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Rui Chen
Ball State University, Rchen3@bsu.edu

Sushil K. Sharma
Ball State University, ssharma@bsu.edu

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Organizational Capabilities in Emergency Incident Response: An Empirical Examination

Rui Chen
Ball State University
rchen3@bsu.edu

Sushil K Sharma
Ball State University
ssharma@bsu.edu

ABSTRACT

Emergency incidents interrupt socio-economic systems and cause significant loss of human life and property. To date, there is a dearth of empirical research that investigates the key organizational capabilities that impact incident response outcomes. Through the lens of capability literature, we identify and contend that information systems capabilities and human capabilities jointly determine response functional competency, which in turn shapes the response process performance. Further we identify the major sources of these two important response capabilities. We validate the research model using survey data that is collected from 119 fire chiefs and find strong support to the research model. The current study confirms the imperative roles of information systems capabilities and human capabilities, and it therefore contributes to the emergency response literature. Findings that are reported also help incident response organizations to prioritize their investment and training resources on interoperable communication systems, resource management systems, teamwork, and stress resistance.

Keywords

Emergency incident, incident response, capability literature, survey

INTRODUCTION

Emergency response is the process of gathering and deploying resources to reduce loss of life and property when an incident strikes (e.g., Gulf coast oil explosion on April 20, 2010). Emergency incidents may be natural or manmade and include traffic accidents, fire and explosion, floods, tornados, earthquakes, nuclear or biological attacks, chemical leakage, and cyber-attacks. To minimize incident loss, it is imperative that response teams properly exercise all task-critical capabilities, technical and non-technical, to mitigate the immediate threats and bring the affected community back to normal. Although there have been many successes, failures in incident response are frequently documented in large scale incidents such as the 9/11 attack and Hurricane Katrina. Understanding of past responses and informed preparation for future responses can increase efficiency and ultimately efficacy.

Despite the significance of incident response, there is a dearth of studies that explore incident management and identify the imperative success factors. The vast majority of the prior literature in this area explores the technical designs of emergency response systems. Little is known about the management of incident response systems and response organizations. This article represents a preliminary effort to answer the research question of "*What organizational capabilities are imperative to support incident response?*" Bharadwaj suggests that technology capabilities combine or co-presents with other organizational capabilities (Bharadwaj 2000). Similarly Wade and Hulland advocate that "*information systems exert their influence on the firm through complementary relationships with other firm assets and capabilities*" (Wade et al. 2004). In line with the capability literature, we identify information systems capabilities and human capabilities as the two focal response capabilities, and we capture the major sources that build these capabilities as interoperable communication systems, resource management systems, teamwork, and stress resistance. We contend that information system capabilities and management capabilities jointly cultivate incident response functional competency, which in turn shapes emergency response process outcomes such as response process effectiveness and stakeholder satisfaction. We validate the research model using empirical data that is collected from a research survey for the fire chiefs across the U.S. The analysis results support the research hypotheses.

This paper makes a noticeable contribution to the emergency response literature. Empirical research in emergency response is scanty with very few exceptions such as (Chen et al. 2010). Our paper is among the first to apply established management frameworks into emergency response phenomenon and to identify critical organizational capabilities that impact incident response outcomes. It further validates the research model using data from a nationwide survey for fire chiefs; empirical survey data as such is hard to find and is rare in prior emergency response studies. The current study therefore directly contributes to the development of emergency response literature and helps lay the foundation for future research. Findings

that are reported also inform practice as they help incident response organizations to prioritize their investment and training resources on interoperable communication systems, resource management systems, teamwork, and stress resistance.

The rest of the paper is organized as follows: the subsequent section reviews the literature as well as the theoretical underpinning of the current study. Next we present the research model and hypotheses. This is followed by a discussion of research methodology and data analysis. We conclude the paper by discussing its contributions and venues for future research.

LITERATURE REVIEW AND THEORETICAL BACKGROUND

Literature Review

Technology-enabled emergency management has been the interest of information system discipline since the 1980s. In the wake of incidents such as the 9/11 attack, more research endeavors have been observed. Existing research in emergency management has primarily focused on the principles of emergency response system design and evaluation. This stream of research concerns the development of general design principles for dynamic emergency response management information systems (Turoff et al. 2004). There have been several efforts each involving a unique approach. Chen et al explored system designs that support simple-single, complex-single, and multi-incident emergencies (Chen et al. 2007). Others have proposed methods for assessing the quality of emergency information systems (Papamichail et al. 2005), while still others have developed and validated instruments that evaluate the efficiency of critical incident management systems (Kim et al. 2007). Some researchers in this stream have developed architectures and a prototype of a virtual information center (VIC) (Bui et al. 2001), while others have developed palm-based mobile clinical support systems for Mobile Emergency Triage (MET) (Michalowski et al. 2003). This stream also includes papers that have examined the use of data warehousing in the design of bioterrorism surveillance systems (Berndt et al. 2007). Chen et al. developed a data model to support information sharing among key stakeholders in chemical incident response (Chen et al. 2008). In a similar vein, Fruhling designed and analyzed a public health emergency response system STATPack (Fruhling 2008).

Much of the advancement so far is achieved through technology-oriented designs and analysis of life experience. Empirical studies that borrow established management literature to examine incident response phenomenon are rare except pioneer studies such as (Chen et al. 2010). In this subsequent section, we draw on capability literature to offer a preliminary framework that helps explain the imperative factors that affect incident response management.

Theoretical Background

In this paper, we explore emergency response management through capability literature. Capability literature argues that organizations create competitive performance by collecting, binding, and leveraging firm resources to create organizational capabilities (Grant 1991; Makadok 2001). Organizational capability is defined as "*a set of differentiated skills, complementary assets, and routines that provide the basis for a firm's competitive capacities and sustainable advantage in a particular business*" (Teece et al. 1990). Capabilities are repeatable patterns of actions that are effective in utilizing resources in meeting operational and strategic goals and objectives. Capabilities function through procedures and processes that allow organizations to coordinate activities and strategically utilize task critical assets.

Leonard-Barton suggested that organizational capability is embodied in employee knowledge and skills and embedded in technical systems as well (Leonard-Barton 1992). Knowledge and skills embodied in people are those that are most often associated with capabilities and one that is relevant to innovative organizational practices. These knowledge and skills encompass organizational specific understanding in firm procedures, policies, and operational techniques. Technical systems, on the other hand, are co-structured and created by employee, organizational routines, and the social environment over years of accumulation. These physical productions of information systems represent complications of knowledge and relatively more important to organizations that have intensive demand on information processing, decision making, coordination, and collaboration. Following the capability literature, in this paper, we recognize information systems capabilities and human capabilities as two focal organizational capabilities that may affect incident response.

CONCEPTUAL MODEL AND RESEARCH HYPOTHESES

In this section we develop a theoretical model that highlights the imperative roles of information systems capabilities and human capabilities in supporting incident response (see Figure 1). The model suggests that, within an incident response organization, the two organizational capabilities jointly shape the functional competency of a response organization, which in turn affects the response process outcomes. Drawing upon pertinent literature, the research model underlines the effective use of interoperable communication systems and resource management systems as key information systems capabilities and recognizes teamwork and stress resistance as primary human capabilities. The research model finally considers response effectiveness and stakeholder satisfaction as the main performance indicators of incident response process.

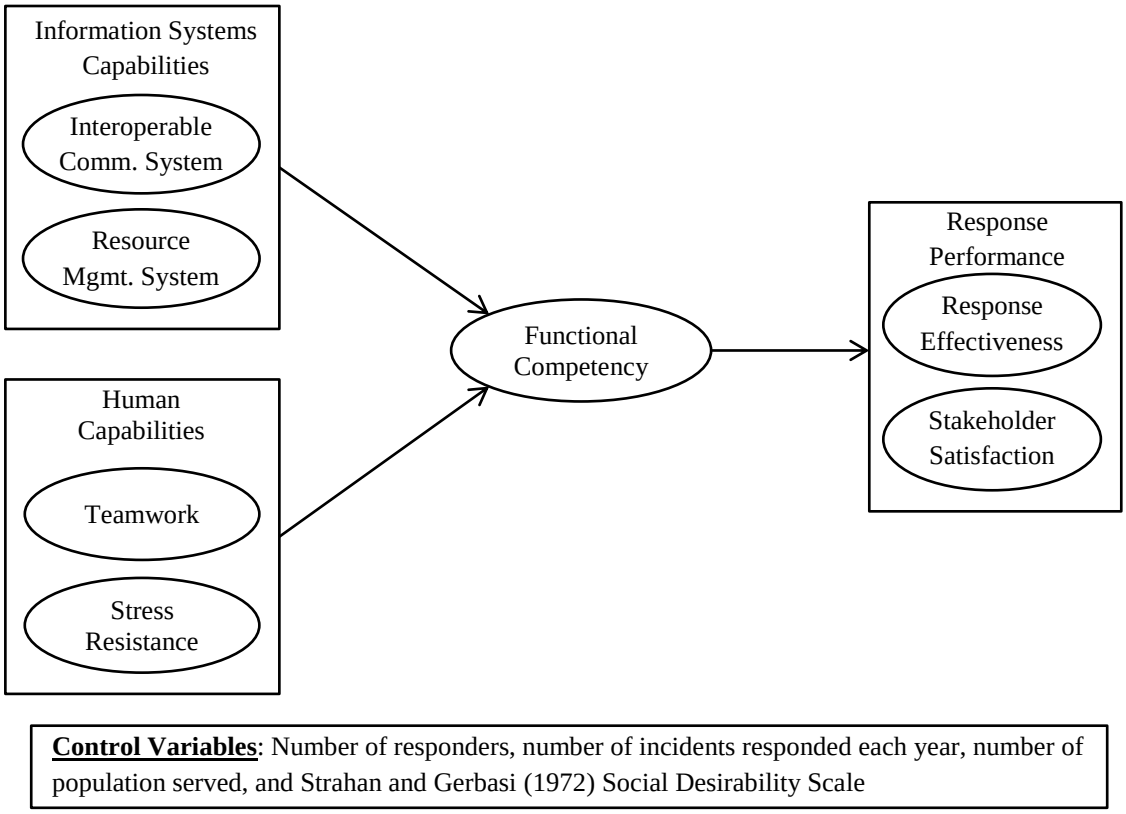


Figure 1. Research Model

Information Systems Capabilities

Bharadwaj et al theorized IT capabilities and identified major contributors such as IT business process integration and IT infrastructure (Bharadwaj et al. 1999). IT business process integration refers to the ability of an organization to align IT investments with organization objectives. It requires the restructuring of existing IT systems and processes to ensure that business is served and that new opportunities for process efficiency are exploited. IT infrastructure, on the other hand, refers to the foundation for organizational applications and services and it consists of data, network, and processing architectures. Efficiency and reliability of IT infrastructure influence the reach and range of opportunities available to organizations.

Within the context of emergency response, we consider two imperative information systems enabled capabilities: effective use of *Interoperable communication systems (ICS)* and effective use of *resource management systems (RMS)*. Post-analyses of major extreme events reveal that communication is critical for effective emergency response. The lack of consistent data standards for current emergency management practice, however, hinders efficient critical communication among incident responders. The U.S. Department of Homeland Security (DHS) has pointed out that response agencies typically use systems that are heterogeneous and independently operated and managed (DHS 2008). When these systems are not interoperable, response agencies cannot share task-critical information in a timely manner. As a consequence, their collaboration and coordination in incident response will not be possible. To this end, an effective ICS will help improve an emergency response organization with its functional competency, which is defined as the ability to effectively execute operational emergency response processes.

Hypothesis 1: Effective use of ICS will positively relate to functional competency.

Meanwhile, emergency response resource is defined by The U.S. DHS as "*personnel, teams, facilities, supplies, and major items of equipment available for assignment to or use during incidents*" [DHS 2004]. They may be deployed in configurations of single asset, task forces, or strike teams. In the U.S., resources are often limited in most response districts due to a lack of financial resources. To this end, resource management systems (RMS) may be employed to properly manage personnel and organizational contacts, training, certification, and special skills; equipment inventory for organizations, departments, and facilities; and equipment description and specification. They may also match available assets with requests,

schedule transportation and delivery, and track the deployed asset through integrated Geographic Information Systems. An effective RMS is therefore likely to strengthen response operations. And thus, we postulate:

Hypothesis 2: Effective use of RMS will positively relate to functional competency.

Human Capabilities

When response organizations are considered, the literature of emergency response has highlighted several management capabilities that are imperative to support response functions: teamwork and stress resistance. In response to an emergency incident, emergency responders work in teams to form attack forces and work collaboratively to create synergy. Take a residential fire incident for example, the onsite response team may consist of first responders who secure the perimeter, launch attacks from multiple entries (e.g., front door and back door), operate tanks for water supply, and stand by as backup forces. As an incident changes its course of development, response teams may be restructured to cope with the changing tasks requirements. Responders may join or leave an existing response team and assume different roles during an incident. The quality of the teamwork, therefore, affects how well first responders are able to work with one another in a cooperative manner. Good teamwork aligns members towards a common goal of the incident response and leverages their response abilities. And thus we expect:

Hypothesis 3: Effective teamwork will positively relate to functional competency.

Responders' ability to execute response operations may be hampered by the presence of psychological stress. Due to the fact that incidents are highly unexpected in nature and that they are of high social and economic impacts, emergency response introduces psychological stress which concerns the state of mental tension, preoccupation, and agitation. Responders may also experience stress out of concern for their families who may be in the affected region. This psychological stress may lead to physical and mental dysfunction and disorder, prohibiting responders from fully engaging in incident response. Stressed individuals tend to underperform in their tasks and even make mistakes, creating disasters inside a disaster. Furthermore, psychological stress may also reduce the ability of individuals to improvise on issues that are not addressable through routine procedures. As a consequence, stress resistance is vital to responders when undertaking emergency response tasks. When responders are stress resistant, they are more likely to perform well under the demanding environment. Therefore we hypothesize:

Hypothesis 4: Effective stress resistance will positively relate to functional competency.

Lastly, we expect that a higher functional competency of emergency response organizations will lead to more positive response outcomes. When a response organization is equipped with greater competency to execute operational emergency response processes, they are more likely to reduce the loss of human lives and properties while subsequently satisfying the affected community.

Hypothesis 5: Functional competency will positively relate to response effectiveness.

Hypothesis 6: Functional competency will positively relate to stakeholder satisfaction.

METHODOLOGY AND DATA ANALYSES

The research model was empirically tested using survey data collected from chiefs of 119 fire companies across the U.S. The fire chiefs were guaranteed both confidentiality and access to the aggregated survey results. Participation was voluntary and no incentive was offered. Table 1 provides brief demographic information. Survey data from emergency response organizations is rare in information systems research. We are among the first to collect empirical data for research analyses.

Average # of employees	Average # of citizen served	Average # of incidents responded annually (over the last 3yr)	Average annual operational budget (over the last 3yr)	Average percentage of annual budget for information technologies (over the last 3yr)
104	71,893	8,629	$11,923,639	4.88%

Table 1. Demographic Information

Most measurement items for the principal constructs in this study were borrowed directly from existing measures to ensure validity. The others were adapted to fit the current research context and the literature sources of the principal constructs. In the survey, we also included a short version of the Crowne and Marlowe's Social Desirability Scale to control for the potential impact of social desirability on the research model (Strahan et al. 1972). Due to page limit, the measurement items are omitted from here. We employed partial least squares (PLS) which employs a component-based approach for estimation and places minimal restrictions on sample size and residual distributions.

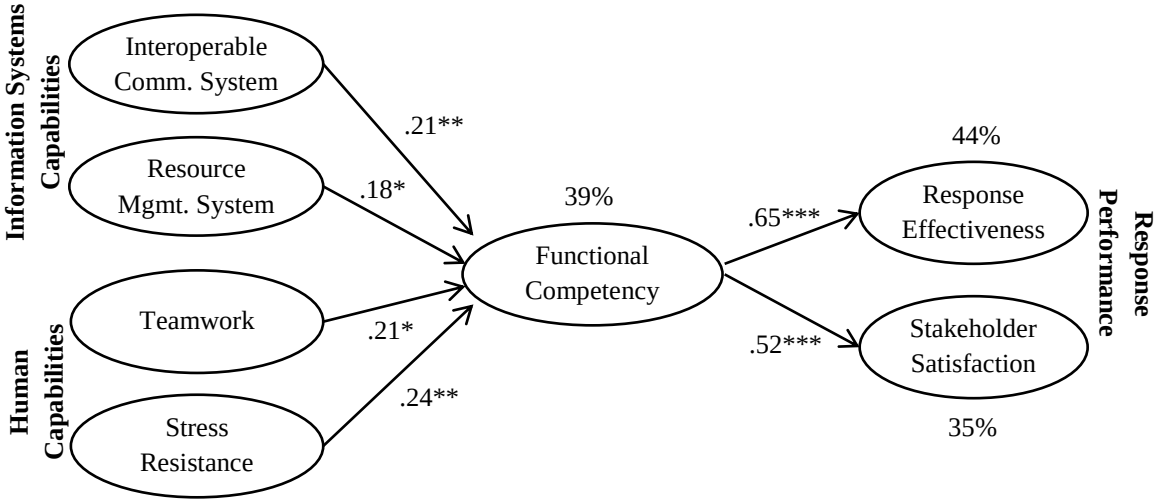
Table 2 reports the correlation matrix, the AVEs, and the descriptive statistics of the principal constructs. Measurement reliabilities are excellent. Convergent and discriminant validities are also excellent. We checked for the extent of common method bias and found no evidence. Details of the tests are omitted here to conserve page length.

	Principal Constructs	Mean	Stdev	CR	CA	1	2	3	4	5	6	7
1	Functional Competency	5.66	0.99	.91	.86	**.88**	0	0	0	0	0	0
2	Interoperable Comm. System	3.33	1.54	.97	.95	.45	**.96**	0	0	0	0	0
3	Response Effectiveness	5.67	0.90	.92	.88	.65	.42	**.90**	0	0	0	0
4	Resource Mgmt System	3.64	1.63	.96	.93	.41	.60	.35	**.96**	0	0	0
5	Stakeholder Satisfaction	5.86	0.84	.87	.78	.55	.35	.65	.45	**.83**	0	0
6	Stress Resistance	5.38	0.89	.93	.88	.47	.26	.43	.17	.52	**.90**	0
7	Teamwork	6.02	0.88	.95	.90	.45	.24	.33	.22	.44	.68	**.95**

CR: Composite Reliability, CA: Cronbach's Alpha
The diagonal elements (in bold) represent the square root of AVE

Table 2. Descriptive Statistics, Correlations, and Average Variance Extracted

The PLS path coefficients are shown in Figure 2. All paths are statistically significant. The structural model explains 39% of the variance in functional competency, 44% of variance in response effectiveness, and 35% of variance in stakeholder satisfaction. The theoretical model thus offers satisfactory explanatory power in capturing emergency management.



Control Variables: Number of responders, number of incidents responded each year, number of population served, and Strahan and Gerbasi Social Desirability Scale

Figure 2. PLS Results

CONCLUSION

In this paper we explore emergency response through the lens of capability literature. In line with the capability literature, the research model posits that information systems capabilities and human capabilities jointly cultivate the functional competency of incident response, which in turn shapes the response outcomes. Drawing upon prior studies of incident response, we identify effective interoperable communication systems and resource management systems as two important information systems capabilities and identify teamwork and stress resistance as two focal human capabilities. The empirical

survey data that was collected from 119 fire chiefs attests to the model validity and confirms the hypothesized relationships among the principal research constructs.

Future studies include a continued search for the imperative sources of information systems capabilities and human capabilities. In addition, it will be interesting to find out how environment factors (e.g., response task characteristics) influence the impact of the two capabilities on incident response outcome. Finally, it is important to detect and address potential self-selection issues with the current research sample.

REFERENCES

Omitted due to page limit. Available upon request.