Dealing with Task Uncertainty in Disaster Management:
The Role of Knowledge Sharing for Exploration and Exploitation

Jose Rocha
Florida International University
jose.rocha@business.fiu.edu

Irma Becerra-Fernandez
Florida International University
becferi@fiu.edu

Weidong Xia
Florida International University
xiaw@fiu.edu

Arvind Gudi
Florida International University
AGudi@aol.com

ABSTRACT

Each disaster presents itself with a unique set of characteristics that are hard to determine a priori. Using combinations of qualitative and quantitative methods, we develop the dimensions and their corresponding measures of the dynamic characteristics of disaster management tasks and test the relationships between the various dimensions of task uncertainty and knowledge sharing purposes. We conceptualize and assess task uncertainty along five dimensions: novelty, unanalyzability, amount of information, urgency, and impact. We distinguish knowledge sharing for knowledge exploration and knowledge exploitation purposes. Analysis results of survey data collected from Miami-Dade County emergency managers suggest that knowledge sharing for the purpose of exploration is associated with tasks uncertainty dimensions of novelty, unanalyzability, and impact. In contrast, knowledge sharing for the purpose of exploitation is associated with task uncertainty dimensions of unanalyzability, amount of information, urgency, and impact. Implications for research and practice as well directions for future research are discussed.

Keywords

Disaster management, task uncertainty characteristics, knowledge management, knowledge sharing for exploration, knowledge sharing for exploitation.

INTRODUCTION

Disasters are characterized by a series of dynamic and constant changing events that are difficult to anticipate and plan a priori, and are therefore inherently uncertain. The uncertain nature of disasters with regard to attributes such as time, geographic place, sixe, periodicity, circumstances, magnitude, information and knowledge puts dramatic pressures on the organizations and managers involved in dealing with disaster management tasks [Kumar, 2000]. Oftentimes, during the response to a disaster event, unexpected events arise and there is a great deal of uncertainty in figuring out the most efficient and effective ways to perform the task at hand, given that many of the involved tasks are novel, unstructured, and often with conflicting information and interpretation [Becerra et al., 2008]. As a result, disaster management organizations have repeatedly encountered significant challenges in understanding and responding to the uncertainties presented by every new disaster event [Paton and Jackson, 2002]. With disaster events such as 2004 Indian Ocean earthquake and tsunami; Arizona, California, Florida, and Texas wildfires; hurricanes Katrina, Rita, and Wilma; tornados in the mid-west; and more recently events such as Australia's wildfires and US Airways Flight 1549 landing on the Hudson river, there is a renewed interest among both researchers and practitioners in understanding and more effectively managing disaster task uncertainties.

The dynamic and constant disaster changes during a disaster event become even more critical when the relevance, impact, and urgency of these conditions jeopardize human lives and incur a great deal of economic repercussions. As a result, the large number of organizations involved must work together seamlessly by sharing relevant knowledge to make timely decisions. However, both anecdotal stories and research show that disaster management organizations continuously suffer from lacking the ability to effectively cooperate and coordinate through information and knowledge sharing [Jenkins 2006; Smith and Dowell, 2000]. A critical challenge that managers often face is the lack of understanding about what types of knowledge sharing are required for the various types of task uncertainties they face in managing a particular disaster.

In this paper, using combinations of qualitative and quantitative methods, we develop the dimensions and their corresponding measures of the dynamic characteristics of disaster management tasks and test the relationships between the various dimensions of task uncertainty and knowledge sharing purposes. We conceptualize and assess task uncertainty along five dimensions: novelty, unanalyzability, amount of information, urgency, and impact. We distinguish knowledge sharing for knowledge exploration and knowledge exploitation purposes. Field observations and interviews with managers from Miami-Dade County Emergency Management Operations Center were used to conceptualize the dimensions of task uncertainty and develop initial measures of those dimensions.

A sample of 168 survey responses collected from managers involved in Miami-Dade County emergency management was used to validate the measures and test the relationships between the dimensions of task uncertainty and knowledge sharing purposes. The paper is organized into the following sections. The next section reviews and discusses the relevant literatures and key concepts. Our research model and hypotheses are presented in the following section. We then discuss our research methods, sample characteristic, and results. We conclude the paper with discussions of the implications of our results for research and practice as well as directions for future research.

LITERATURE BACKGROUNDS

Task Uncertainty

When unexpected events arise during a disaster event, there is a great deal of uncertainty in resolving the tasks at hand since these tasks present themselves as dynamic and novel undertakings. More specifically, we conceptualize five dimensions of task uncertainty: task novelty, task unanalyzability, amount of task information, task urgency, and task impact. Task uncertainty is defined as "the difference between the amount of information [and knowledge] 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] to perform a task. Task uncertainty has a direct relationship with information and knowledge available, "as information [and knowledge] increases, uncertainty decreases" [Daft and Lengel, 1986, p. 556].

Task novelty is often described as "unexpected and novel events that occur in performing a task" [Daft and Macintosh, 1981 in Karimi, Somers, and Gupta, 2004, p. 177]. Task unanalyzability is the complement of "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 Uhlbien, 1992 in Larsen, 2003, p. 185]. Further, task unanalyzability is directly related to the difficulty "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].

Amount of task information is another dimension of task uncertainty that is needed to successfully perform the task at hand given the intrinsic equivocality of the task through "the multiplicity of meaning conveyed by information" [Daft and Macintosh, 1981, p. 211] which "lends itself to different and perhaps conflicting interpretations about the work [and task] context" [Daft and Macintosh, 1981, p. 211].

Lastly, task urgency and task impact deal with "the degree to which the job [and its tasks have …] 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 Oldham1980, p. 79 in Larsen, 2003, p. 190] and the economic consequences. While task urgency focuses on the immediate priority and timeframe a task is needed to be done, task impact refers to the analysis and assessment of the extent of potential repercussions to prioritize when a task needs to be done.

Knowledge Sharing for Exploration and Exploitation

Knowledge sharing refers to the process through which explicit or tacit knowledge is communicated to other individuals [Becerra-Fernandez, Gonzalez, Sabherwal, 2004]. Knowledge sharing processes are a "conscious strategy of getting the right knowledge to the right people at the right time and helping people share and put information into action in ways that strive to improve organizational performance" [O'dell and Jackson, 1998, p. 4]. Knowledge sharing has also been defined as "the process through which one unit (e.g., individual, group, department, division) is affected by the experience of another" [Argote et al., 2000, p. 3].

Knowledge sharing can be utilized for either knowledge exploration purpose or knowledge exploitation purpose, or both. Knowledge exploration refers to the search of new information, methods, and alternatives by generating variation from what is known [March, 1991, McGrath, 2001]. Exploration activities can be summarized in "search, variation, risk taking, experimentation, play, flexibility, discovery, or innovation" [March, 1991 in Schildt, Maula, and Keil, 2005, p. 494].

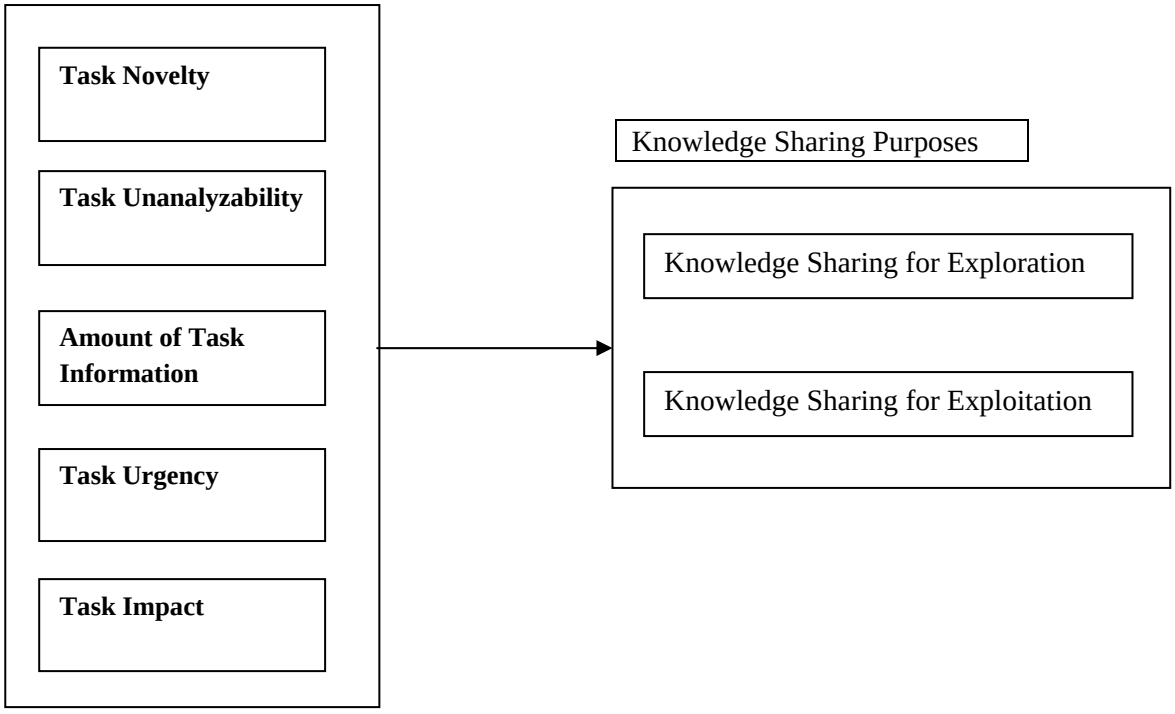
Knowledge for exploitation is defined as "a directed search emphasizing limiting variety and building closely on the existing knowledge base" [Schildt, Maula, and Keil, 2005, p. 495, McGrath, 2001]. In addition, knowledge exploitation activities focus on "refinement, choice, production, efficiency, selection, implementation, and execution" of knowledge [March, 1991 in Schildt, Maula, and Keil, 2005, p. 494]. In summary, knowledge sharing can involve activities that serve the purpose of "exploration of new possibilities and the exploitation of old certainties" [March, 1991, p. 71] to take action on the tasks at hand.

RESEARCH MODEL AND HYPOTHESIS

Research Model

Based on the five dimensions of task uncertainty and two types of knowledge sharing purposes, we propose a research model as shown in Figure 1 to examine which task uncertainty dimensions are associated with what types of knowledge sharing purposes in the disaster management context.

Figure 1. Research Model.



Research Hypothesis

Disaster management tasks are highly uncertain, involving many organizations and managers each of who deals with a specific aspect or domain of the task. Often times those involved in the task must communicate, coordinate and knowledge sharing to make fast response to emerging events. Depending on the specific dimensions of the task at hand, managers may need to share knowledge for different purposes. In cases where the novelty dimension of task uncertainty is high, because of no prior experience and knowledge exist, managers may need to share knowledge for the purpose of exploring new problem-solving and decision-making methods.

Similarly when the unanalyzability dimension of task uncertainty is high, managers must come up with new context specific solutions to solve the unstructured problems presented by the task, therefore, they must engage in knowledge sharing activities for exploration purposes. When the urgency and impact dimensions of the task uncertainty are high, the task must be done within a given timeframe without incurring negative consequences [Becerra et al., 2008]. As a result, disaster management teams need to resolve these tasks, factoring in their significance in terms of urgency and impact, using and sharing knowledge that closely resembles the unexpected characteristics of the task needed to be performed. Dealing with uncertain task characteristics, emergency response personnel often must balance between how much information is needed to efficiently and effectively perform task. In some instances, emergency respondents may be able to wait until sufficient relevant information referred to the task is gathered and examined before deciding a course of action, while in other circumstances they may need to proceed even if there's no clear course of action.

With this context as the reference point, disaster management personnel engage in knowledge sharing for exploration activities that "often involve search, variation, risk taking, experimentation, play, flexibility, discovery, or innovation" [Becerra et al., 2008, p. 2]. Thus, we propose the following hypotheses:

H1. Uncertain dynamic task characteristics are positively associated with knowledge for sharing for exploration
- H1a. Task novelty is positively associated with knowledge sharing for exploration
- H1b. Task unanalyzability is positively associated with knowledge sharing for exploration
- H1c. Task urgency is positively associated with knowledge sharing for exploration
- H1d. Task impact is positively associated with knowledge sharing for exploration
- H1e. The amount of task information is positively associated with knowledge sharing for exploration

On the other hand, most disaster management organizations and managers bring with them a rich set of prior experience and knowledge when they go into any new disaster management situations. While the overall disaster event may have new idiosyncratic characters that are different from past events, organizations and managers who specialize in a particular aspect or domain of the disaster are always able to draw some levels of similarities between the current event and past events. As such, exploitative knowledge sharing is necessitated in two aspects. First, when the dimensions of task novelty and unanalyzability are high, managers will draw on and apply their past experience and knowledge to come up with new knowledge and solutions. Once a new solution is formed, they must be able to exploit and utilize the new knowledge to complete the task on hand. The amount of information that is available to managers is a prerequisite for them to engage in knowledge sharing for knowledge exploitation purpose. In addition, novel and unanalyzable task characteristics with significant urgency and impact attributes often face short span of timeframe when these kind of tasks need to be performed, which requires managers to engage in knowledge sharing for exploitation activities to look for "refinement, choice, production, efficiency, selection, implementation, and execution" of current information and knowledge [March, 1991 in Schildt, Maula, and Keil, 2005, p. 494].

Therefore, we propose the following hypotheses:

H2. Uncertain dynamic task characteristics with significant urgency and impact characteristics are positively associated with knowledge sharing for exploitation
- H2a. Task novelty is positively associated with knowledge sharing for exploitation
- H2b. Task unanalyzability is positively associated with knowledge sharing for exploitation
- H2c. Task urgency is positively associated with knowledge sharing for exploitation
- H2d. Task impact is positively associated with knowledge sharing for exploitation
- H2e. The amount of task information is positively associated with knowledge sharing for Exploitation

RESEARCH METHODS

Research Design

We used a systematic five-stage approach to conduct our research. The research site for this research work is the Miami-Dade County Office of Emergency Management (MD-OEM) in Miami, Florida, USA. Given the number of disaster events faced every year (mainly tropical depressions, storms, and hurricanes), the MD-OEM is viewed as one of the most active, well trained, and prepared emergency management centers in the world. The MD-OEM endorsed our research project and managers from the MD-OEM actively participated in all stages of our research.

In the first stage, we developed our initial conceptualization of the dimensions of task uncertainty, two knowledge sharing purposes and a research model based on extensive literature review, field observations and interviews with disaster managers. Second, an initial list of measurement items was generated through review of the literature, interviews with disaster mangers, and pre-test of the instrument with disaster managers. Q-sorting procedures (Benbasat and Moore 1991; Xia and Lee, 2005) were used to refine the measures and to ensure construct validity of the measures. A pre-test of the instrument with a five disaster managers was conducted to ensure the appropriateness of the questions. Third, using both online and paper-based questionnaires, we collected 168 usable responses from disaster managers involved in the Miami-Dade County Emergency Operations Center activities. Fourth, the measures were refined and validated using exploratory factor analysis and reliability analysis. Lastly, the research hypotheses were tested using regressions with the survey data. Table 1 presents the constructs and key literature sources.

Table 1. Constructs and Literature Sources.

Task Novelty Fields, D.L., 2002, Dean, J. W. and Scott. A. Snell, 1991, Snell, S.A. and James W. Dean, Jr., 1994, Daft and Macintosh, 1981 in Karimi, Somers, and Gupta, 2004
Task Unanalyzability Van de Ven and Delbecq, 1974, Daft and Macintosh, 1981, Daft and Lengel, 1986
Amount of Task Information Daft and Macintosh, 1981, and Daft and Lengel, 1986
Task Urgency Karasek, 1979 in Fields, 2002
Task Impact Hackman and Oldham, 1974 in Fields, 2002
Knowledge Sharing for Exploration Tom J. M. Mom, Frans A. J. Van Den Bosch and Henk W. Volberda, 2007, Yi 2005
Knowledge Sharing for Exploitation Tom J. M. Mom, Frans A. J. Van Den Bosch and Henk W. Volberda, 2007, Becerra-Fernandez and Sabherwal, 2001, March, 1991

Survey Data Collection

Our target survey respondents are those involved in disaster management response activities of the MD-OEM. These respondents belong to 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 agencies. The targeted 734 potential respondents were individuals who had experience in disaster management response events.

Before respondents answer questions related to task uncertainty measures, they were asked to identify a specific disaster task that they were recently involved and were asked to refer to that specific task when answering all questions. To make the interpretations of tasks consistent, a list of typical disaster management tasks were provided as examples. Respondents first answered questions related to measures of the different dimensions of task uncertainty. They then assessed the extent to which they were engaged in knowledge sharing for the purpose of knowledge exploration and knowledge exploitation. A total of 168 usable responses were received and used in our data analysis, representing an overall response rate of 22.9%. Characteristics of the respondents in the sample are presented in Table 2.

Table 2. Relevant Sampling Characteristics of the Respondents of our Survey Instrument.

Years of experience had to coordinated and/or performed this task	9.41 Years
Years worked in the emergency management field	10.09 Years
Years worked at current organization	13.50 Years
Years worked at the Emergency Operations Center	5.74 Years
Organizational Level	
Senior Management	41.70%
Middle Management	30.40%
Operations Management	28.00%
People belonging to the following Office of Emergency Management and/or Emergency Operations Center functional groups:	
· Infrastructure Group	23.80%
· Human Services Group	14.30%
· Public Safety Group	35.70%
Other:	
· Hospitals/Health Care	3.57%
· Planning and Logistics	3.57%
· Staff and Support Organizations	2.97%
· Operations	2.38%
· City/Municipal	1.78%
· Other	11.90%

RESULTS

Measurement Validation

The measures are refined and validated using reliability and exploratory factor analysis. Internal consistency estimates of reliability, Cronbach's alpha, were computed for the five dimensions of task uncertainty (novelty, unanalyzability, amount of information, urgency, and impact) and two purposes for knowledge sharing (exploration and exploitation). As shown in Table 3, the reliability estimates for all variables are above .60, indicating satisfactory levels of reliability (Hair, Anderson, Tatham & Black, 1998).

Table 3. Reliability estimates (Cronbach's alphas) for the constructs

Task Uncertainty Dimensions	Cronbach's Alpha	Number of Items
Task Novelty	0.826	3
Task Unanalyzability	0.792	5
Amount of Task Information	0.797	3
Task Urgency	0.647	3
Task Impact	0.654	3
Knowledge Sharing Purposes		
Knowledge for Exploration	0.813	4
Knowledge for Exploitation	0.776	4

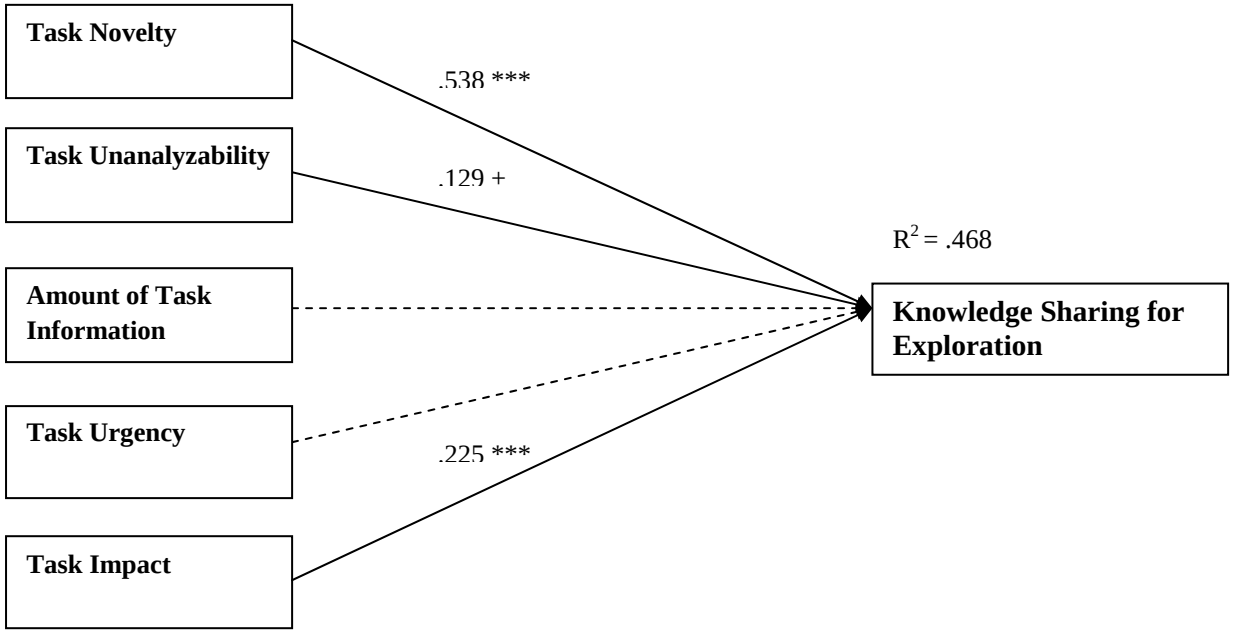
The convergent and discriminant validity of the measures were validated using factor analysis. The dimensionality of 17 items from the task uncertainty measure and 8 items from the knowledge sharing purposes measure were analyzed using maximum likelihood factor analysis with varimax rotations. The rotated factor matrix for the 17 task uncertainty items yielded 5 interpretable factors (novelty, unanalyzability, amount of information, urgency, and impact) that are consistent with the five dimensions that were conceptualized for task uncertainty. And the 8 items that we used to measure knowledge sharing purpose yielded two interpretable factors that are consistent with our definitions of knowledge sharing for the purpose of exploration and knowledge sharing for the purpose of exploitation.

Hypothesis Testing Results

To test the research model, two regression analyses were performed with the five 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. Significant results of the first regression analysis are shown in Figure 2. Task novelty is the most significant positive determinant (β = 0.538, p <0.001) of knowledge sharing for exploration. Task impact is another uncertainty dimension that is a significant determinant (β = 0.225, p <0.001) of knowledge sharing for exploration. And lastly, task unanalyzability, is another uncertainty dimension that is a significant determinant (β = 0.129, p <0.01). Therefore Hypothesis 1a, 1b, and 1d are supported while hypothesis 1c and 1e are not supported. Overall, the task uncertainty dimensions explained 46.8% of variance in knowledge sharing for exploration.

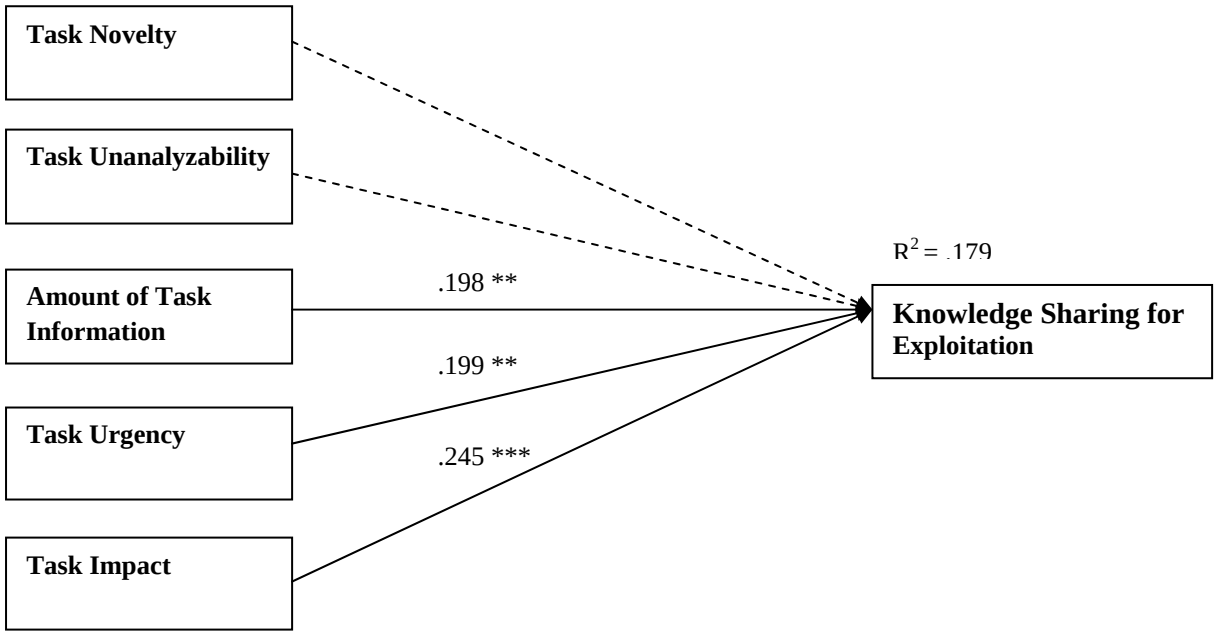
Significant results of the second regression analysis with the five dimensions of task uncertainty as independent variables and knowledge sharing for exploitation as dependent variable are shown in Figure 3. Task impact is the most significant dimension of task uncertainty that determines knowledge sharing for exploitation (β = 0.245, p <0.001). Task urgency (β = 0.199, p <0.005) and amount of take information (β = 0.198, p <0.005) are two other uncertainty dimensions that are significant determinants of knowledge sharing for exploitation. Therefore, Hypothesis 2c, 2d and 2e are supported. An interesting result is that task unanalyzability is significantly associated with knowledge sharing for the purpose of exploitation purpose, but the direction is opposite as we proposed. Therefore, Hypothesis 2a and 2b are not supported. Overall the task uncertainty dimensions explained 17.9% of variances in knowledge sharing for exploitation.

Figure 2. Model Testing: Knowledge Sharing for Exploration



Note: Dotted lines indicate insignificant paths

Figure 3. Model Testing: Knowledge Sharing for Exploitation.



Note: Dotted lines indicate insignificant paths

DISCUSSION AND CONCLUSIONS

We aimed at achieving two research objectives in this paper. First, we conceptualized dimensions of task uncertainty and developed measures for assessing those dimensions. Second, we tested the relationships between the dimensions of task uncertainty and the purposes for knowledge sharing.

Using a sample of survey responses from emergency managers, we tested the relationships between the five dimensions of task uncertainty and the two knowledge sharing purposes of exploration and exploitation. The test results supported half of the hypotheses we proposed (H1a, H1b, and H1d; H2c, H2d and H2e). Knowledge sharing for the purpose of exploration is positively associated with task novelty, unanalyzability, and impact. On the other hand, knowledge sharing for exploitation was positively associated with task urgency, impact, and the amount of information. Lastly, knowledge sharing for exploitation is positively associated with tasks characterized by high uncertainty.

The results for hypothesis H1c did not support the claim that task urgency determines knowledge sharing for the purpose of exploration. A reason why this hypothesis might not have been supported is that given the short time span to react and make a quick decision in this kind of urgent tasks (where for example lives may on the line) there is no time to engage in activities associated with knowledge sharing for exploration. These kinds of tasks must be executed effectively to avoid fatalities. Research hypothesis H1e, which states the positive relationship between tasks characteristics related to the amount of information and knowledge sharing for the purpose of exploration, was not supported. One possible explanation for this outcome may that the lack of sufficient information to perform this task may not have provided sufficient uncertainty to the task as compared with some of the other dynamic characteristics of the task. Lastly, the results for hypothesis H2a which states that task novelty is positively associated with knowledge sharing for exploitation was not supported. An explanation for this result could be attributed to the intrinsic nature of task novelty, where there is no previous information or knowledge available to address a course of action for this task. An unexpected result was the significant negative relationship between task unanalyzability and knowledge sharing for exploitation (hypothesis H2b). One possible explanation for this result may be that the less structured and ambiguous the task is, the less emergency personnel know about what information and knowledge to explore and exploit when completing the task.

Our results have significant implications for research. While it has been widely recognized that disaster management tasks are difficult to perform because they are inherently uncertain, little research has been reported that examines the dimensions that constitute task uncertainty. Most research has treated task uncertainty as a single dimension construct. Our research suggests that task uncertainty is a multi-facet construct. The five dimensions and the corresponding measures that we developed and empirically validated provide a starting point for theory development and testing. Second, our testing results of the complex relationships between the five dimensions of task uncertainty and the two purposes for knowledge sharing suggest a rich set of theories can be developed to explain conditions under which knowledge sharing for exploration is required and others under which knowledge sharing for exploitation may be required. Third, this study results suggest that knowledge sharing for the purpose of exploration is associated with tasks uncertainty dimensions of novelty, unanalyzability, and impact. In contrast, knowledge sharing for the purpose of exploitation is associated with task uncertainty dimensions of unanalyzability, amount of information, urgency, and impact.

Our research also has important implications for practice. While practitioners often attribute the challenges they face in successfully managing disaster tasks to the high uncertainties embedded in the tasks, they often cannot effectively articulate and assess the specific types of uncertainties that they encounter during the disposition of a specific task. The framework of the five dimensions of task uncertainty can be used by managers as a language to describe and distinguish different types of task uncertainties.

Further, the measures that we developed and validated in this research can be used by managers at the planning stages of standard operating procedures before a disaster event occurs or when the after action report processes take place after a disaster event occurred to assess the potential levels of uncertainty that they might face when responding to a particular task. In addition, the relationships between task uncertainty dimensions and knowledge sharing purposes provide insights and guidelines that managers can use to determine whether they should focus on knowledge sharing for exploration or knowledge sharing for exploitation, or both, when facing a given set of uncertainty dimensions.

RESEARCH LIMITATIONS AND FUTURE RESEARCH OPPORTUNITIES

The limitations of this research work are basically related to the task characteristics addressed in this work. Across the research literature, there are other task characteristics found such as complexity, variety, and interdependence [Dean and Snell, 1991]; however, these task characteristics are more intrinsic (also refereed as static) to the nature of the task as opposed to dynamic and uncertain. For this reason, this work purposely left out these intrinsic (static) task characteristic in this research. Also, our target survey respondents were those involved in disaster management response activities at the Miami-Dade County Office of Emergency Management. It is recommended for further studies to research into other offices of emergency management at the city, county, state, and federal government.

Important research still issues remain to be explored, in terms of how knowledge sharing affects task performance. Therefore, other future studies may extend this research by examining the mediating role of knowledge sharing between task uncertainty dimensions and task performance. We hope this research serves as a stepping stone for developing a stream of research that will cumulatively form and test a rich set of theories that could provide useful guidelines for helping emergency management organizations better respond to uncertain tasks when restoring a community to continuity following a disaster.

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