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Structural equation modeling for multi-stage analysis on Radio Frequency Identification (RFID) diffusion in the health care industry

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ABSTRACT

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Faced with an increasingly competitive business environment, organizations in the health care industry are applying Radio Frequency Identification (RFID) to improve operational efficiency and to gain a competitive advantage over their competitors. This research provides a multi-stage analysis on the antecedents that affects the diffusion of RFID in the health care industry. Data collected from 182 health care organizations were analyzed using structural equation modeling analysis. The result shows that variables within the Technology-Organization-Environment (TOE) framework and the Diffusion of Innovation (DOI) theory have different effects on the evaluation, adoption, and routinization stages of RFID diffusion. This is one of few empirical studies on the factors influencing the diffusion of RFID in the health care industry. The results of this study will help decision makers in the health care industry to better understand the diffusion process of RFID, and to formulate strategies for successful diffusion of RFID.

1. Introduction

The health care industry is currently one of the fastest growing industries (Curry & Sinclair, 2002; Hegde, 2008). The health care industry is also facing many challenges from the increasingly competitive and globalized business environment (Tsacle & Aly, 1996). In order to stay competitive, businesses in the health care industry have applied new technologies to manage patients, personnel, and inventory to streamline the efficiencies and effectiveness of business functions (Fisher & Monahan, 2008). One technology that has gained attentions from the health care professions is Radio Frequency Identification (RFID) system. RFID is the generic name for technologies that use radio waves to identify and track objects (Jones, Clarke-Hill, Shears, Comfort, & Hillier, 2004). RFID is traditionally applied to improve the supply chain of an organization (Lin, 2009). By implementing RFID system, objects can be automatically recognized, identified, tracked and traced from the factory, shipping, warehousing, hospitals, pharmacies, intermediaries, and customers (Kumar, Swanson, & Tran, 2009; Poon et al., 2009). Although traditionally applied in the manufacturing industry, RFID have now being applied in industries such as health care, life sciences, transportation and the government (Lai, Hutchinson, & Zhang, 2005).

The applications of RFID in the health care industry have much potential. RFID can help to improve the current stock management systems in hospitals and clinics. For example, there are many equipments and medicines that are involved in the management of inventories in hospitals. Hospitals need to keep track of whether they have enough medicine, the expiry dates of medicines, whether the medicines are given to the right patients etc. In many hospitals, certain drugs also need to be kept and prescribed carefully as it needs doctors' special prescriptions. Other applications of RFID include putting an RFID tag to patients to identity and keeping patients records and treatment needs accurately. Health care businesses such as hospitals and clinics have traditionally relied on manual paper process to manage their operations. However, most health care organizations today use information systems to manage their business operations. Although traditional hospital information systems have improved health care industries' operations, there are still many benefits that can be realized by implementing RFID. Through RFID, health care businesses can improve their organizational performance and competitiveness (Lim & Koh, 2009; Loebbecke & Palmer, 2006) besides operations improvements, RFID can also help improve patients' safety (Vanany & Shaharoun, 2009).

RFID has also gained attentions from the health care sector in Malaysia. Health care business is one of the fastest growing service

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industries in Malaysia (Chee & Barraclough, 2007). The Malaysian government has actively promote Malaysia as a destination for medical or health tourism, whereby its high quality medical service and affordable costs are able to attract many customers from different countries. Besides competitions between Malaysian hospitals and clinics for businesses, the Malaysian health care industry is also competing with countries such as Singapore and Thailand (Chee & Barraclough, 2007). Besides offering good medical services to compete, one way in which the Malaysian health care business can compete is to be more efficient and effective in their operations (Chang, 2007). Although RFID is able to help to achieve this, many hospitals for example, are still reluctant to implement RFID (Vanany & Shaharoun, 2009). During the outbreak of bird flu, Singapore's hospitals ensured the safety of medical staffs and patients by identifying and tracing possible-infected individuals. The efforts and time to develop the history of patients' contacts with each other is huge, but RFID was able to help improve this process. As such, the Singapore health care industry adopted RFID, while Malaysia's health care industry chose not to adopt RFID to solve this problem (Vanany & Shaharoun, 2009). Nevertheless, not all health care companies and hospitals are resisting the adoption of RFID. Pantai Hospital, a private hospital in Malaysia, used RFID for patient temperature monitoring, and location tracking (Edwards, 2010). Despite the benefits reported by Pantai hospital, the adoption of RFID in the health care industry in general, remain low ((Kumar et al., 2009; Vanany & Shaharoun, 2009). RFID is also currently widely available, and it is not difficult to integrate RFID into the health care supply chain (Riggins & Hardgrave, 2007). Past literatures have attempted to investigate the factors that affect the adoption of RFID (Brown & Russell, 2007; Mehrjerdi, 2010; White, Johnson, & Wilson, 2008). However, these studies did not propose an empirical model that examines the factors that can affect the implementation of RFID. Among those who did focused on proposing such model such as those conducted by Lee and Shim (2007), Madlberger (2009), Matta and Moberg (2007) and Tsai, Lee, and Wu (2010), their models have specifically examined a single stage adoption (e.g. whether organizations are adopting or not adopting RFID). There is little knowledge on the various stages of RFID diffusion, especially in the health care industry. Existing technology studies from Zhu, Kraemer, and Xu (2006) and Wu and Chuang (2010) have stated the needs to conduct such multi-stage, diffusion studies to understand the process of why organizations choose to implement a technology across time. In order to bridge the gap in existing RFID adoption literature, this research aims to study on the factors that affect the diffusion of RFID in the health care industry, from an organization's decisions to adopt, deploy and assimilate RFID.

2. Literature review

2.1. RFID overview

RFID is the generic term for systems and technologies that use "radio waves to transmit and automatically identify people or objects" (Sharma, Citurs, & Konsynski, 2007). Although RFID was developed in the early 1970s, it has only gained the attentions from both academics and practitioners recently (Mehrjerdi, 2010). One reason for the recent interest in RRID is due to the decreasing costs of RFID (Sharma et al., 2007). A RFID system will usually have three components: tags, readers, and middleware. RFID's role is to support data processing of business activities, and it is always connected to an enterprise application system (Wang, Wang, & Yang, 2010). RFID operates similarly to barcodes, as it usually stores serial numbers for identifying product and related information on a microchip which is attached to an antenna (Mehrjerdi, 2010). The main advantage that RFID has over barcode technology is that RFID is able to track items in the supply chain without requiring a line of sight (Mehrjerdi, 2010). Furthermore, RFID is capable of strong more information compared to bar code, and can typically store up to 2 kb of data.

Companies such as Procter and Gamble, Gilletter, and Kraft have cooperated with Walmart and have successfully implemented RFID technology in their retail supply chain (Kwok & Wu, 2009). Kitchen Inc. reported that it saved $16.7 million in labor costs, and $6.9 millions in errors due to reducing paperwork and vendor mistakes by implementing RFID (Kwok & Wu, 2009). One problem faced by large and traditional warehouse management is the difficulty in identifying locations of products. This often leads to dead inventory, or obsolete stock, which causes companies to lose money (Kwok & Wu, 2009). This problem can be reduced by the applications of RFID, as RFID allows the tracing of the exact locations of the dead inventory (Srivastava, 2004). Other advantages of RFID include more effective materials management processes, fewer out-of-stock conditions, and higher visibility in the supply chain (Broekmeulen & Van Donselaara, 2009; Smith, Lee, & Gleim, 2009).

RFID is widely applied in the health care industry in many developed countries. Hospitals such as the Massachusetts General Hospital, Hospital of the University of Pennsylvania, University of Pittsburg Medical Center, Carolina Medical Center, and Washington General Hospital have all installed RFID systems (Mehrjerdi, 2010). In the case of Massachusetts General Hospital, equipments and suppliers worth more than half a million dollars were tracked through RFID. Other hospitals have used RFID to track medical devices, inventories, patient and health care provider information. According to Mehrjerdi (2010), hospitals have various problems of tracking and managing equipments ranging from "bed facilities, IV pumps, surgical equipments, and wheel chairs". These problem incurred hospital's operations costs such as the labor costs to find the equipments, increasing purchasing or renting costs of equipments, and increasing inventory costs due to mismanagement of equipments (Mehrjerdi, 2010). Despite the potentials of RFID to reduce these costs, and improve health care industry's supply chain, many firms in the health care industry are still reluctant to adopt RFID (Angeles, 2005). Although past studies have often cited cost as one of the main barrier to RFID adoption (Angeles, 2005; Mehrjerdi, 2010), the price of RFID tags and readers have become more affordable, and it is easier to justify to the senior management in terms of RFID's implementation's return on investments. Fisher and Monahan (2008) found that the constraints on hospitals' implementations of RFID are sometimes beyond the financial issues. The constraints can include mal-adaptation of the RFID system, as well as organizational challenges faced by the hospital (Fisher & Monahan, 2008).

Although past studies on RFID adoptions/diffusions have been conducted in the manufacturing settings, little empirical studies have been conducted in the health care industry (Fisher & Monahan, 2008). This study therefore aims to provide an empirical analysis on the factors that affect the diffusion of RFID based on the health care industry.

2.2. RFID technology diffusion models

The Technology-Organization-Environment (TOE) (Tornatzky & Fleischer, 1990) and Diffusion of Innovation (DOI) (Rogers, 1995) models are two of the most commonly applied research models in the study of organizational IT adoptions (Chong & Ooi, 2008). The TOE framework states that an organization's decision to adopt a technology can be influenced by the technological, organizational, and environmental factors. Technological factors describe the internal and external technologies that are relevant to the firm. Organizational factor is the organizational attributes such as its size, structure, and scope. The environmental factor describes the