Decision Support Systems xxx (2013) xxx–xxx

Contents lists available at SciVerse ScienceDirect

Decision Support Systems

journal homepage: www.elsevier.com/locate/dss

Improving RFID adoption in Taiwan's healthcare industry based on a DEMATEL technique with a hybrid MCDM model

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ARTICLE INFO

Article history:
Received 16 June 2011
Received in revised form 11 June 2013
Accepted 11 June 2013
Available online xxxx

Keywords:
Healthcare industry
Radio frequency identification (RFID)
Decision making trial and evaluation laboratory (DEMATEL)
DANP (DEMATEL-based ANP)
Multiple criteria decision making (MCDM)
VIKOR

ABSTRACT

The use of radio frequency identification (RFID) technology has progressed tremendously in recent years. In the healthcare industry, the decision to adopt RFID technology is a problem requiring a multi-criteria decision analysis that involves both qualitative and quantitative factors. The evaluation of this decision may be based on imprecise information or uncertain data. Furthermore, there can be significant dependence and feedbacks between the different criteria and alternatives. However, most conventional decision models cannot capture these complex interrelationships. As a result, in this study we develop a general evaluation framework for industry evaluation, improvement and adoption of RFID. We use a hybrid Multiple Criteria Decision Making (MCDM) method known as DDANPV that combines DEMATEL (decision making trial and evaluation laboratory), DANP (DEMATEL-based ANP), and VIKOR to evaluate the factors that influence the adoption of RFID. Specifically, we study the adoption of RFID in Taiwan's healthcare industry. We find that technology integration is the most influential criterion and the strongest driver in the adoption of RFID of Taiwan's healthcare industry.

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1. Introduction

Radio frequency identification (RFID) is a communication technology that uses radio waves to exchange data. RFID has three components: (1) an antenna for transmitting and receiving signals; (2) a transponder programmed with the identification information; and (3) an RF module (reader) with a decoder or transceiver. RFID has many applications and is an increasingly valuable tool for enabling automatic identification and management. For many industries, RFID is not only a new alternative to existing tracking methods but is also a solution for a range of previously cost-prohibitive innovations in internal control and supply chain coordination [34,46].

RFID has existed for decades. This technology was originally used to identify and track flying aircrafts during the Second World War. Until recently, RFID was deemed to be too expensive and limited in functionality for many commercial applications. As the prices of RFID equipment and RFID tags have dropped in recent years, RFID applications have become increasingly prevalent. Cost is no longer a barrier. However, RFID has not been extensively adopted by the healthcare industry. The relatively conservative attitudes of healthcare providers have prevented hospitals from using the latest information technologies. Furthermore, technology adoption often depends on a critical mass being reached; a manager's decision to adopt a new technology often depends on the technology's diffusion rate, which, in turn, depends on the decisions made by other managers. Furthermore, even if a hospital decides to evaluate the relative costs and benefits of implementing RFID technology, no comprehensive evaluation and adoption model exists that can be used as a reference for the adoption of RFID in the healthcare industry. Thus, it is inappropriate to focus only on the cost of a new IT technology as the primary factor in its adoption [4,7,9,50].

Most of the conventional multi-criteria decision analysis (MCDA) models cannot handle the analysis of complex relationships among different hierarchical levels of criteria. However, the decision to adopt RFID requires a decision model that performs just that analysis. In this paper, we develop a hybrid MCDM model called DDANPV that combines DEMATEL, DANP, and VIKOR. DDANPV overcomes the limitations of existing decision models and can be used to help us analyze the factors that influence industry adoption of RFID technology. In particular, we use Taiwan's healthcare industry as an example to study the interdependence of the factors that influence the adoption of RFID in the healthcare industry, as well as to evaluate alternative RFID adoption processes to achieve the desired levels of performance from RFID technology.

This paper is organized into five sections. Section 2 reviews the literature on the implementation of RFID in the healthcare industry.

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http://dx.doi.org/10.1016/j.dss.2013.06.006

Please cite this article as: M.-T. Lu, et al., Improving RFID adoption in Taiwan's healthcare industry based on a DEMATEL technique with a hybrid MCDM model, Decision Support Systems (2013), http://dx.doi.org/10.1016/j.dss.2013.06.006

We will discuss the advances in evaluating the RFID adoption process, the selection criteria for adopting RFID technology, the decision models currently being used to determine whether RFID technology should be adopted, and the specific problems related to evaluating the RFID adoption process. Section 3 introduces the hybrid MCDM method called DDANPV. In Section 4, we use Taiwan's healthcare industry as an empirical example to illustrate how DDANPV could help select the best RFID adoption method and discuss the results. In Section 5, we draw conclusions.

2. The effects of evaluating the RFID adoption model in the healthcare industry

The purpose of this section is to survey the relevant studies in the RFID adoption process, to investigate and compare various evaluation frameworks, and to identify possible factors that influence the RFID adoption process in the healthcare industry. Due to the lack of previous research on the criteria used in evaluating RFID for adoption, this study expands upon a general evaluation framework used in other industries and compiles four primary factors—technology, organization, environment and cost—with the goal of identifying the criteria that are most crucial for the adoption of RFID.

2.1. Related literature on the factors influencing RFID adoption in the healthcare industry

RFID is one of the most promising technologies with the potential to increase supply chain visibility and improve process efficiency [45]. Once goods have RFID tags attached, their whereabouts can be tracked automatically by radio readers. With applications in transportation payments, asset management, retail sales, and item tracking, RFID technology provides greater inventory visibility, improves business and control processes, and enhances supply management efficiency [26,47]. Hence, many industries are in various stages of applying RFID to experimental projects to improve operational efficiency and gain competitive advantages [5]. RFID has also been receiving considerable attention in the healthcare industry because it addresses the vexing problem of locating people and things in healthcare operations, as demonstrated in the case study examined in this project. RFID applications can be classified into two or more major categories based on different objectives in the healthcare industry. However, we only use two alternatives ("patient tracking management performance (A_1)" and "asset tracking management performance (A_2)") from our project as examples to clearly illustrate two relatively good uses for RFID applications. The first set of applications is mainly designed for managing the patient-tracking system. For example, RFID is used in patient-tracking to automate the check-in process and other outbound logistical processes (i.e., activities that outsource the service to the customer in a service environment). In a healthcare setting, outbound logistics involve getting the right patient to the right place at the right time [21]. The second set of applications is also used for tracking purposes, but these applications are used to control assets. RFID offers active tags for tracking various healthcare assets, such as wheelchairs, infusion pumps and crash carts. In the healthcare environment, assets (e.g., equipment and staff) are essential to providing healthcare services to patients [21].

Schmitt et al. [38] reviewed related work and derived 25 adoption factors from the technological, organizational, and environmental dimensions of the RFID process. These researchers extracted the five most important factors affecting the process of RFID adoption and diffusion in the automotive industry. These factors included compatibility, costs, complexity, performance, and top management support, as well as most of the more technological characteristics. Schmitt et al. [38] concluded that the RFID adoption and diffusion processes were still in the early stages and that the basic technological issues had to be solved first. However, the organizational and environmental factors were found to be less important. Similarly, the inter-organizational factors did not play essential roles because most of the RFID deployments in the automotive industry were intra-organizational applications.

Brown and Russell [6] conducted an exploratory investigation to identify the factors that may influence RFID adoption in South African retail organizations. A combination of quantitative and qualitative data based on six retailers were collected and analyzed using the Technology, Organization, and Environment (TOE) framework. Brown and Russell [6] expounded upon the intention to adopt RFID technology using technological factors (i.e., relative advantage, compatibility, complexity, and cost), organizational factors (i.e., top management attitude, information technology expertise, organization size, and organizational readiness), and external factors (i.e., competitive pressure, external support, and the existence of change agents).

In addition to the TOE framework mentioned above, the key barriers to RFID adoption also stem from the high technology expenditures, such as the software and hardware costs, required by RFID [20]. When an organization plans to adopt RFID, both the implementation costs and the maintenance costs need to be evaluated carefully. Lean information technology budgets suggest that new technologies need to demonstrate compelling business reasons for adoption while promising benefits and short payback periods. As a result, most companies are still waiting for RFID technology to drop in price to make it a more affordable investment [12,20,36]. In addition to the cost-benefit analysis mentioned above, many factors contributing to the adoption of RFID are similar to the factors contributing to the recent adoption of e-commerce technology [12].

Previous studies on RFID adoption have not focused on all three TOE dimensions. Many authors have restricted their discussion to only a few key factors. For example, Hoske [13] highlighted the cost factor, while Jones et al. [18] examined private and public policies on RFID. Thus, in this paper, we take the TOE framework as a basis and add cost, resulting in technology, organization, environment, and cost (TOEC) as the four dimensions of our research framework. The factors relevant to the adoption of RFID within each dimension will be discussed below.

2.2. Criteria for evaluating the RFID adoption process

The criteria for evaluating the RFID adoption process are described below.

Technology dimension (D_1): Technological factors, also referred to as "innovation characteristics" in several studies on organizational adoption processes [36]. Technology integration, technology competence, and security concerns have all been suggested as important to the adoption of RFID technology and are used in our evaluation framework [37,39].

Organization dimension (D_2): Characteristics of the organization that is implementing the new technology are shown by Orlikowski [32] to be highly relevant to the adoption process. Several studies have supported this finding with respect to RFID adoption, with factors such as top management support, firm size, and organizational readiness considered to be potential influences [36,37,39].

Environment dimension (D_3): Orlikowski [32] highlights the role and influence of the external environment in an organization's decision to adopt new technology. Competitive pressure, partner support, and regulatory support are regarded as among the most important external factors [36,37,39].

Cost dimension (D_4): The benefits of any new innovation should exceed the costs of adopting it [36]. Therefore, the costs associated with a new technology have a major bearing on the decision of its adoption. In this respect, RFID technology is no exception [39]. Most companies still have doubts about whether the costs associated

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