What Benefits Can Be Brought Forward by Adopting RFID in Emergency Management?

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ABSTRACT

This paper addresses the impacts of RFID (radio frequency identification) adoption on the performance of emergency management organizations. The research question queries: What are the impacts of RFID adoption on the performance of emergency management operations? In order to investigate the hypothesized impacts including reduced response time, efficient tagging and tracking, compatibility, reduced labor cost and robustness, multiple case study has been employed as the research method. It is anticipated that the findings of this research will assist the emergency management organizations to better plan the adoption of pertinent technologies such as RFID for emergency operations.

Keywords: Radio frequency identification, multiple case study, emergency management

1. INTRODUCTION

Generally, domain-specific requirements play an important role in adoption of a technology. For instance, minimizing the bullwhip effect, maximizing the efficiency of conducting activities, minimizing cycle times and achieving an acceptable level of quality along the supply chain are a few perceived performance impacts behind technological adoption in supply chain management [1]. Similarly, for retailers to adopt a new technology, the improvement in efficiency, accuracy and security of both supply chain and inventory management with considerable cost savings serves as key drivers to the technological adoption process [2]. Consistent with this line of arguments Goodhue & Thompson [3] presented three performance impacts including efficiency, effectiveness and productivity resulted as a successful adoption of IT (information technology) by individuals. In the TTF (task-technology fit) model, Goodhue & Thompson [3] further argued that successful ‘fit’ between task and technology characteristics yields the above mentioned performance impacts. Unlike the original TTF that addresses the post-adoption phase of IT, this paper addresses the phase before the actual deployment of RFID in emergency management. Moreover, by considering the unique characteristics of emergency management and varying nature of RFID from IT, this paper adapted the TTF and highlighted five perceived performance impacts which trigger the successful adoption of RFID in emergency management including reduced response time, efficient tagging/tracking, compatibility, reduced labor cost and robustness. It is understood that emergency management organizations are willing to try to achieve better performance impacts by adopting a pertinent technology such as RFID. Multiple case study is adopted to unfold the role and significance of such performance impacts in RFID adoption process.

The structure of paper is as follows: after introduction presented in Section I, Section II of the paper presents our previous work related to the adoption of RFID in emergency management. Then, the detailed description and the hypotheses related to the perceived performance impacts are discussed in Section III. Methodology for this research along with the approach to data collection and analysis is discussed in Section IV. The research findings drawn from multiple case study are presented in Section V. The paper ends with a conclusion section.

2. PREVIOUS WORK

Our research aims to explore the potential of RFID in emergency management. In order to do so, we adapted TTF model and developed a research framework based on loose interpretation of TTF. Such framework addressed various aspects of RFID adoption in emergency management including:

a. Task characteristics of emergency management [4].
b. Contributing factors in adoption of RFID in emergency management [5].
c. Perceived performance impacts of RFID adoption on emergency management organizations.

In our previous work, we submitted that the best ‘fit’ between task characteristics of emergency management (such as authentication, automation, tagging/tracking and information management) [4] and features offered by RFID yields several benefits to emergency management
organizations, furthermore, several factors which contribute in decision of adopting RFID in emergency management have been discussed in [5].

Based on that, this paper explores and discusses several performance impacts which resulted from the successful adoption of RFID in emergency management. By using a conceptual study, five perceived performance impacts are presented and are discussed in this paper. Furthermore, five hypotheses (one hypothesis associated with each perceived performance impact) are also developed and discussed below:

3. PERCEIVED PERFORMANCE IMPACTS AND THEIR ASSOCIATED HYPOTHESIS

It is anticipated that successful deployment of RFID in emergency management results in some improvements in organizational performance. Therefore, in order to advocate the performance impacts of RFID adoption in emergency management, three performance impacts (such as effectiveness, performance and productivity) suggested by Goodhue & Thompson [3] are adapted along with the findings of emergency related studies [6-9]. Consequently, five performance impacts such as reduced response time, efficient tagging and tracking, compatibility, reduced labour cost and robustness are derived from the theory of TTF. Such performance impacts address the impacts of RFID adoption on emergency management and are as follows:

3.1. Reduced Response Time

Goodhue & Thompson [3] suggested that a proper ‘fit’ between task and technology characteristics results in better performance of users. Similarly, it is anticipated that a proper ‘fit’ between task characteristics of emergency management and technology characteristics of RFID would help in increasing the effectiveness of emergency management organizations. By using RFID for various emergency related operations, emergency management organizations are expected to be more effective in their operations such as by responding to emergencies in minimum possible time. Overall, response time is considered as a crucial factor during and after an emergency situation [10]. Therefore, emergency managers are quite concerned with the time required to respond to an emergency [11]. Shaluf [12] asserted that quick response to emergencies help in saving lives, minimizing property damages and enhance the beginning of recovery from emergencies. In the case of RFID as a potential technology to be used in emergency management, it has the ability to minimize the time required to respond an emergency situation and also shrinks the procedural delays in all phases of emergency management life cycle. For instance, Fry & Lenert [6] proposed an integrated hardware-software system (MASCAL) based on RFID technology that enhanced the management of resources at a hospital during a mass causality situation. It includes interfaces for a hospital command centre, local area managers (emergency room, operating suites, radiology, etc.) and registration personnel. Its potential value lied in providing visibility into supply and demand workflows, augmented with select data considered helpful in making appropriate management decisions. Based on the above discussion, this research argues that RFID has a potential to help organizations in responding to emergencies in the minimum possible time. To support the above argument, following hypothesis is developed:

**Hypothesis 1 (H1):** Adoption of RFID in emergency management will have a significant positive relationship with reduced response time to an emergency situation.

3.2. Efficient Tagging and Tracking

Efficiency is generally described as useful work per quantity of energy. As compared to the other technologies used for tracking such as GIS (global information system) and GPS (global positioning system); RFID needs fewer efforts in order to put it in action. Furthermore, the characteristics of RFID such as contactless and no-line-of-sight put this technology on top priority where efficient and reliable tracking is required. During and after an emergency situation, tracking humans (people management) and other objects (management) are very important and required specific tools and technologies for such purpose [13]. In the case of RFID in emergency management, it can help in managing people and other objects before, during and after an emergency situation. Example of using RFID during an emergency situation is the placement of radio frequency identification device (RFID) microchips inside victim bodies that provided a practical solution to the problems of body tagging and attribution in the DVI (disaster victim identification) setting encountered by the Austrian DVI team in Thailand in early 2005 [9]. The following hypothesis describes the association of use of technology with efficient tagging and tracking during emergency situations:

**Hypothesis 2 (H2):** Adoption of RFID in emergency management for tagging and tracking of people and other objects yields better people and object management.

3.3. Compatibility

Generally, working conditions are not normal during emergencies. Unfavorable working conditions and task requirements of emergency management are hard to carry out by the use of only one technology. Overall,
emergency management need “teamwork” of technologies. Therefore, a technology which offers better compatibility with other technologies is highly desired. RFID has ability to work along with various other technologies. Compatibility of RFID with other technologies such as telecommunication, information technology, and robotics has already been proven [6, 14-16]. Hence, to deal with emergency situation, RFID can play an important role with other supporting technologies in emergency management activities. The following hypothesis was developed to describe the association between compatibility and technology used in emergency management:

**Hypothesis 3 (H3):** Adoption of RFID in emergency management will have positive relationship with its compatibility with other technologies.

3.4. Reduced Labour Cost

High labor costs are involved in gathering data in various phases of emergency management [11]. Since RFID tags can be read without having a person to gather data, there can be significant labor savings. As line of sight is not required, and since multiple tags can be read simultaneously instead of one at a time, the savings on data collection could be huge. Reduction in labor cost with RFID deployment in many sectors has already been proven [17-20]. Similarly, the labor saving due to RFID use in various emergency management activities can lead to significant performance impact. The following hypothesis represents the association between the uses of technology with the reduction in labor cost.

**Hypothesis 4 (H4):** Adoption of RFID in emergency management will have negative relationship with the labor cost and other expected benefits.

3.5. Robustness

To work in an emergency situation, technology should be reliable and robust enough to survive in the harsh and varying conditions of an emergency. According to Graves [21] robust network connectivity is the underlying critical ingredient to all timely information sharing during emergencies. In short, the technologies deployed in emergencies are likely to face extreme weather conditions to adverse working environments. RFID is a technology that can consistently work in different environmental and situational circumstances. According to Massload [22], commonly RFID tag specifications include 16 Bytes memory, - 40°C to 185°C for its temperature range, with three years standard life cycle at one data pulse every two seconds. Such specification makes RFID tag an attractive option to be used in many emergency management activities because of its technological robustness that can survive even in unfavorable environmental conditions. The association between use of technology and the robustness is presented in the following hypothesis:

**Hypothesis 5 (H5):** Adoption of RFID in emergency management will have significant positive relationship with robustness which is highly desired in emergency management life cycle.

4. METHODOLOGY

Multiple case study method is adopted to test the hypotheses. The criteria in selecting the participating organizations are that they have already used or willing to use any technology such as RFID in emergency management. The selection criteria are imposed to achieve analytical generalization for emergency management organizations, whereas statistical generalization is targeted in this paper.

4.1. Number of Cases and Their Selection

To improve the generalisability of the research findings and performs the theoretical replication across the cases, five organizations were selected. In order to maintain the privacy of participating organizations, they are coded as A, B, C, D and E. The following table (Table 1) lists the details of the participating organizations along with the roles of representatives selected from each case organization.

4.2. Strategy for Data Collection and Data Analysis

In-depth interviews were sought from three types of informants (i) emergency managers (ii) senior executives and (iii) emergency coordinators. The interviews were conducted over eight month period from October 2007 to June 2008. During this period, data from multiple sources, such as formal in-depth interviews with the key participants, organizational web sites, organizational documents and telephonic conversation were collected. However, this paper mainly relies on formal in-depth interviews with key informants, whereas sources (official documents, organizations’ websites) other than formal interviews were primarily used to assist in understanding and explaining the interviews material and results. Once all the data was collected, it was transcribed in full and sent back to the participants for data verification. Pattern matching technique by using software (that is, NViVo) is used to analyse the empirical evidences collected from participating case organizations.
Table 1: Overview of Participating Organizations

<table>
<thead>
<tr>
<th>Case</th>
<th>Key Operations</th>
<th>Key Informant</th>
<th>Location</th>
</tr>
</thead>
</table>
| A    | • Responsible for the state disaster management arrangements, the core staffing of the State Disaster Coordination Centre and State Emergency Services  
      • Manages government support to Volunteer Rescue organizations. | Director, DO                  | Australia |
|      |                                                                              | Executive manager, DO         |          |
| B    | • Involved in different types of activities including fire drills, running trainings and coordinating with other emergency management agencies  
      • Maintains an emergency coordination centre which provides the necessary information to different emergency management agencies in the time of emergency within a large city in Australia. | Coordinator, EM               | Australia |
|      |                                                                              | Team leader, spatial systems  |          |
| C    | • Plays a key role countering the effects of emergencies.  
      • Perform a wide range of roles including planning for and responding to floods, severe storms, earthquakes, road accident, victims’ search and rescue. | Regional director, EM         | Australia |
|      |                                                                              | Director, EMC                 |          |
| D    | • Work with communities to reduce risk, mitigate the effects of, prepare to respond and recover from disasters. | Senior logistic officer       | Switzerland |
| E    | • Maintain supplies and running a national disaster victim enquiry service, together with other emergency management activities. | Logistics delegate           | New Zealand |


5. EMPIRICAL FINDINGS

Analysis of empirical findings collected from case organizations revealed that reduced response time, efficient tagging/tracking, compatibility and robustness are the most important performance impacts resulted in the successful adoption of RFID in emergency management. Similarly their associated hypothesis (H1, H2, H3, H4, H5) were also strongly supported. On the other hand, reduced labor cost and its associated hypothesis was partially supported by case study participants. The following table (Table 2) presents the outcome of five hypotheses (H1 – H5) associated with each perceived performance impacts.

Table 2: Research Findings

<table>
<thead>
<tr>
<th>Case</th>
<th>Participant</th>
<th>H1</th>
<th>H2</th>
<th>H3</th>
<th>H4</th>
<th>H5</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Director, DO</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
</tr>
<tr>
<td></td>
<td>Executive manager, DO</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
</tr>
<tr>
<td>B</td>
<td>Coordinator, EM</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Neutral</td>
<td>Supported</td>
</tr>
<tr>
<td></td>
<td>Team leader, spatial systems</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Neutral</td>
<td>Supported</td>
</tr>
<tr>
<td>C</td>
<td>Regional director, EM</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
</tr>
<tr>
<td></td>
<td>Director, EMC</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>None</td>
<td>Supported</td>
</tr>
<tr>
<td>D</td>
<td>Senior logistic officer</td>
<td>Supported</td>
<td>Supported</td>
<td>Supported</td>
<td>Neutral</td>
<td>Supported</td>
</tr>
<tr>
<td>E</td>
<td>Logistic delegate</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Neutral</td>
<td>Neutral</td>
</tr>
</tbody>
</table>

In addition to the five perceived performance impacts presented by this paper, few additional performance impacts were also suggested by participants of case organizations. In the context of additional performance impacts, representatives of case A highlighted the importance of warning systems before an emergency situation. It was further suggested that the warning system should be smart, quick and need less resources and should be able to pass required information (warning) to the public effectively and efficiently. Representative of case A revealed that passing the warning information to other emergency agencies is equally important as passing information to the public.

Careful consideration in generating and broadcasting processes of warning signals can be summarized by the followings activities:

a. Use of sensors to auto detects several types of signals.
b. Pass those signals to the alarms.
c. Process the signals.
d. Generate warnings.
e. Broadcast warning to the potential audience.

These activities fall under two groups of activities, namely automation (auto detection of inputs, pass signals to alarms, process the inputs) and information management (pass signals to the alarms, broadcast warnings to the public). Our previous research has already presented these two activities as the main activities involved in emergency management [4]. Therefore, the findings from case A further strengthened the significance of the major activities presented in this research.

Similar to the representative of case A, representative case B also suggested that, if the information can be accessed directly by the authorized external users, it can help in saving precious time of this organization which can be required in validating and providing the requested information. It was suggested that in deploying a rigorous and flawless authentication protocol, the role of technology in offering direct external access is crucial. This performance impact was also linked with the activities mentioned earlier in this research such as authentication and information management.

Representatives of case C and D did not suggest any other benefit except the five proposed in this research whereas the representative of case E further expressed the importance of response time, compatibility and robustness as perceived benefits and the role of technology in achieving these benefits.

In conclusion, performance impacts such as better warning system and direct data access mentioned by the representatives of case A and case B further supported the main activities of emergency management activities. Moreover, based on the empirical evidence collected from case organizations, Table 3 presents the importance of these potential benefits. The significance of such benefits and any other performance impacts were also presented in Table 3.

<table>
<thead>
<tr>
<th>PERFORMANCE IMPACT</th>
<th>Case A</th>
<th>Case B</th>
<th>Case C</th>
<th>Case D</th>
<th>Case E</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>S</td>
<td>N</td>
<td>NS</td>
<td>S</td>
<td>N</td>
</tr>
<tr>
<td>Response Time</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Tagging/Tracking</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Compatibility</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td>✓</td>
</tr>
<tr>
<td>Labor cost</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>Robustness</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td>Better warning system</td>
<td>Direct data access</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
</tbody>
</table>

Legend: S = Supported, N = Neutral, NS = Not Supported
CONCLUSION

This paper reported the empirical findings on performance impact of adopting RFID in emergency management. Based on the empirical findings, five hypotheses (H1 to H5) are also tested. The empirical findings of this research suggests that adoption of RFID in emergency management is mainly triggered by organizations’ goals to reduce response time, achieve better compatibility among their technological infrastructures and acquiring robust technologies which can work consistently in unfavorable working conditions. Similarly, efficient tagging/tracking was proved comparatively less important performance impact whereas empirical findings suggests that reduction in labour cost is the least important performance impact that triggers the adoption of RFID in emergency management.

REFERENCES