Task Uncertainty and Emergency Management Task Performance: The Mediating and Moderating Roles of Knowledge Sharing

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ABSTRACT

Each emergency management presents itself with a unique set of characteristics that are hard to determine a priori. Thus emergency management tasks are inherently uncertain, requiring knowledge sharing and quick decision making that involves coordination across different levels and collaborators. While there has been an increasing interest among both researchers and practitioners in utilizing knowledge sharing to improve emergency management performance, little research has been reported about how the role of knowledge sharing mediates and moderates the relationship of emergency management tasks and emergency management task performance (task effectiveness and task efficiency). Using combination of qualitative and quantitative methods, we developed the dimensions and their corresponding measures of emergency management tasks and test the relationships between the various dimensions of management tasks and emergency management performance through the mediating and moderating roles of knowledge sharing purposes.

Keywords

Knowledge Management, Emergency Tasks, Knowledge Sharing, Task Performance, Mediating and Moderating Effects, Knowledge Sharing for Exploration, Knowledge Sharing for Exploitation

INTRODUCTION

Emergency management involves complex tasks that require effective knowledge sharing and coordination among various personnel from different organizations. The literature on emergency management and knowledge management has not adequately addressed how task characteristics and knowledge sharing practices interplay to affect emergency management task performance. As a response to these shortcomings in the literature and continuing challenges in emergency management, the research objectives of this study are driven by the need to better understand:

- The characteristics and dimensions related to emergency management tasks, and
- The mediating and moderating effects that knowledge sharing can have on the performance of emergency management tasks.

In this paper, we report a study that examines the mediating and moderating effects of knowledge sharing on the relationships between task uncertainty and task performance in emergency management. The study is conducted at the emergency operations center (EOC) of the Miami-Dade Counties. Using combinations of interviews, field observations and survey, we found that different types of knowledge sharing practices both mediate and moderate how task performance is affected by characteristics of task uncertainty.
LITERATURE REVIEW

Emergency Management Task Uncertainty

A task is the unit of analysis that is unique and perfectly identifiable for any job [Kim and Dagobert, 2005; Larsen, 2003]. Every task possesses a set of characteristics that play significant roles in influencing the outcomes of the task. Given the unstable and changing conditions surrounding an emergency management task, the characteristics effects of the response activities involved in the task can be classified influenced by their dynamic or uncertain characteristics or uncertainty. The uncertainty of an emergency response task incorporates the decision maker and the cognitive context in which the decision-making process occurs. In this paper, we conceptualize emergency management task uncertainty in terms of novelty (newness and non-routineness), task un-analyzability (difficulty, equivocality, and the amount of task information), and task significance (urgency and impact); all of which are relative to the person faced with completing the task.

Our conceptualization of emergency management task uncertainty is consistent with the other task dynamic tasks’ characteristics defined in the literature, such as “the difference between the amount of information required to perform the task and the amount of information already possessed” [Galbraith, 1973, p. 36-37 in Larsen, 2003, p. 188] and “the absence of information” [Daft and Lengel, 1986, p. 556] required to perform a task. Task uncertainty has a direct relationship with the available information and knowledge; “as information [and knowledge] increases, uncertainty decreases” [Daft and Lengel, 1986, p. 556].

In this research, task novelty is defined as the result of the aggregation of task newness and task non-routineness. Task newness describes frequent encounters with “unexpected and novel events that occur in performing a task” [Daft and Macintosh, 1981 in Karimi, Somers, and Gupta, 2004, p. 177]. Task non-routineness refers to “the extent to which a [task] involves performing a number of different [activities] and frequently encountering exceptional circumstances requiring flexibility” [Fields, 2002, p. 100; Dean and Snell, 1991]. As task novelty and non-routineness increase, so does task uncertainty, making this type of task hard to predict [Goodhue, 1995; Van de Ven and Delbecq, 1974]

Task un-analyzability denotes “the extent to which workers can follow unambiguous processes to solve task-related problems: that is, the degree to which the task is structured” [Dunegan, Duchon, and Uhlenbien, 1992 in Larsen, 2003, p. 185]. As a result, “task un-analyzability represents the degree to which the task is unstructured and the information required to perform the task is equivocal thus leading to conflicting interpretations” [Daft and Lengel, 1986; Daft and Macintosh, 1981; Dunegan, Duchon, and Uhlenbien, 1992]. In other words, task un-analyzability can be interpreted as the circumstances surrounding an unstructured task that makes it difficult and challenging to determine a clear course of action.

Task difficulty refers to impediments “in seeing into the task and in analyzing it in terms of alternative courses of action, costs, benefits, and outcomes” [Daft and Macintosh, 1981, p. 209]. In fact, task difficulty relates to “the way individuals respond to problems that arise” [Larsen, 2003; Van de Ven and Delbecq, 1974 in Karimi, Somers, and Gupta, 2004, p. 177], and it is directly associated with “the analyzability and predictability of work [and tasks] undertaken by an organization unit” [Van de Ven and Ferry, 1980 in Karimi, Somers, and Gupta, 2004, p. 177].

Task un-analyzability and task difficulty basically differ in the unclear and ambiguous characteristics of the task at hand, and the challenging and demanding course of actions to follow to successfully accomplish it respectively. A typical example of task un-analyzability in this context is when an emergency task presents itself and there are several alternatives to accomplish the task but none of them seem to be the more appropriate or suitable. On the contrary, for task difficulty in this context, the task at hand has been figured it out already and defined but the steps to successfully accomplish this task are challenging and arduous to perform for all the parties involved.

The significance of the task is defined as the aggregation of task urgency and impact. The concept of task significance is primarily defined as “the degree to which the job has a substantial impact on the lives of other people, whether those people are in the immediate organization or in the world at large” [Hackman and Oldham 1980, p. 79 in Larsen, 2003, p. 190]. Whereas task urgency focuses on the immediate priorities and timeframe in which a task needs to be performed, task impact refers to the analysis and assessment of potential repercussions in order to prioritize tasks.
Knowledge Sharing for Exploration and Exploitation

According to Nonaka [1994], knowledge management leverages the creation, sharing, use, and reuse of prior knowledge through the continuous interactions among people who possess different knowledge that collectively is required to perform the task at hand. In this study, we focus on different purposes for knowledge-sharing via the purposes of interactive activities among emergency management (EM) personnel used to identify and use needed knowledge. The purpose of knowledge sharing is either knowledge exploration or knowledge exploitation.


Performance of Emergency Management Tasks

In this study, we conceptualize and measure two dimensions of emergency management tasks: task effectiveness and task efficiency. Task effectiveness refers to the extent to which the disaster task requirements were met. It represents the extent to which the task outcome was satisfactory and how well the task was executed without disrupting other tasks according to the perception of the OEM/EOC actors. Task efficiency refers to the extent to which the task was completed in the required time frame and within the allocated budget and resources. The efficiency will depend on whether the task was completed on time using the available resources.

RESEARCH MODEL AND HYPOTHESES

According to the uncertainty characteristics of the task, different knowledge-sharing strategies in terms of exploration and exploitation may be employed to increase the possibility of effective and efficient task performance. As shown in Figure 1, this research study aims to understand better the interaction of these three constructs.

![Figure 1. Research Model](image-url)
The inclusion of knowledge sharing for exploration in terms of discovering new data, information, and knowledge; knowledge sharing for exploitation in terms of directly searching and using existing knowledge as mediating activities help explain how tasks with high level of uncertainties are ultimately successfully executed. The mediating effects of knowledge sharing for exploration and exploitation are reflected at the sub-dimensional levels between dimensions of task uncertainty and task performance in terms of task effectiveness (meeting the requirements of all stakeholders) and task efficiency (specific timeframes, budgets, and available resources for performing a given task). EOC personnel in the various functional groups and related organizations use a combination of knowledge-sharing strategies to respond to an uncertain situation, specifically when the tasks on hand are subject to restricted timeframes, controlled budgets, and limited resources.

As result, it is expected that the dimensions of knowledge-sharing strategies (exploration and exploitation) significantly mediate and therefore reduce the direct effects of task uncertainty on task performance. The level of task uncertainty requires a corresponding appropriate knowledge sharing strategy which in turn will affect task performance in terms of task effectiveness and task efficiency. Accordingly, we propose:

H1. Knowledge sharing strategies (exploration and exploitation) mediate the relationships between task uncertainty and task effectiveness.

H2. Knowledge sharing strategies (exploration and exploitation) mediate the relationships between task uncertainty and task efficiency.

In addition to the mediating hypotheses, we propose that knowledge sharing plays a significant moderating role that influences the relationship between task uncertainty and task performance. In the EOC context, we have frequently observed that even with the same levels of task uncertainties, different EOC groups reached different levels of task performance. The differences can often be attributed to the different knowledge sharing strategies that the various groups used. In other words, the effects of task uncertainty on task performance are contingent on the knowledge sharing strategies being employed by the EOC personnel. The differences between our mediating hypotheses and moderating hypotheses are that the former states that task uncertainty determines the type of knowledge strategies needed to mediate the difficulties of successfully executing the task caused by the uncertainty whereas the later states that tasks with the same level of uncertainty may have different effects on task performance depending on the types of knowledge strategies that the EOC personnel used to actually perform the task.

During an emergency management event, EOC personnel from the different functional groups and related organizations are often under dramatic time pressures and resource constraints. While rationally a certain types of knowledge sharing strategy should have been used given a particular uncertainty task circumstance, the EOC personnel may have to improvise often due to the lack of access to information and knowledge sources, or the lack of time to identify and access needed information and knowledge, or combinations of the different constraints and limitations. As a result, the knowledge sharing strategies that are actually used in dealing with an emergency situation is often not the most appropriate strategies, which in turn, often fail to reduce the task uncertain that is critical in successfully perform the task. Thus, we propose:

H3. Knowledge sharing strategies (exploration and exploitation) moderate the relationships between task uncertainty and task effectiveness.

H4. Knowledge sharing strategies (exploration and exploitation) moderate the relationships between task uncertainty and task efficiency.
RESEARCH METHODS

To test our research model and hypotheses, we carried out a multi-year field study with combinations of qualitative, at the beginning stages, and quantitative methods including interviews of EOC personnel, participation of emergency management training drills, observations of EOC activations during several emergency events, analysis of EOC archives and documents, and surveys of EOC personnel. For the purpose of this paper, we used specifically a four stage approach as shown in Table 1 (Creswell, 2003; Xia and Lee, 2005).

<table>
<thead>
<tr>
<th>Phase 0, Research Context</th>
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<tr>
<td>Phase 1, Conceptual Development and Initial Item Generation</td>
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<td>Phase 2, Conceptual Refinement and Item Modification</td>
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<td>Phase 3, Survey Data Collection</td>
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<td>Phase 4, Data Analysis, Measurement Validation and hypothesis testing</td>
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Table 1. Research Outline (Adapted from Creswell, 2003 and Xia and Lee, 2005)

Survey Data Collection

This study was conducted at the Miami-Dade County Office of Emergency Management (MD-OEM) in Miami, Florida, USA. The target survey respondents included those who were directly involved in emergency management response activities at the Miami-Dade OEM/EOC. The respondents were members of various emergency executive groups, functional groups (human services, infrastructure, and public safety), support groups (311 answer center, geographic information systems, logistics section, planning and information section, and special needs support center), information communication systems, and other related public agencies and private corporations. The targeted 734 potential respondents were individuals with experience in emergency management response events. A total of 168 usable responses were received and used in our data analysis, representing an overall response rate of 22.9% (detailed relevant sampling characteristics of the respondents of our survey instrument is presented in Appendix A of this paper). Potential biases due to common-method (single respondent) and non-response were investigated using the Hermon one factor test and comparisons of the characteristics of respondents with those of the non-respondents. The results suggest that the sample does not present common-method and non-response biases that may affect the data analysis and hypothesis testing results.

RESULTS

Measurement Validation

To assess whether the measurement items were reliable, this research study used internal consistency estimates of reliability based on Cronbach’s alpha test. Cronbach’s alpha test determines the “consistency in scores among equivalent items” [Green and Salkind, 2004, p. 325]. Cronbach’s alpha values were computed for the three dimensions of uncertain dynamic emergency management tasks (novelty, unanalyzability, and significance), two purposes for knowledge sharing (exploration and exploitation), and task performance. The reliability estimates for all variables were above 0.60, indicating satisfactory levels of reliability (Hair, Anderson, Tatham & Black, 1998).

The convergent and discriminant validity of the measures were validated using factor analysis. The rotated factor matrix for the 20 task uncertainty yielded 6 factors (newness, non-routineness, difficulty, amount of task information, urgency, and impact) that are consistent with the six dimensions of task uncertainty we had conceptualized. The 8 items used to measure knowledge sharing strategies yielded two factors that are consistent with knowledge sharing for exploration and knowledge sharing for exploitation. The 6 items used to measure task performance yielded two factors that are consistent with our definitions of task performance (task effectiveness and task efficiency).
HYPOTHESES TESTING RESULTS

To test the mediating and moderating effects of knowledge sharing strategy on the relationships between task uncertainty and task performance, the following regression analyses were performed. First, two regression analyses were performed with the six dimensions of task uncertainty as independent variables in both equations, and knowledge sharing for exploration and knowledge sharing for exploitation as dependent variable in each of the equations respectively. For the direct effects of task uncertainty on knowledge sharing strategies, task newness ($\beta = 0.540$) and task impact ($\beta = 0.226$) were significant predictors of knowledge sharing for exploration. Task difficulty ($\beta = -0.244$), task impact ($\beta = 0.241$), task urgency ($\beta = 0.196$), and amount of task information ($\beta = 0.203$) were significant predictors of knowledge sharing for exploitation. Task urgency is also a significant determinant ($\beta = 0.196, p < 0.01$) of knowledge sharing for exploitation. Task difficulty is the most negative and significant determinant ($\beta = -0.244, p < 0.01$) of knowledge sharing for exploitation.

Second, six regression analyses were conducted to assess the direct effects of task uncertainty on task performance (effectiveness and efficiency, respectively) the direct effects of task uncertainty and knowledge sharing strategies on task performance (effectiveness and efficiency, respectively), and the interaction effects of task uncertainty and knowledge sharing strategies on task performance (effectiveness and efficiency, respectively). For the direct effects of task uncertainty on task effectiveness, task urgency had the most significant and positive effect ($\beta = 0.285$), followed by task impact ($\beta = 0.178$) and task difficulty ($\beta = -0.177$). For the direct effects of task uncertainty on task performance when knowledge sharing strategies were also included, task urgency had significant and positive effect on task effectiveness ($\beta = 0.264$) and amount of task information had significant and positive effect on task efficiency ($\beta = 0.168$).

For the interaction effects of task uncertainty and knowledge sharing strategies on task effectiveness, the most significant positive interaction effect ($\beta = 0.767, p < 0.1$) is when knowledge sharing for exploration interacts with task newness. However, the most negative significant interaction effect ($\beta = -1.377, p < 0.05$) is when knowledge sharing for exploitation interacts with task impact. The most Knowledge sharing for exploration and task non-routineness had the significant and positive interaction effect on task efficiency. Therefore, hypotheses 3is partially supported.

To assess the mediating role of knowledge sharing strategies on the relationships between task uncertainty and task performance, the regression analyses results were used to calculate the indirect effects and their corresponding significance levels. “A meditational structure posits a particular conceptualization of the mechanism through which an independent variable might affect a dependent variable – not directly, but rather through an intervening process, captured by the mediator variable” [Iacobucci, 2008, p. 1].

The Sobel test statistics [Sobel, 1982] for task difficulty (indirect effect=2.365, $p=0.018$) and amount of task information (indirect effect = 2.316, $p=0.020$) are significant. The results suggest that task difficulty and amount of task information indirectly affect task efficiency through knowledge sharing for exploitation. Therefore, hypothesis 2 is partially supported. The Sobel [Sobel, 1982] test statistics for task difficulty (indirect effect=2.443, $p=0.014$), task urgency (indirect effect = 2.284, $p=0.022$) and task impact (indirect effect = 2.583, $p=0.009$) are significant. The results suggest that task difficulty, task urgency and task impact indirectly affect task effectiveness through knowledge sharing for exploitation. Therefore, hypothesis 1 is partially supported.

DISCUSSIONS

The significance of natural and man-made emergencies that have recently occurred around the world both in human and financial terms spiked the interest in research on emergency management. The constantly changing conditions of emergencies, where almost everything is an exception to the norm, call for efficient emergency management through effective information and knowledge sharing [Kapucu, 2006; Turoff, 2002].

Our study aims to understand the circumstances surrounding emergency management response and their effect on task performance. To understand the uncertain characteristics of emergency management, we conceptualized three dimensions of emergency management task uncertainty: novelty (task newness and task non-routineness), un-analyzability (task difficulty and amount of task information), and significance (task urgency and task impact). We conducted an empirical study to examine the mediating and moderating roles that knowledge sharing strategies (exploration and exploitation) play on the relationships between task uncertainty and task performance (effectiveness and efficiency).
The test results partially supported our knowledge sharing mediating hypotheses: H1 (task difficulty/task urgency/task impact – knowledge sharing for exploitation – task effectiveness) and H2 (task difficulty/amount of task information – knowledge sharing for exploitation – task efficiency). Similarly, test results partially supported our knowledge sharing moderating hypotheses: H1 (task newness-knowledge sharing for exploration-task effectiveness, task impact-knowledge sharing for exploitation-task effectiveness), and H2 (task non-routineness-knowledge sharing for exploration-task efficiency).

For task newness, the interaction-moderating effects of knowledge sharing for exploration had the most significant positive impact on task effectiveness. In contrast, the interaction-moderating effects of task impact and knowledge sharing for exploitation had the most negative effect on task effectiveness. From the standpoint of practical implications, these findings suggest that better task effectiveness might be achieved when EOC personnel, infrastructure groups and related organizations use higher levels of knowledge sharing for exploration when faced with uncertain dynamic emergency management tasks with newness characteristics. Furthermore, when EOC personnel, infrastructure groups and related organizations face uncertain dynamic emergency management tasks with impact characteristics, they can achieve higher task effectiveness with lower levels of knowledge sharing for exploitation activities.

For task non-routineness, the interaction-moderating effects of knowledge sharing for exploration had the most significant positive impact on task efficiency. In contrast, the interaction-moderating effects of task non-routineness and knowledge sharing for exploitation had the most negative effect on task efficiency. From the standpoint of practical implications, these findings suggest that better task efficiency might be achieved when EOC personnel, infrastructure groups and related organizations use higher levels of knowledge sharing for exploration when faced with uncertain dynamic emergency management tasks with non-routineness characteristics. Furthermore, when EOC personnel, infrastructure groups and related organizations face uncertain dynamic emergency management tasks with non-routineness characteristics, they can achieve higher task efficiency with lower levels of knowledge sharing for exploitation activities.

CONCLUSIONS

This study has significant implications for practice. EOC personnel and emergency management teams usually cannot precisely identify the uncertainty dimensions of emergency management tasks during an emergency event or threat. This study provides an initial framework used to conceptualize and characterize task uncertainty and developed approaches to address them. In addition, by better understanding the novelty, un-analyzability, and significance aspects of task uncertainty, EOC personnel and emergency management managers and planners can use these dimensions as a reference point for developing appropriate response strategies during the emergency event as well as for reviewing and deriving lessons learned in post-mortem analyses.

Understanding the mediating and moderating roles that knowledge sharing strategies exert on the relationships between task uncertainty and task performance would help EOC personal and emergency management managers to better plan and design appropriate knowledge sharing mechanisms and coordination to proactively manage the complex and uncertain emergency situations. They can determine the choices and prioritizations of different knowledge sharing strategies to fit the types and levels of task uncertainty, and as results, efficiently and effectively accomplish the performance of these tasks.

RESEARCH LIMITATIONS AND FUTURE RESEARCH OPPORTUNITIES

The limitations of this research are inherent to the task characteristics that it addresses. Within the research literature, other task characteristics can be found, including complexity, variety, and interdependence [Dean and Snell, 1991]. However, for the purposes of this research, these task characteristics are considered to be more intrinsic (also referred to as static) to the nature of the task, as opposed to dynamic and uncertain. For this reason, this research purposely did not address these intrinsic (static) task characteristics.

Furthermore, the results presented in this research paper are quantitative in nature; consequently, further research studies must confront these quantitative results with the qualitative work and outcomes of this stream of research.
The survey respondents in this research were involved in emergency management response activities at the Miami-Dade County Office of Emergency Management. Further studies might therefore be necessary in order to conduct research at other offices of emergency management at the city, county, state, and federal government levels. In addition, specific discussions of knowledge sharing strategies for other practitioner stakeholders are needed to provide useful insights in other contexts than public service.

The uncertain emergency management tasks and knowledge sharing measures utilized in this study were exploratory in nature; as such, further research is needed to validate and improve these measures using confirmatory methods.
APPENDIX A
Relevant Sampling Characteristics of the Respondents of our Survey Instrument.

<table>
<thead>
<tr>
<th>Years of experience had to coordinated and/or performed this task</th>
<th>9.41 Years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Years worked in the emergency management field</td>
<td>10.09 Years</td>
</tr>
<tr>
<td>Years worked at current organization</td>
<td>13.50 Years</td>
</tr>
<tr>
<td>Years worked at the Emergency Operations Center</td>
<td>5.74 Years</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Organizational Level</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Senior Management</td>
<td>41.70%</td>
</tr>
<tr>
<td>Middle Management</td>
<td>30.40%</td>
</tr>
<tr>
<td>Operations Management</td>
<td>28.00%</td>
</tr>
</tbody>
</table>

People belonging to the following Office of Emergency Management and/or Emergency Operations Center functional groups:

<table>
<thead>
<tr>
<th>Group</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure Group</td>
<td>23.80%</td>
</tr>
<tr>
<td>Human Services Group</td>
<td>14.30%</td>
</tr>
<tr>
<td>Public Safety Group</td>
<td>35.70%</td>
</tr>
<tr>
<td>Hospitals/Health Care</td>
<td>3.57%</td>
</tr>
<tr>
<td>Planning and Logistics</td>
<td>3.57%</td>
</tr>
<tr>
<td>Staff and Support Organizations</td>
<td>2.97%</td>
</tr>
<tr>
<td>Operations</td>
<td>2.38%</td>
</tr>
<tr>
<td>City/Municipal</td>
<td>1.78%</td>
</tr>
<tr>
<td>Other</td>
<td>11.90%</td>
</tr>
</tbody>
</table>
REFERENCES


