use of KMS on a different purpose. In many cases, a KMS user does not know what information or knowledge is inside the document or report before she actually opens it. In this regard, an increase in our exploratory KMS usage index may also indicate the user's inefficiency in finding what she actually needs, which may decrease one's performance. Our finding that more exploratory usage is more beneficial is thus even conservative because the user can improve her performance even under possible search inefficiency. Another possibility is that our measure is simply influenced by the way employees use electronic documents. For example, employees may request the same document multiple times or reuse it after saving in their hard drives. As many employees have a stronger tendency of saving and reusing documents, our usage variable is likely underestimate one's actual usage while our measure of exploration tends to overestimate one's actual exploration. That is, if it is the case, the two measures are likely to be negatively correlated. Since they are positively correlated in table 3-2, we believe that one's tendency of saving documents for future use does not seriously affect our results. Nevertheless, we cannot completely rule out this possibility in our field research setting and thus more research in the experimental setting will be needed.

3.7. Conclusion

As a field study, our research may be generalizable to other contexts. We found a very significant impact of KMS, but the retail grocery chain may be the industry where KMS can benefit employees more than other industries. Providing employees in stores with information and codified knowledge collected from various sources in a timely manner is critical in the retail grocery industry. The benefits from mass distribution of knowledge may be smaller in an industry where personalized tacit knowledge is more important (e.g., the consulting industry). Furthermore, the economies of scale at our research site were relatively higher because there were many employees with similar roles. For example, meat managers in 200 stores are likely to have similar needs. We also have to note that KMS in the company was very well-managed by an independently operated knowledge management support group. Mismanagement of IT is one of the major reasons why it is hard to find a positive IT impact (Brynjolfsson 1993). It is also evident that the support from the knowledge group with expertise in both IT and business is essential in the early stage of KMS deployment.

Overall, the study enhances our understanding of how KMS enables a knowledge worker to improve her job performance. Our research makes an important contribution to the literature by providing a systematic approach to measure the contingent values of KMS at the individual level. Our study reveals who within an organization are likely to be more or less resistant to KMS as new sources of knowledge by showing who will appreciate more or less benefits from KMS. We also found that more detailed data may be available to study the impact of KMS or even other information systems than prior research has used. More commercial software these days automatically logs usage patterns of individual users. It suggests a great opportunity to develop theory based econometric models of systems usage and its impact unique to the IS domain. More efforts are also needed to study why and under what conditions different types of KMS help different types of knowledge workers.

Appendix 3-A. Survey Measures

Alternative Sources of Information & Knowledge (Social) (alpha = 0.768)

- My supervisor often provides useful information and advice that I need to do my work
- My colleagues are accessible for information and advice that I need to do my work
- I know many employees outside my own department from whom I can get information and advice for doing my work
- The people whom I work with provide me with useful information and advice

Alt. Sources of Information & Knowledge (Physical Documents) (alpha = 0.865)

- I get a lot of the information that I need to do my work in printed reports and documents
- The printed reports and documents I get are useful for my work

Computer Application Competency (alpha = 0.842)

- How comfortable do you feel using each of the following? - Email
- How comfortable do you feel using each of the following? - Excel
- How comfortable do you feel using each of the following? - Word
- How comfortable do you feel using each of the following? - Internet
- How comfortable do you feel using each of the following? - Google/Yahoo

Time Pressure (alpha = 0.873)

- I need more hours in the day to get my work done
- I have to overextend myself to find the time to get my work done
- I feel like I am always 'fighting fires'
- I often have to take shortcuts to get my work done on time

Source: Andrews and Smith (1996) and Sethi (2000)

Tenure in the Organization/ Position

- How long have you worked for Ace Grocery?
- How long have you been in your current position?

1) 0 to 6 months	2) 6 months to 1 year	3) 1 to 5 years
4) 5 to 10 years	5) 10 to 25 years	6) 25 + years

Appendix 3-B. Analytical Model and Proof

Consider the relative performance of a knowledge worker i when there is another knowledge worker j: $RP_i = F(AP_i, AP_j)$. We formulate that the relative performance of i increases in her own absolute performance but decreases in the absolute performance of her co-worker j. Because we define two symmetric knowledge workers, we assume $\partial RP_i / \partial AP_i = -\partial RP_i / \partial AP_j$.[23] Define two symmetric absolute performance functions such that $AP_i = f_i(K_i, K_j)$ and $AP_j = f_j(K_j, K_i)$. We assume that one's absolute performance increases in one's own knowledge sourcing and her co-worker's knowledge sourcing such that $\partial f_i / \partial K_i > 0$ and $\partial f_i / \partial K_j > 0$.[24] However, we additionally assume $\partial f_i / \partial K_j < \partial f_j / \partial K_j$ and $\partial f_j / \partial K_i < \partial f_i / \partial K_i$ such that the marginal effect of one's own knowledge use on absolute performance is greater than the marginal effect of co-worker's knowledge use. Then, it is easy to show $\partial RP_i / \partial K_j < 0$ (See Appendix for Proof). Furthermore, we can also show $\partial^2 RP_i / \partial K_{-i} \partial K_i < 0$ if we assume $\partial^2 F_i / \partial f_i^2 < 0$ and $\partial^2 F_i / \partial f_j \partial f_i < 0$ such that one's relative performance increases in one's own absolute performance at a decreasing rate and the positive externalities by other peoples' knowledge uses is smaller when one is already a heavier user of knowledge.[25]

[23] This assumption implies that an increase in one's own absolute performance and a decrease in co-worker's absolute performance lead to an increase in one's own relative performance at the same rate.

[24] This assumption is plausible since here may exist positive externalities by other peoples' knowledge uses that may improve one's absolute performance (e.g., knowledge transfer by colleagues).

[25] The first assumption is justifiable considering the distribution of the relative performance in Figure 3-1 where only a small fraction of employees could receive a score close to 4.0 (greatly exceeds expectation). The second assumption makes sense because if one is already a heavy user of KMS whatever her colleagues may inform her is unlikely to be unique or valuable as much as when she was not aware of the informed knowledge.

(1) $\frac{\partial RP_I}{\partial K_J} = \frac{\partial F}{\partial f_I} \cdot \frac{\partial f_I}{\partial K_J} + \frac{\partial F}{\partial f_J} \cdot \frac{\partial f_J}{\partial K_J} < \left(\frac{\partial F}{\partial f_I} + \frac{\partial F}{\partial f_J} \right) \cdot \frac{\partial f_J}{\partial K_J} = 0$

(2)

$$\frac{\partial^2 RP_I}{\partial K_J \partial K_I} = \left(\frac{\partial^2 F_I}{\partial f_I^{\,2}} \right) \cdot \frac{\partial f_I}{\partial K_I} \cdot \frac{\partial f_I}{\partial K_J} + \left(\frac{\partial^2 F_I}{\partial f_J \partial f_I} \right) \cdot \frac{\partial f_I}{\partial K_I} \cdot \frac{\partial f_J}{\partial K_J} + \left[\frac{\partial F_I}{\partial f_I} \cdot \left(\frac{\partial^2 f_I}{\partial K_J \partial K_I} \right) + \frac{\partial F_I}{\partial f_J} \cdot \left(\frac{\partial^2 f_J}{\partial K_J \partial K_I} \right) \right]$$

$$= \frac{\partial f_I}{\partial K_I} \left[\left(\frac{\partial^2 F_I}{\partial f_I^{\,2}} \right) \cdot \frac{\partial f_I}{\partial K_J} + \left(\frac{\partial^2 F_I}{\partial f_J \partial f_I} \right) \cdot \frac{\partial f_J}{\partial K_J} \right] + \left(\frac{\partial F_I}{\partial f_I} + \frac{\partial F_I}{\partial f_J} \right) \left(\frac{\partial^2 f_I}{\partial K_J \partial K_I} \right) < 0 \,.$$

Chapter 4

STUDY 3: AN EMPIRICAL STUDY OF THE DIFFERENTIAL USE OF MULTIPLE KNOWLEDGE MANAGEMENT SYSTEMS

4.1. Introduction

The foundation of industrialized economy is shifting from natural resources to intellectual assets and today's executives are compelled to understand the dimensions of knowledge underlying their business and tasks (Hansen et al. 1999). The knowledge-based view of the firm considers knowledge as the most strategically important resources that are hard to imitate and socially complex to create sustainable competitive advantage against competitors (Grant 1996; Kogut and Zander 1992). As an effort to manage firm's own knowledge assets more effectively with the power of IT (Information Technologies) that allow easier codification, collection, distribution, and transfer of knowledge than ever before, many firms have deployed KMS (Knowledge Management Systems). KMS gained its popularity as a point of innovation in the next generation.

So far, many studies focused on the contribution aspect of KMS (Bock et al. 2005; Wasko and Faraj 2005). However, searching and learning new knowledge from KMS requires substantial efforts by adopters of knowledge. Due to the challenge of adoptions by knowledge seekers, it is an important issue why certain knowledge workers will decide to obtain knowledge from KMS instead of his or her existing sources of knowledge. Low usage of IT artifacts has been considered one of the major factors underlying the phenomenon known as "productivity paradox." The recent progress in the business value of IT literature showed that IT investment bears fruits when systems implemented are actually used by employees (Devaraj and Kohli 2003). In the same venue, even when employees contribute what they know to KMS, KMS may not create any value unless other employees are motivated to use the knowledge contributed by others.

In fact, systems adoption and usage has been one of the core research questions in the IS literature. The literature provides useful insights into why a certain user adopts (or intents to adopt) any given systems based on such theories as TAM (Technology Acceptance Model) (Davis 1989; Davis et al. 1989), TRA (Theory of Reasoned Action) (Ajzen 1991; Fishbein and Ajzen 1975), and IS success model (DeLone and McLean 1992, 2003). While these theories provide basic ideas of why employees adopt KMS at the pre-adoption stage, they are not sufficient to understand why certain knowledge workers continue to use it more or less after implementation. We illustrate the potential limitations of the prior studies in understanding the continued KMS usage and how we attempt to address the issues.

- The prior studies do not incorporate the factors specific to the knowledge management (KM) context. They instead attempt explain user's intention to use systems by a relatively simple model with abstract constructs such as perceived usefulness and perceived ease of use. Furthermore, the technologies studied in many of them have been relatively simple and the participants are students (Venkatesh et al. 2003), which makes it hard to directly apply the traditional models to the KMS setting in organizations. Our study proposes KMS-specific factors such as task information and knowledge intensity, actual usage by frequently interacting employees, and alternative sources of information and knowledge that lead to actual KMS usage behaviors.
- The prior studies rely on self-reported usage or/and intent to use systems that not only ignore a user's actual usage over time, but also may be biased (Straub et al. 1995). While using intention as a predictor of behavioral usage is a well-established tradition, the decision on the acceptance needs to be made based on the nature of the technology being examined (Agarwal 2000). As complex systems involving many employees within an organization, where intention may not be simply linked with actual usage, it would be of greater value to examine the actual usage rather than intention. Furthermore, one's usage level changes over time, and

thus it is not appropriate to explain one's fluctuation of usage level over time only by intention in understanding post-adoptive usage. Our econometric model allows us to consider the dynamics such as prior use, seasonality, habit persistence, and unobservable heterogeneity that were often ignored in the literature (Jasperson et al. 2005).

- The interdependency of system usage behaviors by a user has not been much studied yet. For example, Kraut et al. (1999) demonstrated that email use drives people's use of the Internet. Information systems have become essential in accomplishing tasks in today's business environments and there exist multiple information systems within an organization. When two applications can be used for similar purposes, "residual demand" may lead to more usage of the other application as in the Internet search engines (Telang et al. 2004). Consideration of such interactions will help develop and design new systems in the presence of other systems in the organizational setting.
- The differential effects of various usage drivers on different types of KMS have been hardly understood because the prior studies focus on a single IT artifact. We consider these differential effects in a multiple KMS setting and demonstrate that the usage behaviors of different types of KMS can be influenced by the same factor but to a different degree or even in the opposite direction.

Overall, the explanation of systems adoption by users is well-established at the abstract level, but not yet sufficient to understand the post-adoptive usage behaviors of multiple types of KMS over time. Considering the organizational effort to effectively manage knowledge in the era of "hyper-competition" (D'Aveni 1994) and growing interests in applying technologies, the more in-depth studies specific to KMS are imperative. Our rich dataset collected from a large company in the retail industry allows us to test our hypotheses with a rigorous econometric model. This study has several important implications. First, KMS-specific individual and task characteristics such as social capital and task knowledge intensity are important factors that influence the variations in the KMS usage. However, those factors have the differential effects on the use of different types of KMS. Second, the assimilation of KMS can be accelerated by 1) promoting the usage the users or groups who are connected with a greater number of other knowledge workers, 2) implementing other types of KMS that complement each other, and 3) differentiating organizational efforts by knowledge worker's individual and task characteristics.

4.2. Knowledge and Knowledge Management Systems

A common view of knowledge is based on the hierarchy of data, information, and knowledge. According to this view, data is raw numbers and facts, and information is processed data, and knowledge is authenticated information (Dretske 1981; Machlup 1983). Thus information is the "commodity capable of yielding knowledge," and knowledge is "a high value form of information that is ready to apply to decisions and actions." (Davenport and Prusak 1998). Alternatively, knowledge may be viewed as an object, access to information, a process of applying expertise, and so on (Alavi and Leidner 2001). The lesson from the prior literature is that knowledge is a multidimensional construct with more complex characteristics than those of information (Kulkarni et al. 2006; Nonaka 1994). As two widely acknowledged dimensions of knowledge, tacit knowledge refers to knowledge that is unarticulated, rooted in actions and experience, and situated in context, while explicit knowledge refers to knowledge that is articulated in some symbolic forms (Nonaka 1994; Polanyi 1962, 1967). Knowledge management is a process of facilitating knowledge creation, knowledge storage, knowledge transfer, and knowledge application within an organization. Since information is consumed to generate new knowledge and knowledge is recombined to generate new knowledge (Kogut and Zander 1992), KM activities should range from providing a knowledge worker with any factual information to be combined with one's prior knowledge to facilitate transfer of personalized "tacit" knowledge through socialization (Nonaka 1994; Polanyi 1962, 1967). In this respect, it is difficult to distinguish any information systems that provide a knowledge worker with highly customized actionable information from any commonly cited forms of KMS such as a repository of codified knowledge (Alavi and Leidner 2001). Since the nuances are lost during codification and the task environments and cognitive capability of every knowledge worker are not identical, it may be even more useful for a certain knowledge worker to receive well-processed and presented information rather than to receive other people's interpretation of the same information.

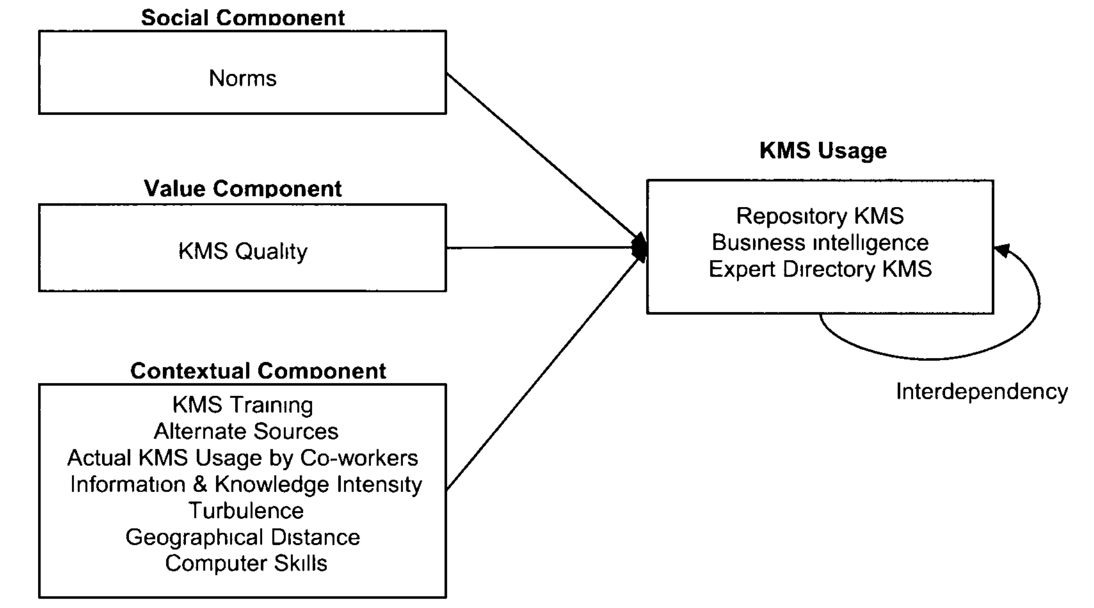
In this paper we consider multiple KMS as important sources of information and knowledge. We focus on the three common types of KMS that are popular in many industries: knowledge repository, business intelligence, and expert directory and communication. As the sources of information and knowledge, they share common goals but have distinct characteristics. A knowledge repository model is one of the most common forms of KMS adpoted by firms. A repository stores explicit knowledge (Nonaka 1994; Polanyi 1962, 1967) codified by other employees within the organization. The codified knowledge stock in a repository ranges from corporate policies, best practices and procedures(O'Dell and Grayson 1998) to suggested improvements by other employees.

Employees in organizations access information from various computer application systems from accounting, and inventory control to payroll systems. Often, data warehouses combine such information over a long period of time, and act as a source of knowledge. Data mining tools are used to assist one's decision making, and facilitate the generation of new knowledge and insights. Given the vital role of business intelligence in organizational decision-making, we also include the business intelligence explicitly as one type of KMS to facilitate knowledge creation. Business intelligence systems such as data warehouses are often considered a repository of corporate data and classified within the same category as a document repository (Hahn and Subramani 2000). However, there exist some differences between business intelligence and a document repository. First, business intelligence such as data warehouse is relatively devoid of context and potentially requires substantially more interpretation and cognitive processing (Ruggle 1998). Despite the potential cognitive processing and interpretation load, it provides an opportunity to create new knowledge without being biased by anyone else. One may receive even misinterpreted knowledge if the same information has been processed by someone with poor cognitive processing capability. For example, a corporate executive and a sales clerk may arrive at different conclusions from a long range sales report. Second, if well-managed, business intelligence can process a large volume of information quickly and provide knowledge in a timelier manner than a knowledge repository can.

With the expert directory KMS a company creates and maintains a list of subject matter experts to map internal expertise (Alavi and Leidner 2001). While this yellow page of experts (Hahn and Subramani 2000) may be linked with experts' email accounts to transfer explicit knowledge only via emails, a directory KMS is likely to trigger new discussions via other media such as telephone or other collaborative tools. It also provides an opportunity to develop a shared understanding of context and social relationship, which may enable an employee to transfer more sophisticated and complex knowledge that is even "tacit."

Notice that the first two types of KMS are efficient methods to store and distribute codified knowledge throughout the organization while the expert directory KMS is focused on matching and communication. The expert directory KMS recognizes that knowledge generation and knowledge application are fundamentally social processes that take place most efficiently through direct interactions and communications among members of communities (Alavi 2000). The need for cognitive processing is likely to be highest for business intelligence, but business intelligence is likely to face the lowest organizational barrier related to sharing knowledge between people.

Figure 4-1. Overview of Model



4.3. Hypotheses

Figure 4-1 illustrates the overview of our proposed model Our model includes three components value, social, and contextual components The contextual component refers to "situational influences" (Agarwal 2000) specific to the combination of knowledge workers and their contexts within an organization Since searching and applying knowledge from KMS is costly and knowledge in KMS is often limited due to its codification and generalization compared to existing social capital, the contextual component is related to what factors may increase the relative value of even the limited knowledge The factors such as environmental turbulence and computer skills may make one type of KMS more attractive than the others The value and the social components appear in many other studies of technology adoption Since the literature has heavily discussed the value and social influence as drivers of system usage already, we aim to focus on how KMS-specific factors may influence knowledge workers' actual usage

Contextual Factors

Alternative Sources of Information and Knowledge While KMS can provide users with useful knowledge, users have to spend time, make efforts to search for the exact knowledge they need, and learn how to use the systems. As a result, those who can easily obtain equivalent or comparable knowledge from other sources are less likely to use KMS. In organizations employees can learn either from own experiences or from the experiences of others (Levitt and March 1988). We identify two traditional sources of information and knowledge that are potentially competing with KMS: physically-printed documents and social networks.[26] Our interview with one of executives, who was not frequently using any of KMS in the research site, pointed out why he was not a user of KMS even with access to it: "If I need more information, it is their job (those who report to the executive) to get the information for me." One manager during our interview also indicated that he received the same document as what he could obtain from a repository from his supervisor, which is likely to reduce his use of the repository KMS. We thus hypothesize that possession of alternative sources of information and knowledge reduces one's motivations to use any type of KMS.

- ***Hypothesis 1-a***: Alternative social sources of information and knowledge are negatively associated with the use of repository KMS.
- ***Hypothesis 1-b***: Alternative social sources of information and knowledge are negatively associated with the use of business intelligence.
- ***Hypothesis 1-c***: Alternative social sources of information and knowledge are negatively associated with the use of expert directory KMS.
- ***Hypothesis 2-a***: Alternative physical sources of information and knowledge are negatively associated with the use of repository KMS.

[26] For example, Gray and Mesiter (2004) have identified three types of knowledge sourcing: dyadic, group, and published knowledge sourcing. Notice that the first two forms rely on person(s) while the last form relies on codified document as a channel for knowledge transfer.

- ***Hypothesis 2-b***: Alternative physical sources of information and knowledge are negatively associated with the use of business intelligence.

- ***Hypothesis 2-c***: Alternative physical sources of information and knowledge are negatively associated with the use of expert directory KMS.

Actual Usage by Frequently Interacting Knowledge Workers The actual usage by frequently interacting knowledge workers can influence users' use through multiple paths. First, there may exist network effects (Katz and Shapiro 1985) because of shared language, enhanced communication and better coordination. As shared "mutual knowledge" within and across groups has been found to improve performance (Cramton 2001; Krauss and Fussell 1990), a user has more incentives to use systems in case his or her co-workers are also sourcing knowledge from the same systems. Second, words-of-mouth effect (Ellison and Fudenberg 1995; Vettas 1997; Whyte 1954) can also have a direct effect on this link. Especially for a repository KMS, an employee is more likely to be informed about any useful knowledge by his or her colleagues. [27] However, the use of the expert directory KMS is dependent more on one's sporadic demand for expertise. Since more customized and personalized knowledge is expected to be transferred through expert directory KMS, neither network effects nor words-of-mouth effect is likely to be present in using the expert directory KMS.

- ***Hypothesis 3-a***: The actual usage by knowledge workers in one's social network is positively associated with the use of repository KMS.

- ***Hypothesis 3-b***: The actual usage by knowledge workers in one's social network is positively associated with the use of business intelligence.

Geographical Distance While geographical distance from the headquarters may increase the likelihood to obtain location-specific knowledge, it decreases the likelihood to obtain generic

[27] One main distinction between subjective norms and the actual usage by frequently interacting knowledge workers is that norms are quasi-fixed, but the actual usage varies over time.

enterprise-wide knowledge when know-hows are concentrated in the headquarters. Geographical distance makes it harder to gain knowledge that is available to others when know-hows are concentrated in the headquarters. Geographical distance degrades relationships and reduces group interaction (Kiesler and Cummings 2002). Geographical distance often decreases the chances of formal knowledge transfer such as training. It also decreases the chances of knowledge transfer through informal channels by reducing face-to-face interactions (e.g., Allen 1977). The use of KMS enables a remotely located employee to overcome the communication deficiency by providing a chance to search for knowledge available in other parts of an organization.

- ***Hypothesis 4-a***: Geographic distance is positively associated with the use of repository KMS.
- ***Hypothesis 4-b***: Geographic distance is positively associated with the use of business intelligence.
- ***Hypothesis 4-c***: Geographic distance is positively associated with the use of expert directory KMS.

Environmental Turbulence The performance under turbulent environments relies more on one's capability to cognitively process and interpret knowledge learned from external sources and transform it by combining it with one's unique context. The needs for timely acquisition of knowledge increase under turbulent environments (Nayyar and Bantel 1994), which can be facilitated by business intelligence with rapidly updated knowledge. However, a simplified and generalized component of knowledge in the repository KMS is less likely to be helpful under turbulent environments (Haas and Hansen 2005). Experts are not always available, and waiting until the experts are available becomes more costly under turbulent environments. Therefore, a user under turbulent environments is more likely to use the business intelligence that provides unprocessed knowledge possibly faster than the repository can. To the contrary, a user under stable environments is more likely to use both the repository and the expert directory KMS.

- ***Hypothesis 5-a***: Environmental turbulence is negatively associated with the use of repository KMS.
- ***Hypothesis 5-b***: Environmental turbulence is positively associated with the use of business intelligence.
- ***Hypothesis 5-c***: Environmental turbulence is negatively associated with the use of expert directory KMS.

Task Information and Knowledge Intensity Although most modern workers are considered knowledge workers, their demand for information and knowledge varies depending on the nature of tasks. We define task information and knowledge intensity as the degree to which an individual's tasks involve acquisition, processing, and distribution of information and knowledge. In the information processing literature, (Schroder et al. 1967) viewed that tasks vary in three dimensions - information load, information diversity, and the rate of information change - that contribute to task complexity. Complex tasks involve multiple paths of actions and desired outcomes, make the links between paths and outcomes may be even uncertain (Campbell 1988), and lead to higher intellectual demand (Gray and Meister 2004). Based on Schroder et al. (1967), we view 1) volume of information and knowledge needed and 2) rate of change in needed information and knowledge as two sub-dimensions of task information and knowledge intensity. In general, as one's demand for knowledge is greater, she is more likely to be in need of more codified knowledge and use repository and business intelligence more. However, since expert directory KMS is effective in solving unroutinized and unstructured problems rather than in obtaining easily codifiable knowledge, general task information and knowledge intensity does not necessarily increase the use of the expert directory KMS. Environmental turbulence needs be distinguished from task information and knowledge intensity. The former determines the fit between one's environments and a specific type of KMS and applicability of obtained knowledge from external sources while the latter increases users' motivations to source information and knowledge from any possible source.

- ***Hypothesis 6-a***: Task information and knowledge intensity is positively associated with the use of repository KMS.
- ***Hypothesis 6-b***: Task information and knowledge intensity is positively associated with the use of business intelligence.

Computer Application Skills If a user is efficient and effective in using computer applications other than KMS, she is likely to have less cognitive cost to learn about new systems. Today, many computer applications are based on similar platforms such as the Web environments. Therefore, we hypothesize that computer application skill is positively associated with the use of repository and business intelligence. However, one without much knowledge in searching information and knowledge from other types of KMS would prefer to use expert KMS, where a user can obtain more customized treatments. In the presence of other types of KMS, a user with poor computer skills is more likely to use expert KMS to receive an assistance in finding relevant information and knowledge from other types of KMS. We thus hypothesize that computer application skill has a negative effect on the use of the expert KMS.

- ***Hypothesis 7-a***: Computer application skills are positively associated with the use of repository KMS.
- ***Hypothesis 7-b***: Computer application skills are positively associated with the use of business intelligence.
- ***Hypothesis 7-c***: Computer application skills are negatively associated with the use of expert directory KMS.

KMS Training User training is known to be one of the most important methods to enhance actual usage by lowering any resistance to adopting new systems in many previous studies (Delone 1988; Fuerst and Cheney 1982; Igbaria et al. 1995). Since a user of KMS has to compare the traditional sources of knowledge with the IT-enabled knowledge sources, it is even more important to reduce any cognitive burden in using KMS. Training also reduces a user's cost of searching knowledge from KMS. However, since using the expert directory KMS does not involve as much cost of searching and learning knowledge as business intelligence or repository KMS, the effect of training is likely to be little.

- ***Hypothesis 8-a***: Training is positively associated with the use of repository KMS.
- ***Hypothesis 8-b***: Training is positively associated with the use of business intelligence.

Interdependency of Systems Usage Information systems have become essential in accomplishing tasks in today's business environments and there exist multiple information systems within an organization. When two applications within the organization can be used for similar purposes, "residual demand" may lead to more usage of the other application as in the Internet search engines (Telang et al. 2004). Kraut et al. (1999) showed that more email uses drives more uses of the Internet in households in the subsequent period. In the context of KMS, a user is likely to contact experts when their demand for best practices is not met by using repository KMS. The difficulty in interpreting information and knowledge from business intelligence may also lead to the use of expert directory KMS. One's past usage may influence his or her future usage behaviors by motivating users to gather more knowledge. Information or knowledge from one type of KMS may be incomplete and need additional inputs from other systems to create new knowledge. That is, consumption of knowledge creates additional demand for other complementary knowledge across different types of KMS in the future. We do not believe that the use of expert directory KMS does not necessarily lead to more use of repository KMS or business intelligence because it is often used as the last resort to solve unroutinized problems.

- ***Hypothesis 9-a***: The use of repository KMS in the prior week positively influences the current use of business intelligence.
- ***Hypothesis 9-b***: The use of repository KMS in the prior week positively influences the current use of expert directory KMS.
- ***Hypothesis 9-c***: The use of business intelligence in the prior week positively influences the current use of repository KMS.
- ***Hypothesis 9-d***: The use of business intelligence in the prior week positively influences the current use of expert directory KMS.

Value Component

Perceived KMS Quality The perceived benefit of using systems is one of the most frequently cited predictors of systems usage behaviors (Mahmood et al. 2001). A series of studies based on IS success model (DeLone and McLean 1992, 2003) suggest that ease of use, information quality, and IS service quality are important sub-dimensions of perceived value of using systems. The past studies based on TAM (Davis 1989; Davis et al. 1989), and TRA (Ajzen 1991; Fishbein and Ajzen 1975) also show that usefulness and ease of use are the two of the most direct predictors of usage intention. Perceived KMS quality in this paper refers to the extent to which a user perceives that sourcing knowledge from any KMS is beneficial to her. We conceptualize that the perceived value is determined by five factors: ease of use, information and knowledge quality, support from a KM group, support from business experts, and end-user systems quality.

- ***Hypothesis 10-a***: Perceived quality of KMS is positively associated with the use of repository KMS.
- ***Hypothesis 10-b***: Perceived quality of KMS is positively associated with the use of business intelligence.

- ***Hypothesis 10-c***: Perceived quality of KMS is positively associated with the use of expert directory KMS.

Social Component

Subjective Norms One's perception of other people's favor or disfavor towards using systems has been found to influence one's usage in many studies. The rationale is that if people believe their important referents think they should use systems they will behave in a desired way even when they are not favorable toward using systems (Venkatesh and Davis 2000). From an organizational hierarchy, we identify that there are three layers of important referents: top management, supervisors, and colleagues (Igbaria et al. 1995; Lewis et al. 2003; Mahmood et al. 2001). Since KMS as organization-wide systems introduces dramatic organizational changes, and top management support can overcome political resistance while encouraging participation (Markus 1983), top management support in KMS has greater importance than transactional systems. We view that expert directory KMS is less influenced by norms because they are used more on a need basis where unroutinized and unstructured problems occur.

- ***Hypothesis 11-a***: Subjective Norms are positively associated with the use of repository KMS.
- ***Hypothesis 11-b***: Subjective Norms are positively associated with the use of business intelligence.

4.4. Research Method

We collected our data from Ace Grocery (a pseudonym), a grocery chain with more than 200 stores nationwide and around 40,000 employees in total. A fraction of the stores is independently owned by individuals. While the independent stores still receive products for inventory from corporate distribution centers and much information from headquarters, they are less subject to corporate policies. To effectively manage organizational knowledge distributed across an organization, Ace Grocery initiated a knowledge management system project and deployed

KnowLink (a pseudonym) over several years. Although the main component of KnowLink is a repository of documents on business plans designed by headquarters, advertising and merchandising plans, product information, procedures, corporate policies, training materials, suggested practices developed by other employees, and so on, KnowLink also includes other tools such as collaboration applications, inquiries to experts, and data warehouse in order to feed important information and knowledge to the right person in the organization whenever she needs in various ways. The systems assist knowledge workers in various roles in the company in making important decisions ranging from the short-term operational decisions to the long-term planning.

Measurements and Operationalization

Use of KMS We collected system-recorded weekly level usage of KMS over 52 weeks as follows.

- Repository Use: the total number of documents opened by an employee per week.
- Business intelligence Use: In Ace Grocery, a user can navigate through a tree of menu in data warehouse application. Once a user knows what information is needed, she can customize the historical data to her needs at the specified aggregation level and for the given time period. The total number of customized reports viewed was counted at the weekly level.
- Expert KMS Use: the total number of inquires submitted by users to a designated subject matter experts at the weekly level.

Environmental Turbulence In the retail grocery chain, one of the main sources of environmental turbulence is to what extent the product handled involves any perishability. We thus operationalized environmental turbulence as the product perishability (0 = non-perishable product, 1 = perishable product). Training was measured by the number of training days taken for business intelligence and repository KMS. The distance between the corporate headquarters and the location of users was calculated from MapQuest.com. The driving distance in miles was coded and then log-transformed.

Survey and Actual Usage by Frequently Interacting Knowledge Workers All survey items are measured based on a seven point Likert scale from "Strongly Disagree" to "Strongly Agree." While we reused items validated in the prior literature, we also newly developed three survey constructs: 1) alternative social sources of information and knowledge, 2) alternative physical sources of information and knowledge, and 3) task information and knowledge intensity. For alternative sources, we used four items to measure social alternate sources of information and knowledge. From an organizational hierarchy, useful information and knowledge can be obtained from one's supervisor, colleagues, and subordinates. We used two items to measure alternative physical sources of information and knowledge. Task information and knowledge intensity was measured in two dimensions: information load and rate of change in information. Computer application skills were measured by asking to what extent users feel comfortable with using popular computer applications in business. We identified three types of social influences on employees - top management, supervisors, and colleague – and measured subjective norm by the three dimensions. We measured perceived KMS quality by five dimensions: ease of use, information and knowledge quality, support from KM group, support from business experts, and end-user systems quality. The actual usage by frequently interacting co-knowledge workers was measured by two-step processes. First, to identify the list of frequently interacting co-workers, we asked each respondent to identify up to six employees in corporate headquarters (excluding temporary employees and contractors) outside one's own department/store with whom she frequently interacts in order to accomplish her job. Then we averaged the level of actual usage by those co-workers for each week.

Our survey items are summarized in Appendix with the sources if they were developed based on the prior studies. To ensure face and content validity of survey items, four iterative procedures were conducted (1) a review of the instruments by faculty experts from different fields, (2) a pretest with university staff to confirm the readability of questionnaire, (3) item-by-item discussion sessions with a head of knowledge strategy group, KnowLink training managers, and KnowLink administrators, and (4) a pilot test with 37 Ace Grocery employees We reworded the items in a way that every employee can easily understand all the questions The third process included two formal sessions with Ace Grocery management and KnowLink specialists For each session at least three Ace Grocery employees attended to share opinions and correct the terms that may not be familiar to store personnel In addition to the two formal sessions, the authors and Ace Grocery employees had several informal discussions before the main survey The survey was initially emailed to 2,000 employees 2,000 employees reflect a broad range of knowledge workers in the company ranging from employees at headquarters, those at distribution centers, store support field group to store department managers 24 emails were returned due to employee turnovers and 1,232 responses were collected (response rate = 1,232/1,976 = 63 2 %)

Control Variables We had other control variables in the analysis We added a user's tenure in the organization and her position, which were gathered by our survey The scope of the repository KMS in the company is rather broad and used as a portal to other applications and documents that are unrelated to KMS Users can click the tab on the top menu bar of the first page to be connected to those sections To control for the view of documents that are irrelevant to the use of codified knowledge, we control for users' clicks on the two navigation tabs each week That is, we intend to control for the variation in the number of document views that were driven by non-KMS related activities Since the usage of systems in the retail industry is very likely to be influenced by seasonal factors, we also controlled for the seasonal factors by including the usage variables lagged by 52 weeks This control is important because even the inclusion of the weekly level fixed effects do not completely account for the seasonal usage for a particular user

Econometric Approach

We used a mixed model regression approach available from SAS Institute (Littell et al. 1996) to analyze our unbalanced panel dataset. The mixed model theory allows modeling the repeated measurements for the same subject and set up the covariance structure of both error terms and random effect coefficients flexibly. In our analysis, users are modeled as a repeated factor with random effects. The same approach was adopted in Kraut et al. (1999) to model the weekly-level Internet usage as a time-series. The one difference is that week in this study has been modeled as fixed effects because our dataset has more users and can model the weekly-level fixed effects without much loss of degree of freedom. The covariance structure of error terms was modeled as AR (1) process within the same user. Setting the structure of error terms as AR (1) is reasonable because the habitual usage can persist and is likely to be correlated with the next period usage in the short-term. A generalized version of the mixed model is $Y = \beta X + Z\gamma + \varepsilon$, where β is a vector of fixed-effects parameters, X is a vector of continuous and dummy variables, γ is a vector of random effects parameters, Z is a known design matrix, and ε is a vector of random errors. In our model, we specified γ matrix unstructured and ε matrix as AR (1). For this structure, FGLS (Feasible Generalized Least Squares) estimator was used. Our model is

$$LogKMS_{iT}^{j} = \alpha_i + \beta_0 + \beta_1 \cdot Week_T + \beta_2 \cdot TRN_{iT}^{j} + \beta_3 \cdot LogIKMS_{-iT}^{j} + \beta_4 \cdot LogKMS_{iT-1}^{j} + \beta_5 \cdot LogKMS_{iT-52}^{j} + \beta_6 \cdot LogKMS_{iT-1}^{-j} + \beta_7 \cdot W_i + \varepsilon_{iT}^{j}$$

where i is an individual user, T indicates week, and j is a different type of KMS. KMS_{iT}^{j} indicates the usage of type j KMS by user i at week T, $Week_T$ is a vector of dummy variables to indicate each week, TRN_{iT}^{j} is the training level of type j KMS by user i up to week T, $IKMS_{-iT}^{j}$ indicates the usage of type j KMS by co-workers identified by user i at week T, KMS_{iT-1}^{j} and KMS_{iT-52}^{j} are vectors of lagged usage variables, $LogKMS_{iT-1}^{-j}$ is a vector of lagged use of non-j type of KMS, and W_i is a vector of time-invariant survey and control variables. We used a maximum likelihood method for the estimation. Since the usage variables were not normally distributed, all usage variables were log-transformed. For easier interpretation and comparisons of the size of coefficients, all variables were standardized to a mean of zero and a standard deviation of one. [28]

4.5. Results

Table 4-1 and Table 4-2 show the descriptive statistics and correlations among the variables used. Note the outcome and KMS usage variables have been masked (multiplied by a positive number) to protect the confidential nature of the data. Table 4-3 summarizes our estimation results for the repository KMS usage. Model (1) did not include actual usage by frequently interacting knowledge workers because of more missing observations than other variables in the survey. Model (2) is the same as model (1) except that we considered the aggregate-level of alternative sources of information and knowledge. Model (3) included actual usage by frequently interacting knowledge workers and usage of other types of KMS in the prior week. We adopted this staged approach because of the missing observations for actual usage by frequently interacting co-workers and easier comparison of the results from different specifications.

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[28] An alternative to our model that treats the usage variables as continuous variables is the count model such as Poisson regression or negative binomial regression. However, we did not observe any dramatic difference in our results when we used the count models.

Table 4-1. Descriptive Statistics

Variable	N	Mean	Std Dev
Weekly Repository KMS Use	63,908	1 423	1 255
Weekly Business intelligence Use	64,064	1 742	1 831
Weekly Expert KMS Use	63,908	0 004	0 054
Weekly Navigation of Intranet	63,908	0 562	0 761
Weekly Navigation of Application	63,908	0 695	0 866
Tenure in Company	59,904	4 393	1 218
Tenure in Position	59,592	3 456	1 200
Repository Training	57,720	1 070	1 178
Business intelligence Training	57,720	0 458	0 780
Log of Distance from HQs	64,064	2 845	2 104
Perishable Department	64,064	0 241	0 428
Perceived KMS Quality	58,812	5 269	0 926
Perceived Norms	62,036	5 293	1 273
Information and Knowledge Intensity	61,100	5 726	0 899
Alternative Social Sources	61,776	5 589	1 024
Alternative Physical Sources	61,672	5 424	1 319
Computer Skills	59,280	5 773	1 076
Repository Use by Co-workers	40,872	2 154	0 928
Business intelligence Use by Co-workers	40,872	2 046	1 503

Table 4-2. Correlations Matrix

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
(1) Repository KMS Use																		
(2) Business intelligence Use	19																	
(3) Weekly Expert KMS Use	05	01																
(4) Navigation of Intranet	65	- 04	04															
(5) Navigation of Application	28	41	03	25														
(6) Tenure in Company	08	19	- 02	- 01	09													
(7) Tenure in Position	00	14	01	- 06	06	56												
(8) Repository Training	17	01	- 01	15	07	25	14											
(9) Business intelligence Training	05	35	00	- 06	09	03	- 02	11										
(10) Log of Distance from HQs	- 15	31	02	- 29	04	07	09	- 24	24									
(11) Environmental Turbulence	- 11	42	- 01	- 20	03	04	12	00	24	22								
(12) Perceived KMS Quality	04	22	02	- 04	06	06	05	05	12	16	22							
(13) Perceived Norms	00	27	01	- 11	09	08	04	- 03	15	30	24	59						
(14) Info and Knowledge Intensity	00	15	01	- 08	06	06	03	00	06	07	09	22	35					
(15) Alternative Social Sources	07	09	01	06	04	05	- 06	11	02	- 09	- 01	31	40	32				
(16) Alternative Physical Sources	- 02	13	00	- 04	07	02	02	00	07	18	10	35	40	30	30			
(17) Computer Skills	16	- 11	- 01	20	- 02	- 16	- 16	08	- 09	- 29	- 24	- 01	- 11	00	18	- 06		
(18) Repository Use by Co-workers	20	- 02	01	13	03	- 01	- 01	07	00	- 12	02	05	03	- 04	03	- 01	05	
(19) Business Intelligence Use by Co-workers	- 03	39	00	- 18	10	07	09	- 03	19	17	35	11	15	11	- 02	06	- 11	15

Table 4-3. Result: Repository KMS Use

Variable	Model (1)	Model (2)	Model (3)
Intercept	-0 1224 *** (0 02786)	-0 1211 *** (0 02782)	-0 1336 *** (0 03354)
Tenure in Company	0 06832 *** (0 01716)	0 06969 *** (0 01707)	0 07417 *** (0 02056)
Tenure in Position	-0 00676 (0 01681)	-0 00762 (0 01678)	-0 02561 (0 01966)
Repository Use at Week t-1	0 06184 *** (0 00394)	0 06179 *** (0 00394)	0 03963 *** (0 00478)
Repository Use at Week t-52	0 01532 *** (0 00425)	0 01532 *** (0 00425)	0 01035 ** (0 005033)
Weekly Navigation of Intranet	0 4943 *** (0 003955)	0 4943 *** (0 003955)	0 5000 *** (0 004656)
Weekly Navigation of Application	0 08024 *** (0 00398)	0 08019 *** (0 00398)	0 08012 *** (0 00474)
Repository Training	0 04738 *** (0 01228)	0 04771 *** (0 01228)	0 04315 *** (0 01391)
Business Intelligence Training	0 04073 *** (0 01109)	0 04066 *** (0 01109)	0 04485 *** (0 01326)
Log of Distance from HQs	0 04679 *** (0 01595)	0 04514 *** (0 01581)	0 03662 * (0 0187)
Environmental Turbulence	-0 1059 *** (0 03594)	-0 1079 *** (0 03585)	-0 1333 *** (0 04306)
Perceived KMS Quality	0 03349 * (0 01715)	0 03354 * (0 01716)	0 04863 ** (0 02014)
Perceived Norms	0 04133 ** (0 019)	0 0431 ** (0 01887)	0 03012 (0 02218)
Information and Knowledge Intensity	0 02756 * (0 01501)	0 02825 * (0 01499)	0 04996 *** (0 01826)
Alternative Social Sources	-0 01522 (0 0169)		-0 01078 (0 02008)
Alternative Physical Sources	-0 04119 *** (0 01523)		-0 04437 ** (0 01764)
Aggregate Alternative Sources		-0 0484 *** (0 01666)	
Computer Skills	0 04118 ** (0 01612)	0 04302 *** (0 01595)	0 06013 *** (0 02025)
Business intelligence Use at Week t-1			0 04766 *** (0 00781)
Repository Use by Co-workers at Week t			0 04289 *** (0 00728)
N	45396	45396	31616
-2 Log Likelihood	93185 4	93186	64672 2
AIC	93327 4	93326	64818 2
BIC	93666 2	93660 1	65140 1

Significant at 1 % ***, 5 % **, and 10 % * The numbers in parentheses are standard errors

In model (1), all the coefficients for our hypothesized variables are in the expected directions and are mostly significant. All contextual variables are significantly predicting one's use of the repository KMS. Log of geographical distance is positively associated with the increased use of repository KMS as we hypothesized (Hypothesis 4-a). Environmental turbulence measured by product perishability negatively influences one's use of the repository and supports our hypothesis implying that environmental turbulence decreases the applicability of codified knowledge to one's tasks (Hypothesis 5-a). This result is somewhat surprising because the business groups in perishable departments tend to submit more documents to the repository at the research site. Task information and knowledge intensity and computer skills are significant and positively associated with one's use of the repository KMS (Hypothesis 6-a & Hypothesis 7-a). Training on repository KMS (Hypothesis 8-a) have a strong positive impact on one's KMS usage. While not hypothesized, it is interesting that training on business intelligence has a positive impact on the use of the repository KMS. Furthermore, despite a slightly larger coefficient estimate for the effect of training on repository (β = 0.04738, p-value < 0.01) compared to that of training on business intelligence (β = 0.04073, p-value < 0.01), the difference is not very large. We have two possible explanations on this result: 1) in the longer term, a user can improve one's absorptive capacity by obtaining better knowledge about the related systems through training and better assimilate even other types of KMS, and 2) since the knowledge from business intelligence needs relatively higher cognitive processing capability and interpretations, a user engages in more knowledge searching in the repository KMS as complements. Since we do not find such a cross-effect in case of business intelligence (i.e., training on repository KMS did not increase the use of business intelligence), the second explanation may be more plausible in this case. That is, if the first explanation is to hold, there is no reason that training on repository KMS does not enhance one's absorptive capacity to adopt repository KMS. One's use of the repository KMS in the prior week is positively associated with one's future usage of the repository even after we take into account one's seasonal usage, the company-wide week effects, habitual usage persistence by autoregressive error terms, and the individual-level unobservables by random effects. That is, once a user is involved with more (less) knowledge seeking from a repository in a particular week, she is likely to engage in more (less) knowledge seeking activities in the following week. The effects of possessing more alternative social (Hypothesis 1-a) and physical (Hypothesis 2-a) sources of information and knowledge are negatively associated with the use of the repository KMS usage, but only the effect of physical sources is significant. That is, it is plausible to believe that KMS has to compete with traditional sources of information and knowledge to a certain degree.

Our next model (2) indicates that the aggregate alternative sources of information and knowledge are negatively and significantly associated with one's use of repository KMS with a slight improvement in the model according to the model selection criteria such as AIC and BIC. We thus interpret that while the much greater incentive to use the repository KMS comes from the lack of alternative physical sources than from the lack of alternative social sources, the general level of alternative sources may be also important in explaining the use of repository KMS. We believe that it is because the repository KMS to a certain extent is used as a substitute for social sources of knowledge. Although not the focus of our research, the value and social components - perceived KMS quality and subjective norms - are significant but at relatively lower significance levels (Hypothesis 10-a & 11-a). One possible explanation is that the two variables are not free from correlations with each others (correlation = 0.59). In fact, it is very hard to distinguish one from the other with a survey because the two perceptions are formulated together. For example, the prior literature often suggests that the perception of social norms leads the perception of the value of systems (e.g., Venkatesh and Davis 2000, Lewis et al. 2003). We should be careful in interpreting the coefficient estimates for the two variables since we adopted an econometric approach to better analyze the time series nature of usage instead of a behavioral structural equation model.

Model (3) indicates that actual usage by frequently interacting knowledge workers is positively associated with one's use of repository KMS (Hypothesis 3-a). It is notable that the coefficient estimates for this effect is much greater in case of the repository KMS compared to the business intelligence in table 4-4 ($\beta_{Repository}$ = 0.04289 and β_{BI} = 0.02004). Since a repository is focused more on sharing knowledge between employees, the larger network effect in repository KMS compared to business intelligence is understandable. Controlling for the lagged usage of repository KMS in the prior week and other controls, model (3) also estimates whether exceptionally heavy or light use of business intelligence changes the use of the repository KMS in the subsequent week (Hypothesis 9-c). The result indicates that one's heavier use of the business intelligence in the prior week leads to more use of the repository KMS in the following week (β = 0.04766). We believe that people engage more in knowledge sourcing behaviors across various types of KMS once they source more knowledge from one type of KMS.

Table 4-4. Result: Business intelligence Use

Variable	Model (1)	Model (2)
Intercept	0 02985 * (0 018)	0 02848 (0 02226)
Tenure in Company	0 04693 *** (0 009601)	0 04241 *** (0 01155)
Tenure in Position	0 002395 (0 009405)	0 005303 (0 01105)
Business intelligence Use at Week t-1	0 6161 *** (0 003673)	0 6036 *** (0 004534)
Business intelligence Use at Week t-52	0 06767 *** (0 003842)	0 07101 *** (0 004582)
Business intelligence Training	0 03103 *** (0 005828)	0 03534 *** (0 007069)
Repository Training	-0 0055 (0 00658)	-0 01088 (0 007568)
Log of Distance from HQs	0 07857 *** (0 008967)	0 08581 *** (0 01052)
Environmental Turbulence	0 1865 *** (0 02027)	0 1689 *** (0 02445)
Perceived KMS Quality	0 01768 * (0 009603)	0 02021 * (0 01132)
Perceived Norms	0 02199 ** (0 01063)	0 01761 (0 01246)
Information and Knowledge Intensity	0 02177 *** (0 008407)	0 03042 *** (0 01026)
Alternative Social Sources	-0 00035 (0 00943)	0 003497 (0 01128)
Alternative Physical Sources	0 003081 (0 008513)	0 002679 (0 009914)
Computer Skills	0 000052 (0 009018)	-0 00534 (0 01138)
Repository Use at Week t-1		0 02132 *** (0 002863)
Business intelligence Use by Co-workers		0 02004 *** (0 004663)
N	45552	31616
-2 Log Likelihood	55336 6	40395 7
AIC	55474 6	40537 7
BIC	55804 1	40850 9

Significant at 1 % ***, 5 % **, and 10 % * The numbers in parentheses are standard errors

Table 4-4 presents the results for the business intelligence usage We used a staged approach again because of the missing observations for actual usage by frequently interacting co-workers Overall, two differences from the results in the repository model are noticeable 1) three variables are not significant alternative social sources (Hypothesis 1-b), alternative physical sources (Hypothesis 2-b), and computer skills (Hypothesis 7-b), and 2) the coefficient sizes are smaller except for the geographical distance variable. Fewer hypotheses may be supported because business intelligence is more task-oriented systems compared to repository KMS as a more general knowledge source. We discuss the difference in the discussion section in more details. The effect of actual usage by frequently interacting co-workers is positive and significant (Hypothesis 3-b). The effects of geographical distance (Hypothesis 4-b) and Information and knowledge intensity (Hypothesis 6-b) are both positive and significant. As we hypothesized, greater environmental turbulence is associated with greater use of business intelligence, which is the opposite to its influence on the use of repository KMS (Hypothesis 5-b). This result has an important implication on the usefulness of the two codification-based KMS. Environmental turbulence in general increases one's incentives to rely more on the fast-updated information and knowledge, and it decreases the applicability of knowledge in the repository developed in other parts of the organization. The knowledge in repository KMS reflects an interpretation and codification by someone else whose environment is likely to be different from that of a user. As a long as a user has a sufficient level of cognitive capability to obtain important insights and create knowledge by using business intelligence, the knowledge without any human bias can be even more useful under turbulent environment. Training on business intelligence has a positive significant effect on the use of business intelligence (Hypothesis 8-b). However, training on repository KMS had a negative coefficient, which is not significant. As hypothesized, the exceptionally heavier (or lighter) use repository KMS in the prior week leads to more use of business intelligence in the subsequent week (Hypothesis 9-a). The coefficient size (β = 0.02132) is much smaller than the cross-effect of repository KMS on the use of business intelligence (β = 0.04766), which implies that the use of business intelligence tends to influence one's use of the repository KMS more than the use of repository KMS influences the use of business intelligence. This supports our earlier explanation about the cross-effects of training:

knowledge in business intelligence needs more knowledge from repository KMS as complements and the reversed case is less certain because of higher level of cognitive processing capability for busmess intelligence.

Table 4-5. Result: Expert Directory KMS Use

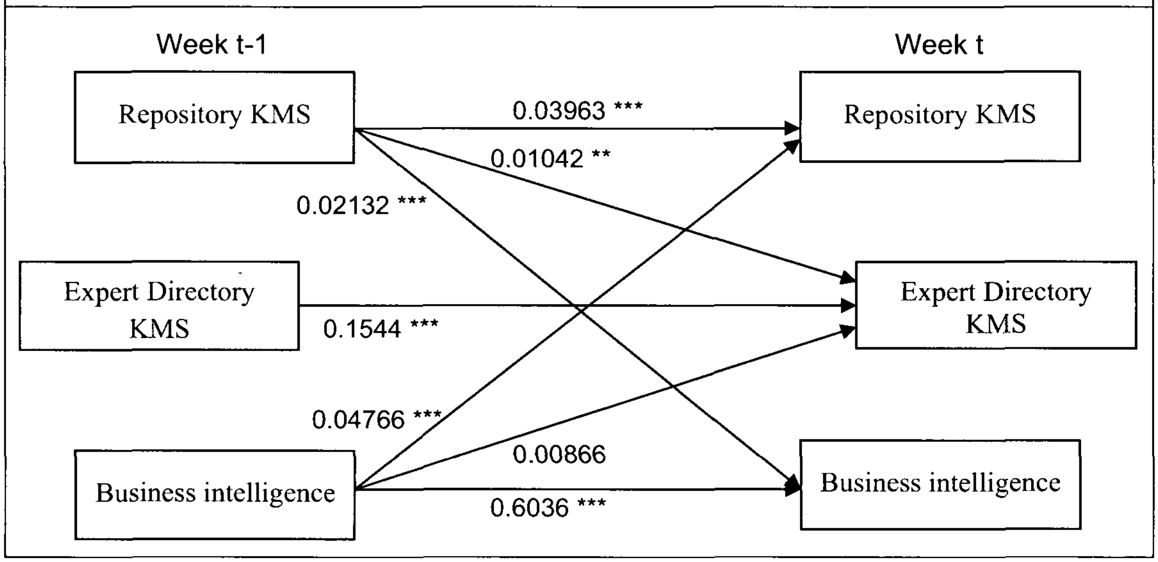
Variable	Model
Intercept	-0 02293 (0 03451)
Tenure in Company	-0 03324 *** (0 007865)
Tenure in Position	0 02557 *** (0 007653)
Expert KMS Use at t-1	0 1544 *** (0 004495)
Expert KMS Use at t-52	0 004304 (0 003854)
Repository Training	-0 00628 (0 006134)
Busmess intelligence Trainmg	0 003124 (0 005952)
Log of Distance from HQs	0 005839 (0.007292)
Environmental Turbulence	-0 02408 (0 01686)
Perceived KMS Quality	0 01211 * (0 007073)
Alternatıve Social Sources	0 00756 (0 007207)
Alternative Physical Sources	-0 00849 (0 006729)
Computer Skills	-0 01202 * (0 007234)
Business intelligence Use at Week t-1	0 00866 (0 006809)
Reposıtory Use at Week t-1	0 01042 ** (0 004999)
N	46800
-2 Log Likelihood	134076 1
AIC	134214 1
BIC	134545 5

Significant at 1 % ***, 5 % **, and 10 % *. The numbers ın parentheses are standard errors.

Table 4-5 shows our results for the use of expert directory KMS. The main reason for the fewer significant effects is that the expert directory KMS is a more contingency-based system and is likely to be used in case of the events that do not occur regularly. Perceived KMS Quality (Hypothesis 10-c) is positive and significant because the support level as a dimension of KMS quality is an important driver of the expert directory KMS usage. Interestingly, computer skills are negatively associated with the use of expert directory KMS and the effect is significant

(Hypothesis 7-c). This suggests that simply hypothesizing that the greater level of computer skills is positively increased with an intention to use any type of technology may be misleading (cf. Mahmood et al. 2001). The effect of computer skills on one's usage should be determined by the nature of systems and if the system can assist a user with limited computer skills, the direction of the effect can be reversed. The effect of environmental turbulence is in the expected direction but is not significant (Hypothesis 5-c). We also find that the greater use of repository KMS in the prior week is positively associated with the increased use of the expert directory KMS (Hypothesis 9-b). The cross-effect of using the business intelligence in the prior week is positive but not significant (Hypothesis 9-d).

Figure 4-2. Interdependency of System Usage



If we summarize the interdependent system usage, more searching behaviors in the repository KMS leads to more active knowledge seeking in both business intelligence and expert directory KMS in the subsequent period. The greater use of business intelligence leads to more use of repository KMS to complement knowledge but does not lead to more expert knowledge. This may suggest that the use of business intelligence becomes routinized rather than simulating demand for more sophisticated knowledge from experts. Figure 4-2 summarizes only the interdependent system usage part Table 4-6 summarizes our proposed hypotheses and the results from our time-series analysis

Table 4-6. Summary of Hypothesis Test

		Hypothesis Tested	Support
H1	a / b / c	Alternative social sources of information and knowledge are negatively associated with the use of repository / business intelligence / expert directory KMS	N / N / N
H2	a / b / c	Alternative physical sources of information and knowledge are negatively associated with the use of repository / business intelligence / expert directory KMS	**Y** / N / N
H3	a / b	The *actual use of repository/business intelligence by frequently interacting co- workers* is positively associated with the use of repository/ business intelligence	**Y / Y**
H4	a / b / c	*Geographic distance* is positively associated with the use of repository / business intelligence / expert directory KMS	**Y / Y** / N
H5	a / c	*Environmental turbulence* is negatively associated with the use of repository / expert directory KMS	**Y** / N
	b	*Environmental turbulence* is positively associated with the use of business intelligence	**Y**
H6	a / b	*Task information and knowledge intensity* is positively associated with the use of repository / business intelligence	**Y / Y**
H7	a / b	*Computer application skills* are positively associated with the use of repository / business intelligence	**Y / Y**
	c	*Computer application skills* are negatively associated with the use of expert directory KMS	**Y**
H8	a / b	*Training* is positively associated with the use of repository / business intelligence	**Y / Y**
H9	a / b	The use of repository KMS in the prior week positively influences the current use of business intelligence / expert directory KMS	**Y / Y**
	c / d	The use of business intelligence in the prior week positively influences the current use of repository / expert directory KMS	**Y** / N
H10	a / b / c	*Perceived quality of KMS* is positively associated with the use of repository / business intelligence / expert directory KMS	**Y / Y / Y**
H11	a / b	*Subjective Norms* are positively associated with the use of repository / business intelligence	**Y / Y**

4.6. Discussion

We did not find any result that is dramatically different from our original hypotheses (i.e., significant effect in the opposite sign). In this section, we intend to refine our ideas on what specific factors explain the post-adoptive of different types of KMS. In fact, there are many laments on the failed efforts to transfer knowledge with a codification approach (e.g., Gilmour 2003). Employees may not want to contribute and selectively release what they know (Gilmour 2003; Kankanhalli et al. 2005). Due to the search and transfer cost of both codified and personal knowledge, application of knowledge from external sources may even hurt performance when a user is already experienced or the environment is more competitive (Haas and Hansen 2005). A recipient's lack of the "absorptive capacity" (Cohen and Levinthal 1990) is likely to limit the knowledge transfer process (Szulanski 1996). A recipient may end up misunderstanding knowledge or applying it even when she is situated in different context due to limited cognitive processing capability (Alavi and Leidner 2001; Poston and Speier 2005). The value of knowledge in a repository may even depreciate and stops being useful (Dennis and Vessey 2005). Even knowledge transfer through the expert directory KMS has to experience a certain degree of codification process. That is, acquisition of knowledge from KMS is not costless. The whole idea of drivers of post-adoptive KMS usage is related to what individual knowledge worker will perceive greater value despite the cost and to what extent such characteristics matter for different types of KMS.

In general, individual characteristics such as task information and knowledge intensity, geographical distance, and fewer alternative sources of information and knowledge makes even the limited codified knowledge from KMS more valuable and the cost of search and application pays off. Since repository KMS and business intelligence "store" knowledge and make it readily available, the network effects and word-of-mouth effects may be present. Subjective norms are relatively more important for repository and business intelligence that entail greater search and application cost than expert directory KMS. In fact, the use of expert directory KMS require less sophistication and can be promoted when computer skills are not yet developed. Similarly, training lowers the cost of search and application, and thus is a better way of promoting the usage of the repository and business intelligence than the expert directory KMS. Environmental turbulence increases one's demand for knowledge but the applicability of knowledge created by other individuals whose environment is different is lower under turbulent environments. Thus, users under more turbulent environments are more likely than those under less turbulent environments to use business intelligence. Knowledge seeking from different types of KMS should be viewed as interrelated intellectual activities to better accomplish tasks within an organization. They complement each other and one's knowledge seeking from one type of KMS triggers more intensive and extensive search of knowledge from other types of KMS subsequently. Therefore, if different types of KMS can be managed well, it is desirable to make the various types of KMS available and let the users choose for their best outcomes.

The interdependency of system usage across different types of KMS and different users of KMS has important implications on how to promote usage within an organization. First, it may be desirable to deploy different types of KMS because they as a whole stimulate more knowledge seeking behaviors, and the assimilation of KMS can be accelerated. Second, a company may be able to identify who are the "central" actors (Freeman 1977) in a social network and focus on the usage by these employees to accelerate the assimilation of KMS first. The effectiveness of leveraging the central actors will be greater when the target technology exhibits stronger network externalities.

We found more supports for the hypotheses on the use of repository KMS. This tendency is related to the task-oriented nature of the business intelligence compared to repository KMS as a more general knowledge source. The customizability of business intelligence to individuals' needs is limited, and all the query views and specifications of reports should be provided by developers Since designing the reports and making it available to users need relatively more efforts and time than codifying one's knowledge into a document, the value of the reports even to other employees should be well justified in order to appeal to the developers For example, the company's data warehouse may provide a store manager with such information as how much she sold in total in comparison with other managers in other stores with similar sizes, but the group of stores with similar sizes may be already determined by the headquarters If the report is considered valuable for other employees as well, it is worth designing the report and spending resources For the reason, the business intelligence is likely to collect and incorporate the business requirements that can be routinely exploited Business intelligence by nature is more tightly coupled with common business practices and is embedded in the business processes than repository KMS is It makes individual characteristics like alternative sources of information and knowledge and computer skills less significant, while task-related characteristics such as task information and knowledge intensity, environmental turbulence, and geographical distance are still significant

In general, it is more difficult to explain the post-adoptive usage of expert directory KMS because it is often used after one's knowledge search from other sources rather than as a primary source of knowledge The following example illustrates this *'Hello, we have a customer requesting [Brand name] no fat shredded mozzarella /cheddar cheese Is it possible to get this? I searched retail pricing and couldn't find it "* Since employees listed as an expert may receive too many inquires and may become overwhelmed (Ackerman 1998, Hansen et al 1999), users of the expert directory KMS tend to avoid asking questions too frequently Such cases where the experts' help is needed may not take place often for a person who has worked in the same position and company for a while As the last source of information and knowledge, the expert directory KMS does help employees without social capital When one of the authors was staying in the company, many cases were observed that a user initially submits an inquiry and more rich communications are triggered for detailed discussions. Despite its value, the occurrence of the cases in need of expert's resources was not sufficiently frequent to support our hypothesis.

Our research is not without limitations. As a field study, its generalizability to other contexts may be limited. The employees in the research site may have two major differences from other industries that should be considered when the results are to be applied to other settings. First, the employees in the retail industry suffer geographical dispersion to a greater extent compared to those in other industries. Second, the tenure of employees at management level is longer and many employees are relying more on the traditional social network. Many store employees are locally employed and the senior people were not familiar with computers in the early day of KMS deployment. Since the stores still have old computers, the importance of end-user systems quality is greater in the company and we had to include it as one of important dimensions of KMS quality perceived by employees. Third, we still had to measure individual characteristics using a survey method. Especially, we believe that it was major reason why alternative social sources of information and knowledge were not significant across models. We found that employees in the independently owned stores are using the expert directory KMS more than other parts of the organization do. The employees in the independent stores are given relatively fewer chances to get to know other employees beyond their own stores, so the expert directory KMS is likely to be more helpful. In fact, the independent store personnel pertained to the business group with the lowest level of alternative social sources of information and knowledge. We would need a more objective measure of alternatives sources of information and knowledge in our future research. One way of achieving it is through the observation of email and telephone communications on which we could not collect data. Obtaining and processing such data will be very challenging, but will provide a good opportunity to study the use of KMS and one's reliance on existing knowledge network.

4.7. Conclusion

Because of the widespread underutilization of the majority of installed IT applications, "organizations need aggressive tactics to encourage users to expand their use of installed IT-enabled work systems" (Jasperson et al 2005) The adoption of technology has a long tradition of research in the IS literature drawing on diverse theories to explain the adoption and usage behaviors It reflects its importance as one of the core research questions in the IS field The usage in the voluntary settings is considered a proxy for systems success and the actual usage was found to be critical for any technology to make any organization-wide impact Nevertheless, the existing literature provides limited understanding of the post-adoptive differential usage of multiple KMS Despite the growing popularity of KMS, the KMS specific factors and the interdependency of system usage have been little studied yet

We contribute to the literature by modeling user's knowledge sourcing behaviors at the weekly level and consider time-series dynamics across users and different types of KMS The characteristics of specific technology needs to be incorporated to the IS research if the technology requires organization-wide efforts and resources to facilitate its assimilation to the organization More commercial software these days automatically logs usage patterns by individual users and there are great opportunities for further studies We hope that our research triggers more research to take the advantages of the opportunities

Appendix 4-A. Survey Items and Reliability

PERCEIVED KMS QUALITY

1 Ease of Use (Alpha = 0 928) [29]

- Overall, KnowLink [30] is user friendly
- Overall, KnowLink is easy to use
- It is easy to customize KnowLink in order to meet my needs
- It is easy to browse and navigate by mouse clicks in KnowLink
- It is easy to search for information using a "Search" tool in KnowLink
- It is easy to submit any knowledge (e g an electronic document that you created) through KnowLink in order to share it with other employees

2 Information Quality (Alpha = 0 933) [31]

- KnowLink provides the knowledge and information I need
- The knowledge and information in KnowLink is up-to-date
- I am satisfied with the accuracy of information and knowledge obtained from KnowLink
- KnowLink provides me with information and knowledge in a timely manner
- KnowLink provides me with the right information and knowledge to help me to do my tasks

3 KM Support from Business Area Experts (Alpha = 0 948) [32]

- Stewards (i e my business area experts in KnowLink) give prompt responses to users
- Stewards (i e my business area experts in KnowLink) are always willing to help users
- Stewards (i e my business area experts in KnowLink) have expertise and knowledge to assist users

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[29] The first two measures were Adapted from Rai et al (2002)

[30] KnowLink (a pseudonym) is the name of KMS

[31] Item 3 and 5 were adapted from Rai et al (2002) We selected the five most relevant categories from Bailey and Pearson (1983) currency, completeness, relevancy, timeliness, and accuracy

[32] Selected and adapted from SERVQUAL measures

4. KM Support from KM Group (Alpha = 0.960)

- The KnowLink support team gives prompt responses to users
- The KnowLink support team is always willing to help users
- The KnowLink support team has expertise and knowledge to assist users

5. End User Systems Quality (Alpha = 0.708) [33]

- My computer systems are fast enough to support my work
- I can use my computer to access KnowLink any time I wish
- My computer system needs to be upgraded (R)
- I can download any document from KnowLink quickly

SUBJECTIVE NORMS [34]

1. Top Management Support (Alpha = 0.923)

- Overall, Ace Grocery [35] management encourages the use of KnowLink
- Ace Grocery management has been concerned regarding user satisfaction with KnowLink
- Ace Grocery management tells employees the strategic importance of knowledge management
- Ace Grocery management is interested in identifying what information and knowledge needs employees have for work

2. Norms - Colleague (Alpha = N/A)

- My colleagues think that I should use KnowLink for my work
- The opinions of my colleagues are important to me

3. Norms - Supervisor (Alpha = N/A)

- My supervisor thinks that I should use KnowLink for my work
- The opinions of my supervisor are important to me

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[33] All items were newly developed.

[34] Developed based on Bock et al. (2005), Lewis et al. (2003), and Wixom and Watson (2001)

[35] Ace Grocery (a pseudonym) is the company that allowed us to collect data for this research.

TASK INFORMATION AND KNOWLEDGE INTENSITY [36]

1. Information & Knowledge Intensity - Volume (Alpha = 0.882)

- I need to keep up with a lot of information to do my work
- It is important for me to bring together information from many sources in my job
- I have to compare many alternatives to make work-related decisions
- My job requires me to stay on top of a variety of information

2. Information & Knowledge Intensity - Volume (Alpha = 0.754)

- The information I need to do my work changes a lot week to week
- I have to pay attention to changes in information related to my work
- If I can respond quickly to changes in information, I can do my job better
- I have to make new decisions each week, because the environment changes quickly

ALTERNATIVE SOCIAL SOURCES OF INFORMATION & KNOWLEDGE (Alpha = 0.768) [37]

- My supervisor often provides useful information and advice that I need to do my work
- My colleagues are accessible for information and advice that I need to do my work
- I know many employees outside my own department from whom I can get information and advice for doing my work
- The people whom I work with provide me with useful information and advice

ALTERNATIVE PHYSICAL SOURCES OF INFORMATION & KNOWLEDGE (Alpha = 0.865) [38]

- I get a lot of the information that I need to do my work in printed reports and documents

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[36] Developed based on Schroder et al. (1967) and Campbell (1988).

[37] All items were newly developed.

[38] All items were newly developed.

- The printed reports and documents I get are useful for my work

COMPUTER SKILLS (Alpha = 0.842) [39]

- How comfortable do you feel using each of the following? - Email
- How comfortable do you feel using each of the following? - Excel
- How comfortable do you feel using each of the following? - Word
- How comfortable do you feel using each of the following? - Internet
- How comfortable do you feel using each of the following? - Google/Yahoo

N.B.

- All items were measured using the 7-point Likert scale between "Strongly Disagree" and "Strongly Agree." The Cronbach's alpha values are not applicable for norms because they were multiplied to produce the final score as in Lewis et al. (2003).
- To obtain the list of frequently interacting co- knowledge workers, we asked each respondent to identify up to six employees in corporate headquarters (excluding temporary employees and contractors) outside one's own department/store with whom she frequently interacts in order to accomplish her job.

[39] All items were newly developed.

Chapter 5

Discussion and Conclusion

5.1. Summary

Knowledge will remain as a foundation of a firm's competitive advantage in years to come. Overall, my dissertation intend to enhance the understanding of how different types of KMS enables a firm to effectively manage knowledge assets to improve job performance of knowledge workers over time and how to improve KMS use within an organization. The returns on knowledge from different types of KMS are affected by various group and individual characteristics (e.g., social networks and physical documents available, geographical distance from headquarters, usage patterns, usage by other employees in the same business group as internal competitors), external environments (business dynamics), and technology characteristics (e.g., access to other types of KMS). My results will inform managers how to promote usage depending on the characteristics of individuals and their tasks.

Study 1 examined the contingent impact of KMS usage as a production factor on the group level performance measured by department-level weekly sales in a retail grocery chain. First, I find the direct positive impact of repository, business intelligence, and expert directory KMS usage on weekly sales of a store department. For example, I find that one percent increase in the repository use is associated with 0.018 percent increase in weekly sales of a store department, which is substantial. Second, I find that the positive impact of KMS use on sales as the group performance measure is greater when a group is endowed with fewer alternative sources of information and knowledge (in terms of social capital and physical documents), or the external business environments are less dynamic, or knowledge workers are more geographically dispersed. Third, I find that the use of knowledge from repository KMS and business intelligence produce substitutive outcomes on the output level. Fourth, I find that as the level of business dynamics increases, it is more beneficial for knowledge work groups to increase the proportion of shorter life-span knowledge and fine-grained knowledge in knowledge consumption. Overall, Study 1 contributes to general understanding of the differential value of knowledge contingent on the mix of the type of knowledge, group conditions, and external business environments.

Study 2 examines how and why KMS in business environments influence individual knowledge workers. I find that knowledge worker can not only perform better than their colleagues by more use of KMS but also improve (deteriorate) her performance by increasing (decreasing) the amount of knowledge sourcing from KMS. Interestingly, I further find that the performance impact of KMS usage is greater when KMS is used in a more exploratory manner. The performance impact of KMS usage is also greater when an employee is endowed with little social capital from which to obtain knowledge as an alternative source. I also find that the overall usage of KMS by the employees in the same business group as one's internal competitors decreases the relative individual performance and slows the rate of one's improvement in relative performance by using KMS. These findings suggest that for those without good alternative sources of knowledge, KMS will help overcome "knowledge divide" within a company due to limited access to information and knowledge. However, those who already with superior alternative knowledge sources to those of internal competitors may be most resistant to the adoption of KMS because of weakened competitive positions.

Study 3 examines what contextual factors specific to different types of KMS influence the usage at the weekly level. For example, I identify such factors as actual usage by frequently interacting co-workers, alternative sources of information and knowledge, environmental turbulence, and task information and knowledge intensity, and study how they drive the usage of each type of KMS to a different degree. I also consider the interdependent nature of different types of KMS and examine how more use of one type of KMS may lead to more use of other types of KMS in the subsequent period. This research sheds light on how to deploy different types of KMS that are appropriate for an organization and better promote the usage by knowledge workers to maximize the organizational returns on investments in knowledge management with technology.

5.2. Managerial Implications

My dissertation has several managerial implications for the successful implementation and assimilation of KMS within an organization. First, if well-managed, KMS will promise positive returns on investments. Despite many laments and skepticism on the codification approach for knowledge management, it is not be true that a codification approach does not work simply because the richness and codifiability of knowledge is limited.

Second, despite the positive returns, the size of returns can be much affected by the characteristics of firms and organizational efforts. Especially when a firm has a large degree of geographical dispersion or its employees are not endowed with a similar quantity and quality of alternative sources of information and knowledge, the benefits are likely to be more easily realized. The important task for managers is to identify and deploy its KMS to target those with greater potential benefits.

Third, although a firm may consider monitoring the adoption level of KMS by its employees, not just an amount of usage but how KMS are actually used is a very important determinant of performance. The value of KMS can be increased when KMS is used in a more exploratory manner. Moreover, what type of knowledge is actually used matters a lot as well. When a firm perceives that its employees have to deal with the high level of business dynamics, it becomes more important to encourage them to turn more attention to short life span knowledge and fine-grained knowledge.

Fourth, it is compulsory for firms to consider various knowledge sources of employees at the same time. They may be substitutive to each other. The use of different types of KMS may be also influenced by a different set of factors Although the marginal value of using one type of KMS decreases in more use of other types of KMS, different types of KMS are complementary in the sense that employees' uses of multiple types of systems are interrelated over time.

Fifth, although KMS may enhance the organizational performance, it is likely to conflict with employees' objectives. Employees' resistance to contributing their knowledge has been often discussed, but such resistance is not simply rooted in a myth or misunderstanding if their relative performance can be harmed Asking the employees without much incentive to use KMS to share their knowledge will not lead to success without the right rewards

5.3. Discussion, Contribution and Conclusion

As all other research, my dissertation is not without limitations One of the most important limitations is the generalizability because the data used in the three chapters came from a single company. Some factors might have been over- or underestimated because of the specific characteristics of the research site as a grocery chain in Pennsylvania area. It should be also noted that I used product perishability as one dimension of the environmental business dynamics in Chapter 2 and as a proxy for environmental turbulence in Chapter 4 [40] There are three reasons for using only a subset of the three dimensions as a proxy in Chapter 4 First, the level of competition, one of the other dimensions of environmental business dynamics in Chapter 2, is relevant only in stores since many of the respondents in Chapter 4 are the employees in the headquarters. Second, the meaning of task information and knowledge intensity, another dimension of environmental business dynamics, is also rather different for the employees in the headquarters. Task information and knowledge intensity increases the overall demand for any information and

[40] They are conceptually the same, but we labeled them differently to avoid any confusion by using different dimensions to measure two identically labeled variables

knowledge although the obtained knowledge may be less useful Therefore, the higher task information and knowledge intensity, the more knowledge employees seek from every possible source of knowledge In store environments where managers are more pressured for time and handle many unexpected situations, an increase in demand for information and knowledge causes increased unpredictability of businesses In chapter 2, every work group in the samples plays basically the similar roles To the contrary, some employees in the headquarters may have to deal with much information that changes over time, but the pattern may be stable and predictable For example, an administrative employee may need much information and knowledge that change over time, but such volume and changes are relatively more manageable than those faced by stores Third, the use of business intelligence is much influenced by the nature of their tasks Although one in the headquarters may have to cope with higher information and knowledge intensity, she does not have to use business intelligence if her job has nothing to do with financial or operation data in the research site The heterogeneity of employees becomes greater when I consider the headquarter employees as in Chapter 4 Thus, the choice of specific measures for environmental dynamics or turbulence must consider different contexts as discussed in Chapter 2

My dissertation makes important contributions to the literature by providing a systematic approach to measure the contingent value of KMS and increase the use of different forms of KMS with more precise measurements of both the use and performance I not only studied whether the implementation of KMS helps an organization better manage organizational assets or not, but also further examined why a specific KMS is more effective for certain knowledge workers and how to target them to promote the use of KMS by their task and individual characteristics I modeled user's knowledge sourcing behaviors at the weekly and yearly level and consider time-series dynamics across users I contribute to the literature by considering multiple sources of knowledge and systems within an organization I showed that the performance impact and its usage are interrelated with the use of other systems More commercial software these days automatically logs usage patterns by individual users and there are great opportunities for further studies with the objectively measured data. I hope that my research triggers more research to take the advantages of the opportunities.

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