The Effect of Organizational/ Technological Factors and the Nature of Knowledge on Knowledge Sharing

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Abstract

This study investigates the dynamics of a knowledge sharing effort in New York State government that involved multiple organizations, divisions, and geographically separated offices in the development of the Multi-Purpose Access for Customer Relations & Operational Support System. Using a case study approach, we address the question of how multiple organizational and technological factors—distributed leadership, alignment of issues and incentives, coordination of a number and variety of groups, trust, technology, and implementation strategy—interact with the nature of knowledge to influence the knowledge sharing process. A major contribution of this study is that it uses a multi-dimensional view of knowledge, examining the interactive impact of the nature of knowledge with multiple organizational and technological factors in public sector knowledge management research.

1. Introduction

In recent years, the importance of knowledge sharing across boundaries or levels of organizations has been increasingly recognized in public sector organizations. Especially in multi-level or federal systems such as the U.S. government, sharing knowledge and information across divisions within large government agencies, across different agencies and levels of government, as well as among public, non-profit, and private organizations, has become vital for government operations and the development of integrated electronic government applications [1-3]. An increased understanding of the need to integrate information across organizations in support of enhanced government service provision, program planning and decision making, along with the potential of information technology to enable information integration and thus further transform the organization, has also driven research efforts on issues of information and knowledge sharing in information innovation initiatives in the public sector. [4-11]

Despite the benefits, knowledge sharing efforts do not always achieve desired results. Many existing structures and practices in organizations, as well as the political and technical environment, impose serious barriers for organizations wishing to initiate and sustain such efforts [12-14]. These difficulties are further intensified by the elusive nature of knowledge. Studies in the fields of knowledge management and organizational learning have found that knowledge is dynamic, socially constructed, and embedded in practice and context; and that knowledge sharing is influenced by the level at which knowledge is codified [15, 16]. These characteristics make the exchange of knowledge across boundaries more complex and difficult. As a result, the success of knowledge sharing processes depends on management innovations that recognize the interaction of a variety of factors that facilitate or impede the sharing activities [17].

While there has been increasing attention in recent years to the nature of knowledge and knowledge sharing in the knowledge management and organizational learning literature, there has been very little empirical research to date that takes into consideration the interaction between the multi-dimensional nature of knowledge and the multi-faceted structures and processes of organizations [18]. Using a case study approach, this study addresses the question of how multiple organizational and technological factors interact with the nature of knowledge to influence the knowledge sharing process. Before presenting the framework for this study, we provide some background information on the MACROS system.

1.1. The Development of the MACROS System

The Division of Municipal Affairs (MA) of the Office of the State Comptroller (OSC) supervises the fiscal affairs of 3200 local governments in New York State [19]. Its employees are located in eight regional offices distributed across the State, as well as in the central office. For many years, MA saw as its primary responsibility the monitoring and controlling of financial operations of local governments, which often led to adversarial relationships between MA and local government agencies. In 1993, the office began an effort to redefine its role from a regulating to a coaching position [20]. As part of this effort, the agency developed the Municipal Government Partnership, which offers a range of resources, training and information, to increase the professional development opportunities for municipal officials [21]. Managing information about the

local governments is complicated because of the diversity of sources and users, the variety of channels of collection and distribution, and the geographical separation of the field offices from the central office.

Within this context, and with the help from the Center for Technology in Government (CTG)[1], MA decided in 1998 to develop a knowledge repository with information about municipalities and local officials, past services provided, and preferred channels of communication, resulting in the initial conceptualization of the Multi-Purpose Access for Customer Relations & Operational Support (MACROS) system. Motivated by the need to streamline the collection, organization and distribution of financial and other information from and about local governments, the purpose of MACROS extended further to enhance communication and services provided to local governments by helping OSC employees to know their customers better. As the first enterprise-wide information system successfully developed, MACROS provides an interesting case for examining organizational, technological, and knowledge-related influences on knowledge sharing.

In the case of MACROS, the system was built to enhance the sharing of knowledge about interactions with MA's customers and expanded later to include customers of OSC more generally. Thus, knowledge about the interactions with customers—local governments—is the core knowledge under examination. This knowledge includes the organizational rules, procedures, relationships, and norms necessary to understand how the agency interacts with the local governments. This knowledge is more than mere information, such as the contact information contained in a database. It focuses on both explicit and tacit understanding about the commonality and particularity of the customers, and the procedural knowing of how to handle a particular situation and requests.

2.Research Framework and Literature Review

Our research questions for this research are: How do critical organizational and technological factors facilitate or impede the effectiveness of knowledge sharing; and how do these factors interact with the nature of knowledge to influence the process and outcomes of knowledge sharing? In this section, we present the research framework and provide a brief review of the extant literature that has previously examined these issues.

To a large degree, the problems and issues of knowledge sharing mirror the general issues of collaborative systems in the public sector. To provide guidance to data collection and analysis, this research adopts an existing framework that integrates four factors—trust, leadership, issues and incentives, and number and variety of groups—that have been repeatedly emphasized as significant forces facilitating or impeding the effectiveness of intra- and interorganizational collaboration [14, 18], and have also been increasingly addressed in more recent knowledge-related studies (e.g., [16, 23, 24]). Over the course of the study, two additional factors—implementation strategy and information technology—emerged from the data analysis as important factors influencing the success of the knowledge sharing practices. These are shown in Figure 1. Figure 1 also shows characteristics of knowledge interacting with the organizational and technological factors to influence knowledge sharing.

While sharing knowledge among individuals through face-to-face media has traditionally been an important focus in the literature on knowledge sharing, more recent literature has examined the establishment of sharing routines embedded in group and organizational structure and processes as more important to the success of organizational knowledge sharing and organizational learning [16, 25-27]. Following the prescriptive literature on knowledge sharing, we thus focus on the capability of information systems to institutionalize knowledge sharing as an organizational practice.

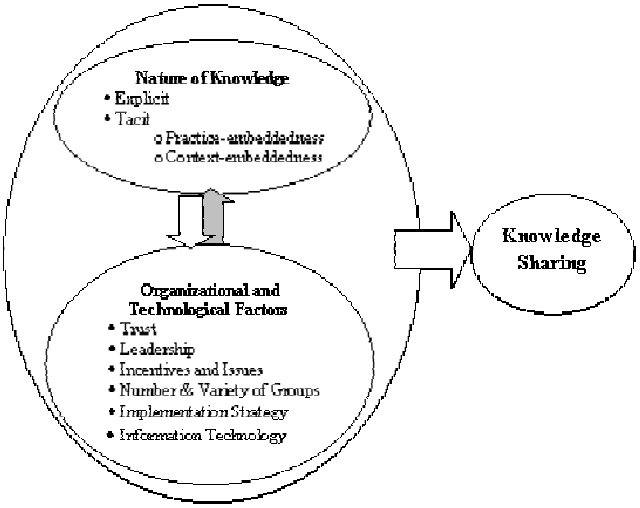

Figure 1: Research Framework

2.1. Organizational and Technological Factors

Trust has been addressed extensively in the research on intra- and inter-organizational collaborations, as well as in research focusing on the effectiveness of information and knowledge sharing [29-32]. For example, Dyer and Singh [32] maintained that goodwill trust is the most effective and least costly means of facilitating complex exchanges, arguing that when the task is to share tacit knowledge embedded in practices, market contracts and authority become inferior means of coordination. Here we adopt the definition of trust developed by Rousseau et al.

[1] CTG is an applied research center devoted to improving government and public services through policy, management, and technology innovation. It is located at the University at Albany, SUNY. [20]

([33], p. 395), "trust is a psychological state comprising the intention to accept vulnerability based upon positive expectations of the intention or behavior of another."

Leadership also plays a key role in collaborative efforts, such as knowledge sharing [16, 34]. Effective leaders are able to promote knowledge sharing through their ability to shape the organizational structures and processes, mobilize the resources, legitimate the changes, and cultivate norms and values in favor of sharing. In examining knowledge sharing across organizational boundaries, it is important to consider the likelihood that leadership will be associated with multiple individuals, as well as with particular organizations and/or units [35]. It is possible for one or more organizations to emerge as leaders, by convening the collaboration, being designated by a policy maker or funder, or providing the institutional home for the interorganizational operations. In this research, we follow Huxham and Vangen [35], who refer to leadership as "making things happen" in collaborations (p. 1160).

Issues and Incentives refer to the motivations and concerns that individuals and organizations have about knowledge sharing in a particular context. According to organizational economists, the incentive problem is fundamental for the success of knowledge sharing—"[t]o the extent that agents' human capital investments consist in the gathering and building up of specialized knowledge and skills, they are not likely to be willing to share the relevant knowledge and skills with other agents, unless they are properly compensated" ([36], p. 83). While, in most collaborative actions it is assumed that, collectively, each participating party can achieve greater benefits than it can achieve by acting alone or competitively, the likelihood of building consensus is often restricted by the ways in which incentives and issues intersect with the self-interests of those involved [18]. To fulfill their own purpose, avoid risks, or to protect themselves, some parties may even be motivated to withhold knowledge [16].

The Number and Variety of Groups greatly influences the effectiveness of knowledge sharing. Difficulties associated with large size and diverse groups of participants can make collaboration less feasible [14, 37]. The effectiveness of sharing knowledge will thus be especially hampered by the size and diversity of the collaboration. While some forms of knowledge, such as those codified in a commonly understandable format, can be transferred among a large number of groups; other forms of knowledge, such as those highly embedded in social and technical practices within specific groups, cannot be easily "moved" and transferred to other groups. As a result, knowledge sharing "require[s] intense interaction and [is] likely to be successfully transferred only in a small group setting at the specific location where the knowledge is used" ([38], p. 348).

Implementation Strategy is an important consideration in modern information system development (ISD). To contain the risks and failures of highly distributed systems linking users and information across functional and organizational boundaries, various project management approaches including formal planning and system analysis and design methodology have been developed to increase to the success rate of ISD [39]. Traditional ISD approaches see ISD as a technology-driven process [40], focusing on the technological complexity and the essential technical skills and expertise of the project leaders and the team, as well as development tools to ensure the rigor and quality of the development. The traditional ISD approaches, however, may be more likely to fail in the future [41, 42]. Some newer ISD approaches that have been created to deal with these more complex social and organizational situations [43-49] treat ISD as a socio-technical process embedded in an emergent process of change in professional practice. The changes are characterized as an iterative process of sense making and negotiations among stakeholders, thus emphasizing the importance of stakeholder participation.

Information Technology plays an important role in supporting knowledge management processes [50]. Prior research has shown that the structure built into the technology can present certain constraints for enactment and the mode of usage when it interacts with the structure of the organization and the environment [51, 52]. The structural properties of technology examined in the literature include restrictiveness, sophistication, and comprehensiveness of its features as well as the technology's "spirit"—the original intent that social actors constructed in it [51, 53, 54]. When there are misalignments between the structure of the technology and the structure of its environment, efforts to adjust the technology or to change the business rules and structure of governance have to be taken [55]. The greater the misalignment, the less likely the IT initiative would be to succeed [56]. In addition, perceived ease of use and usefulness have been examined extensively in the information system literature as key to individual acceptance and adoption of new technologies. [57-61]

2.2. Nature of knowledge

In this section, we explain why the nature of knowledge is a profound factor to be considered in understanding the effectiveness of knowledge sharing based on literature on knowledge management and organizational learning.

Gherardi and Nicolini [63] note that a growing body of literature has established that organizational knowledge can be viewed as distributed social expertise, "knowledge-in-practice situated in the historical, socio-material, and cultural context in which it occurs" (p. 330). This definition of organizational knowledge has important bearing on activities and processes related to knowledge sharing. According to Polanyi [62], the capability to know is learned through a process of experience. Further, Polanyi

asserts that tacitness and explicitness are two dimensions of knowledge, implying tacit knowing is an essential element of any kind of knowledge and is acquired through personal experience ("indwelling"). Similarly, it has been found that organizational knowledge is acquired by a process of participation in communities of practice [64, 65]. Knowing, in this context, is thus not only reflected in cognition, but also embedded in actions; we can not know unless we act on the situations to which we give meaning.

Following the lead of Polanyi, the literature on nature of knowledge has focused on differentiating various types and dimensions of knowledge [66]. The most commonly used classification is along the line of explicitness and tacitness [67]. While explicit knowledge is the set of rules, procedures, and relationships expressed by languages and other artifacts, tacit knowledge refers to the subjective understanding and intuition that is not directly expressed and encompasses the not-easily expressed as well as the not-expressible. The effort to classify knowledge is often motivated by the desire to align strategies and technologies with the sharing of different types of knowledge and/or the transformation of knowledge across different types [66, 68]. A more important contribution of research along this line is the understanding of the limitation of information technology in sharing tacit knowledge, or the lack of effectiveness of knowledge transfer from one organizational unit to another when information technology is constructed without serious consideration of the embedded nature of knowledge. While it is possible to codify knowledge into "thingness" such as language, symbols, formal procedures and explicit techniques, and thus extend its explicitness, some knowledge, such as reading a document or even watching a video clip of surfing, eludes sharing efforts as its tacitness can still be largely intact.

Arguably, the tacitness of knowledge in organizational context can be seen as a function of its practice-embeddedness and context-embeddedness. ***Practice-embeddedness*** refers to the degree to which knowledge is situated in or generated by ongoing practice and learning by doing. It has been found that decision-making processes always involve an element of preconscious recognition and comprehension of patterns and possibilities which can only be recalled during practice [69, 70]. ***Context-embeddedness*** refers to the degree to which knowledge is situated in the historical, social, and cultural context of a community of practice. It has been recognized that knowledge is neither pre-existing nor is it created from scratch; it is constructed through a process of negotiation of meaning and situated in the context where the meanings are created [64, 65, 71]. The richness and depth of the knowledge cannot be acquired without consideration of the historical, social and cultural background of the communities of practice.

While these two dimensions are interrelated, the epistemic differences created by practices are not exactly the same as those created by community context [15]. The former is a "technical" dimension, which includes hard-to-express or non-expressible personal skills or crafts derived from bodily experience. The later is a "cognitive" dimension, which encompasses beliefs, perceptions, and mental models that are acquired from one's social-cultural background [72].

The overall transferability of knowledge, thus, can be seen as related to level of explicitness, practice-embededdness and context-embeddedness. It can be assumed that it is inherently more difficult to share knowledge that is not explicitly represented, and deeply embedded in actions and associated with diverse communities of practice. As such, the characteristics of knowledge may interact with the organizational and technological factors and affect the processes of knowledge sharing.

3. Research Methods

As noted above, this study uses a case study approach, which seeks an in-depth understanding of a dynamic, complex, and multi-faceted phenomenon—the process and effectiveness of knowledge sharing—in a natural setting [73-76]. The case examined in this research is the building of the MACROS System. Data regarding the context, background, and on-going operations of this case were collected from several sources. Semi-structured interviews and non-participant observation provided the primary data source; archival data and documents from several organizations served as the supplementary sources.

Semi-structured interviews were held with 19 participants across different units, offices, divisions and organizations. Participants in this study are those individuals who were highly involved in major activities in the initiation and development of MACROS and the related knowledge sharing activities. The interviewees were identified through a combination of purposive and snowball sampling. The initial interviewees were selected based on an interview with a key informant in CTG, and further interviewees were identified because they were either referred by other participants during an interview or an event or were recommended by the project leader of MACROS. The sample included a good representation of both central and regional offices, as well as several other highly relevant units and organizations. Each of the interviews lasted for one and half hours to two hours. All of the interviews were taped recorded and transcribed with participants' consent. The semi-structured interviews were guided by a set of interview questions (contact authors for interview protocol).

Observational data were collected at several kinds of events, including training and rolling out sessions in three regional offices, Reflection Workshops administered by CTG, several Expansion Committee meetings, and one

workshop conducted jointly by OSC, CTG, the New York State Forum for Information Resource Management and ComputerWorks. Observational data revealed rich information about the processes of knowledge sharing. The events made it possible to observe directly what people said about knowledge sharing, and how they talked about knowledge transference from individual to group, from group to group(s), and from one organization to other organization(s); as well as to observe instances of various knowledge artifacts such as stories, documents, ideas, and working definitions being transferred or transformed.

During or after an interview or an event, relevant documents and archival data were solicited, with which we were able to track information about the history and background of this project, the legal and policy environment, the objectives, and other issues related to the project.

The interview transcription and observation notes were converted into electronic versions and saved as a Hermeneutics Unit using Atlas.ti software. It should be noted that the text was coded according to the interpretation of the researchers, rather than through matching the code with the exact words spoken by the participants. The data analysis was an iterative process in the sense that data were coded and the emerging themes were explored immediately after several initial data collection activities. This allowed the weaknesses of the available data to be identified so that any insufficiency could be addressed in subsequent data collection activities. In addition, the coding scheme itself was also scrutinized in light of case results.

4. Results

This section presents the results of the data analysis. It first focuses on the organizational and technological factors that influenced knowledge sharing in this case. This is followed by a discussion of how knowledge characteristics interacted with these organizational and technological factors to influence the knowledge sharing process.

4. 1. The Influences of Organizational and Technological Factors

Analyzing the data collected through interviews, observations, and documents, we found those factors that are specified in the original theoretical framework—leadership, issues and incentive, number and variety of groups, trust, and their interactions—to be critical to the success of MACROS. As noted above, two additional factors emerged from the data analysis—technology and implementation strategy—as critical factors.

Trust. As has been found in most previous studies of collaborative efforts, trust was an essential element to alleviate the conflicts and ease the way for risk taking and organizational changes. In the case of MACROS, the development of trust within OSC was fostered by the institutional structure and norms and shared identities, as well as by high trustworthiness and low risks associated with MACROS.

The Comptroller of OSC had demonstrated a strong preference for collaboration and partnership since his inauguration, and he had considerable influence on the agency's collaborative disposition by shaping its culture and structure. He listed "partnership" as a leading principle for the agency, and further institutionalized this value by selecting executives who shared his vision. As a result, it became apparent to the staff in the agency that collaborations would be strongly encouraged, and that they would achieve more by collaborating. The development of MACROS thus was facilitated within this environment, because, as one participant noted, on the one hand, "the impact of MACROS is an example to bring in those principles and values into play"; and, on the other hand, "[t]hat (trust) is infrastructure foundation (emphasis added) for a project like MACROS. You need (trust) regardless of technology."

Trust that results from a shared identity was also an important facilitator in this project. The fact that many leaders at the top shared the value of collaboration, and that there were long-term personal ties and relationships among them, enhanced the communication and minimized the opportunistic behaviors.

A third source of trust, which can not be downplayed, was the trustworthiness of the facilitator—CTG. Funded independently from the consultation it conducts for government agencies and located within a university, CTG has a strong record of facilitating IT initiatives involving diverse groups. The participation of CTG thus added greatly to the credibility of the concept proposed by MACROS.

Even though a certain level of mistrust and risks was also observed in the general relationships among some of the participating groups, it was not enough to create strong resistance. A moderate to high level of trust thus provided an advantageous environment where collaboration was legitimated, conflicts were mitigated, and close contacts were encouraged.

Leadership. The results of the data analysis show leadership to be one of the most influential factors in this project. Leadership, however, did not reside within a single individual. Indeed, although participants often identified the project leader as being at the core of the leadership, they also noted the importance of other types of leadership. Thus, consistent with the literature on collaboration, a distributed leadership—comprised of upper-level management within and external to MA, the project leader, and the champions from different divisions, offices, and units—was crucial for project success.

Many interviewees acknowledged the contribution of the project leader. As one participant pointed out, "she is the heart and soul of the project." One attribute that was

frequently cited was her extensive knowledge and exceptional instinct about the organization—how it works and how different people in different units connect with one another. In addition, interviewees frequently commented on her reputation and trustworthiness in the organization. They noted that she was effective in the leadership role not because she was assigned to this position, but because of what she was able to achieve and the authority she was able to demonstrate. Another leadership attribute frequently cited by the interviewees was her perseverance and passion for MACROS. This project has had a long timeframe, during which several reorganizations, as well as initial rejection from the organizational-level information resources management process and other barriers that constantly confronted the project, all had the potential to alter the course of the project. Interviewees were quick to note that despite of all those difficulties, she persisted.

Although the project leader was pivotal in providing a vision and coordinating the project activities, her efforts would not have been effective without the encouragement and support from upper management. Many participants expressed their belief that the project would not have succeeded had it not had the executive support. As one individual observed,

> … So the combination of that, somebody who could formulate the issue and potential solutions and people who were willing to listen and support to proceed it. I am sure there are a lot of good ideas dying on the desk of the person who thought of them, because they can't find somebody to go along with it. So they gave up. Getting something that is a significant change requires persistence and executive support.

Because of the cross-boundary nature of the project, top management in OSC and executives in other divisions were crucial in balancing the complicated relationships that would not have been encountered in a traditional type of project. Collectively, they contributed to the success by helping to overcome structural barriers, empowering key people, bringing the community together, dedicating resources, and creating a culture that encourages collaboration and sharing.

A third type of leadership role that was carried out by many individuals users throughout OSC emerged from those who were directly involved in the development of the system—the first adopters. Although these individuals have different ranks and professions, they provided leadership within their own division, office, and units. By taking an active role to fill in the knowledge gaps, promote the information system, make incremental changes, tell success stories, and create a momentum to drive the further adoption of the system, these individuals facilitated the development of the MACROS system.

Issues and Incentives. While there were both incentives and disincentives for knowledge sharing and collaboration in this project, the disincentives were ultimately outweighed by the benefits, which only became clear to participants as the project evolved.

The data analysis shows that the incentives perceived by different participants were not entirely compatible at the beginning. The MA central office clearly had a pressing need to gain access to information and knowledge pertaining to local governments. The regional offices, which had access to this information, however, had little motivation to share this information, because they had the expectation that this project would shift existing relationships and add additional burdens, but with no substantial gains accumulated to them. The regional offices also knew, however, that the central office had the authority to mandate the adoption of a system had it chosen to do so. There were, however, clear signs that the central office intentionally refrained from using authority and adopted a participative approach to solicit the concerns and needs from the regional staff. Therefore, these signs that the interests of regional offices would be considered made it possible to initiate an idea that allowed the incentives to be clarified over time. This became an important starting point, where give and take for each party could be negotiated and balanced. Many participants expressed at the beginning that MACROS was too abstract, and they did not understand how they would use it, and how it would help their work. Once it was communicated and presented in a more concrete form, however, MACROS demonstrated benefits that helped people overcome their perception of risks. Under the new circumstances, incentives outweighed the disincentives and supplied sustainable energy to drive the progress of MACROS.

Number and Variety of Groups. Participants also expressed that a critical factor for the success of knowledge sharing was the involvement of diverse groups, which allowed for the transformation of knowledge, as well as the sharing of responsibilities and ownership of the information system. A growing size and heterogeneity of participation, however, could have complicated the processes of communication, consensus building, and resources sharing, and thus created problems for the implementation of the system. In this project, the number and variety of participating groups did not raise substantial barriers for the development of MACROS, however, largely because groups were brought on sequentially. In its early development, the project included a relatively small numbers of groups, and the diversity of those groups was not unmanageable. Indeed, a stakeholder analysis was conducted as a deliberate effort to reduce the size and heterogeneity of the participating groups. The result was that the early discussions were mostly focused on the needs of facilitating communication between and among central and regional offices of MA, and thus avoided becoming distracted and entangled into other cross-agency issues. Once the idea passed the process of deliberation within these initial groups and grew to be a mature proposal and

concrete prototype, the involvement of a larger number of and more heterogeneous groups became less of a problem because the possible variations were automatically limited. Thus, the discussion of expansion did not create an unwieldy wish list, but rather allowed the project to test the feasibility of adopting a similar concept and platform. This order of involvement facilitated the emergence of a context where, with reasonable efforts and costs, differences could be reconciled, and agreements could be achieved.

Technology. Technology in this case refers to the MACROS System, which is a Lotus Notes based application powered by InterTrac (software developed by the vendor, ComputerWorks). The system is comprised of fourteen Notes databases with report capabilities. These databases are combined into a single software system that acts as a multi-purpose tool for management of contacts, documents (policies, procedures and training materials), correspondences (via print, email or fax), projects, workflow, and knowledge base. The founders of Lotus had a vision of collaboration; and they built this system with this vision in mind when it was originally built in 1980 [77]. Thus, the architecture and many characteristics of Lotus were designed to materialize this vision—facilitating communication and collaboration. In this case, there seems to be an alignment between the structure of the technology used and the structure and strategic intention of MACROS; this alignment enabled the collaborative concept of MACROS to seamlessly integrate into the technology. In addition to the architecture, Notes technology also provides several features, such as security, reliability, customization, ease of use, and full-text search that made it easier for users to accept the technology and use it for collaboration purposes.

Implementation Strategy. Finally, effective implementation strategy emerged during the data analysis as playing a crucial role in the success of the project. Many participants pointed out that large scale IT initiatives like MACROS are prone to failure; MACROS has succeeded, however, because (1) the technology adoption was guided by clear business requirements elicited from the stakeholder groups; (2) the system was piloted and tested before large scale implementation; (3) the Expansion Committee was formed, and it had a clear long-term vision and developed appropriate plans for maintenance of the system; and (4) the implementation approach was flexible enough to allow for the evolution of better solutions. Indeed, the initial plan to implement MACROS had focused on a component called "Technical Assistance." All of the offices of MA receive technical assistance calls from local government for guidance and consulting with regard to financial management. This strategy was altered along the way, however, partly because of the discussion of what would be needed to demonstrate that MACROS would result in agency-wide benefits, not just benefits for the MA Division. Thus, a decision was made to implement the "Customer Contact" component first, and then build other components, such as document management, correspondence, and technical assistance, on top of this. This change of strategy paved the way for implementation of the other components, while successfully preserving the objectives and missions stated in the original business case.

Interactions. Implicit in this discussion is the notion that the accomplishments attributed to each of these factors are in fact intertwined with other factors. The interviewees often suggested that, while one factor was crucial, without the others it would not have worked properly. Frequently, the interviewees carried the conversation away from one factor to another naturally because they saw the interaction of two or more factors as contributing to the success, instead of one factor acting alone. While space limits our ability to capture the full complexity of the interactions, we have chosen several important examples to highlight the significance of these interactions: (1) *Leaders* were pivotal in creating the structure and developing a culture that has fostered the development of *trust*; (2) *Trust* ensured that participating parties believed in and accepted the *incentives* that were still in very abstract form and may not have been realized without participants being exposed to vulnerable positions and risks; (3) *Trust* could be difficult to develop and sustain without *incentives* for collaboration, and a fair distribution of *incentives* facilitated the development of *trust* overtime; (4) The alignment of *incentives* augmented the ability to achieve consensus across the *variety of groups*; (5) Alignment between the collaborative spirit of the *technology* and the institutional-based *trust* eased the way for the adoption of a system like MACROS; (6) The *implementation strategy* was aimed toward identifying the *shared interests (incentives)* of *diverse stakeholder groups*; and (7) The *technology* has been flexible enough to accommodate the diverse needs of a larger group, as the *number and variety of groups* expanded. Although these are only a few examples, these interactions are equally important, if not more important than the influence of the individual factors.

4.2. Interaction of the Nature of Knowledge with Organizational and Technological Factors

Case material also suggests that indeed three characteristics of knowledge—level of explicitness, context-embeddedness, and practice-embeddedness—interacted with the organizational and technological factors in important ways. The relationships highlighted in this section are the most prominent ones extracted from participants' narratives, or as a result of our observations, interpretation, and reasoning, but not all the possible linkages.

Levels of Explicitness and the Implementation Strategy. The level of explicitness interacted with the implementation strategy and influenced the potential for knowledge sharing success. As noted above, the project

began with a plan to implement a system to track the technical assistance offered by MA to local government offices; however, as some participants observed, "MACROS was pulled into all the other areas" before the technical assistance component was finally implemented. Most participants recognized the advantages of this change in strategy, but could not really give a clear and consistent explanation of the reasons for this switch. There is, however, an important element that was not specified but often implied in these interviews, a logical order of codification.

Technical assistance was difficult to codify because of the nature of the task as well as the forms it had taken in the past. There was minimal guidance on the definition of technical assistance, and the task varies by staff as well as by customers. Very few codified forms existed before, except in one regional office, where some instances of technical assistance were written in paper form. Most of that knowledge remained tacit, residing in people's memories. Alternatively, customer information is highly codifiable. The ways in which contact information can be used are fairly limited and consistent in OSC, and this already existed in a more or less codified form in the mainframe system. Therefore, when the MACROS team changed the strategy and implemented the component to track customer information first, it met little difficulty in accomplishing this task.

Context-Embeddedness and Number and Variety of Groups. The data also suggest that there was reciprocal interaction between context-embeddedness and coordination of the various groups. When knowledge is deeply embedded in discrete communities, it is more difficult to coordinate group activities than when knowledge is communicated and widely understood across communities in collaboration. Failures in group coordination in turn undermine knowledge transformation across separated communities. The positive interaction, however, was observed in the case of MACROS because of the initiation of knowledge sharing even before any information technology was involved. When the concept of MACROS was first introduced to the larger group, i.e., the OSC divisions external to MA, many people examined it with doubts and suspicions. Some people thought that it was not possible to adopt MACROS across the board because they had different operations and information needs; that is, knowledge was assumed to be substantially embedded within each the community's context. After participating in the workshops conducted by CTG to help them identify what their work is about and how information is involved, individuals across the agency found a great deal of commonalities. As one leader said, "I think we are all surprised over the degree of commonality—the kinds of the information, the kinds of forms, and the same issues we are facing. It's like, 'oh, maybe we are not so different after all.'" As a result, when knowledge became more transparent across communities, this shared understanding reduced the potential barriers that group size and heterogeneity might have led to. The ability to see commonalities then further accelerated the knowledge sharing across groups, reducing the context-embeddedness and even practice-embeddedness, as co-participation was made possible and effective.

Context-Embeddedness and Trust. Initial trust must exist in order for individuals to accept and develop a new mental model necessary for sharing knowledge that was constructed in a different context. In this sense, trust did not reduce the context-embeddedness. Rather, it removed the barriers of a narrow context and established more common grounds, leading to a more transparent context that further gave rise to higher levels of trust. Many participants commented that through their engagement in this project, they gained a more comprehensive picture of the business functions of different parts of the agency as well as the organization as a whole. They said that they understood better how different divisions, offices, units, and teams interact, and how much they actually had been relying on each other in order to accomplish their own tasks. Because of this enhanced comprehension about mutual interdependence, they had more respect and less doubt about the way in which the resources were allocated for this project. As one user said,

> I think in the past, in different times, not all the time, there's been perception about … everyone thinks what they do is the most important thing. So sometimes it's a little friction. But a lot of things that we do are interrelated things. If data verification unit gets the information, there is another unit that is going to look at the data and say, "ok, this town is in good fiscal condition, or is not in good fiscal condition." And based on their report, somebody else is going to go out and visit that town and look at their records. …So I think, for the most part, we can't take everybody's work for granted.

Level of Explicitness and Incentives. The more knowledge is made explicit, the more effective it is in demonstrating concrete incentives. Many participants reflected that initially MACROS was an abstract concept that they had heard of, but that they could not really grasp what the benefits of MACROS to their work would be. Once the knowledge became highly codified and shown in the information system, however, the incentives became much more tangible and vivid. Although they were basically the same incentives as those articulated in the business case, presentations, or newsletters, participants responded to those tangible incentives with higher level of attention and engagement. As one participant observed,

> … So we ended up calling this gentleman and asking him some questions. He just said, "you know, I want to see it." He gets on his computer and he looks it up. He can see it, and his reaction was "oh, this is really cool." We have told them all long ago that this is going to be happening. I think until you actually start to use it, you realize it click, click, that easy. … So my guess is that these people have some of these concerns, when they start to use it like that, they are going to get it.

In addition, as this participant implied, efforts in explication helped to diminish some of the earlier concerns.

For example, one disincentive for knowledge sharing was that many were concerned that there might never be a good solution to reach consensus on the definition of significant technical assistance due to the tacit nature of knowledge. One piloting user of technical assistance in a regional office pointed out that this could not be completely solved but could be helped with the incremental efforts at codification. He said,

> so those kinds of concerns really start to be clearer to people when they start using this system. And I think as more and more people start using it, you're going to start getting more and more input from various sources saying, "that (insignificant technical assistance) should never have been in there. Why did we put that in?" You're going to start narrowing the gray area but you will always, always have a gray area, always.

Technology and Context-Embeddedness and Practice-Embeddedness. As noted above, this particular kind of technology allows for incremental development of applications, which provided building blocks to establish an open context for acquiring and transferring knowledge that is typically embedded in the community practices. One of the difficulties in sharing knowledge is that knowledge is often highly associated with specific social actors and a particular situation. Detaching the contextual information from the knowledge reduces the reusability of knowledge dramatically. Knowledge management efforts have often failed because the technology was not capable of establishing the linkage between the event, social agents, and the context. In the case of MACROS, technical assistance can be characterized as knowledge that is highly embedded in community practices. Simply writing down the answer to a technical assistance inquiry does not convey the full meaning unless there is a context for such knowledge. This technology has the ability to build a common context from which the meaning of the knowledge could be established. Thus, knowledge sharing in the case of MACROS has been successful partly because the requirement of sharing the embedded knowledge was largely matched with the right type of technology. For example, as one key participant who was demonstrating the information system explained,

> [i]f I am planning a service for the city of Binghamton. I can see that we had these conversations. Either there is something about these conversations saying three people asked the same question, and they still didn't get this right, maybe we should focus on this issue when we go there. … Since this is division wide, it doesn't matter if it's somebody in my regional office. They may have talked to John Kelly because he deals with the accounting standards. They may have talked to John Parlor because he may have reviewed the annual financial report documents. They may have talked to me because they met me with a conflict. All of those bits and pieces will be available now for a big picture of the interactions in that place. I am more knowledgeable and better prepared as I work in there.

In addition, one theme that appeared consistently in several interviews and observations of demonstrations and training sessions was that many appeared to be highly impressed with the way in which information is stored and accessible through independent yet interconnected modules. The CEO of ComputerWorks, based on his experiences working with MACROS as well as with several other organizations using the same platform, reflected that once the information about customer contacts, correspondence, MIS, and time management has been available in the information system, the value of technical assistance could be augmented, because customer information provides a frame within which technical assistance can be organized, and information from MIS and time management provides threads to establish the context of any particular technical assistance. As such, the knowledge can be much more meaningful and usable when information is organized in this fashion. In this sense, the alignment between the right type of technology and the embedded nature of knowledge emerges as a key element for the effectiveness of knowledge sharing.

5. Conclusion

The research results showed that, in this case, knowledge sharing across boundaries was successful in that the MACROS project has created and institutionalized an information system as well as other organizational structures and practices that facilitate knowledge sharing in an organization where intelligence had previously been distributed and segmented. The case results showed that, during this process of change, several factors—distributed leadership, alignment of issues and incentives, coordination of a number and variety of groups, trust, technology, implementation strategy, and knowledge transformation—played important roles that influenced the progress of the project. In addition to their unique contribution to the knowledge sharing processes, these factors have also interacted with one another, and these interactions were crucial, if not more important, for the collaborative success. Furthermore, the case results presented here suggest that the nature of knowledge had an important influence on the success of the MACROS project in that it interacts with the organizational and technological factors, and the interactions had a substantial influence on the knowledge sharing process.

A major contribution of this study to theory is that it uses a multi-dimensional view of knowledge, examining the interactive impact of the nature of knowledge along several dimensions. Although the relevance of the nature of knowledge has been widely acknowledged (e.g., [16, 23, 78]), it is not always clear how it comes into play and influences the process of knowledge sharing. This study examined the interaction of the nature of knowledge with organizational and technological factors, and the results showed that the levels of explicitness, practice-embeddedness and context-embeddedness, interact with the influential organizational and technological factors in influencing the processes of knowledge sharing. Therefore, this study provides a new and more comprehensive framework for investigating the relevance of the nature of knowledge in knowledge management research.

Not only does this study contribute to the theoretical development, it also provides practical lessons for other public organizations initiating similar efforts. The number of critical factors, as well as the extensive linkages among the factors may appear to be overwhelming. However, it is precisely this comprehensiveness and interconnection that should be the most important message to be conveyed by this study. Emphasizing only one or a few factors in isolation does not lead to success. In this sense, a systems perspective should be the foremost important understanding a manager has to develop, especially for public sector managers attempting to initiate enterprise-level IT initiatives. It should be recognized that although technology has advanced radically in its capability to meet various organizational needs, it was neither merely a cause nor simply a consequence. Rather, it was a catalyst that prompted the initiation of a series of mutual influences of technology and social processes. The case results showed how the social actors mobilized structural and cultural elements to choose and manipulate technology in order to fulfill their collaborative purpose, and how their collaborative intention as well as the structural and cultural elements could be altered and, in this case, improved by the use of technology. Given that agency boundaries rarely coincide precisely with public program or policy boundaries, agency leaders need to emphasize and support those organizational elements that facilitate knowledge transformation across communities, such as a collaborative culture, cross-pattern teaming, communication, and a shared knowledge repository.

This research explored the dynamics of knowledge sharing. The results provided an integrated framework to capture the impact of interactions of the nature of knowledge and influential organizational and technological factors on knowledge sharing processes. A logical follow-up to this exploration would be to construct research with other approaches, preferably multi-method research, to test the theoretical framework in similar settings, such as other state or federal government agencies; across multiple settings, such as across agency boundaries or levels of government; and in different types of settings, such as in research and development settings crossing public and private sector boundaries, and focusing particularly on question of how the nature of knowledge interacts with the organizational and technological factors.

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