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Exploring radio frequency identification technology's application in international distribution centers and adoption rate forecasting

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ABSTRACT

Radio Frequency Identification Technology's (RFID) application in the global supply chain has seen increased attention, and international distribution centers (IDC) are now playing a more crucial role in the global supply chain operation. This paper adopts structure equation modeling (SEM) to investigate the impact of three factors mainly based on the technology acceptance model (TAM): perceived usefulness, perceived ease of use, and the social norm on the use intention of an IDC. Empirical results indicate that a revised TAM could explain the RFID acceptance behavior. Perceived ease of use, perceived usefulness, and the social norm are demonstrated to have an effect on RFID acceptance intention. The choice of RFID adoption is also impacted by the supply chain's stakeholders. Factors that affect the adoption intention of an IDC thus include customers and partners' request, government policy, and competitors that have already adopted RFID. Furthermore, the study adopts the binary Logit model based on the stated preference method's data to predict the possible adoption rate of the RFID system in the adoption intention of an IDC. This empirical study shows that significant statistical determinants influencing RFID acceptance are: system purchasing fixed cost, variable cost, and perceived usefulness. Our model also predicts that the penetration of RFID application in Taiwan's international distribution centers could hit the 25% adoption rate. The study provides several managerial implications and suggests future research directions.

1. Introduction

Radio Frequency Identification Technology (RFID) is a generic technology concept that refers to the use of radio waves to identify objects [1]. The RFID technology enables automatic data capture, data identification, and information interchanges, making it more efficient for merchandise tracking, product sorting, and distribution data collection and analysis as a result of its use [2,3]. In addition, RFID is implemented for a wide variety of applications, including building access control proximity cards to supply chain tracking, toll collection, vehicle parking access control, retail stock management, ski lift access, tracking library books, theft prevention, vehicle immobilized systems, railway rolling stock identification, and movement tracking [4].

International distribution centers (IDCs) provide a number of service attributes to shippers, such as storage, cargo tracking, customs clearance, consolidation, packaging, labeling, assembly, and documentation services [5]. An IDC could be defined as a place that integrates the operations of manufacturing with land, sea, air transportation, storage, port, and customs operations in order to achieve the efficient distribution of commodities in the global supply chain [6–8]. The role of IDC as a home base for merchandise transportation and distribution has consequently become increasingly important in supply chain management [9].

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Growth in cargo throughput in the past has served as one of the essential objectives for IDCs. In the future, IDCs can focus not only on the growth in cargo throughput served, but also in the diversification of logistics service provided for customers to gain more revenue. Therefore, IDCs should attempt to alter their role to create more value-added logistics services for customers [10]. RFID technology can provide logistics companies with better quality control, financial management, and profitability. The benefits for enterprises implementing RFID technology are excessive inventory prevention and logistic operations' labor force reduction. This enables efficient and accurate item identity and quantity verifications under the just in time philosophy. Investing in new information technology, IDCs can expect new technology to contribute to operation performances. Therefore, it is important for managers of IDCs and designers of RFID to understand and predict system user acceptance if IDCs adopt RFID.

Previous literature on RFID deployments concentrated mostly on the analysis of RFID advantages, efficiency, challenges to RFID adoption, cost effectiveness, and RFID technology trends forecasting [11,12]. Some studies also focused on RFID technical improvement to increase its applicability [13]. The introduction of a new technology requires a trial period for user familiarity, and user resistance to adopting new technology should also be considered [14]. Relatively little previous research has employed a systematic approach to investigate the RFID adoption perceived by IDC. Therefore, this study attempts to examine crucial factors affecting RFID's user intention by IDCs.

In order to examine user acceptance of RFID as perceived by the IDCs, the theory of reasoned action (TRA) and technology acceptance model (TAM) have been found to predict intentions and usage of information technology in previous studies [15–17]. TAM has also been considered to be much simpler and easier to use, as well as a more powerful model to predict user acceptance of computer technology [15,18]. The theoretical insights of TAM could provide a strong basis in identifying contributing factors to RFID adoption. Some articles on RFID technology adoption using TAM or the diffusion of innovation (DOI) theory were conducted [19–24], but relative few studies addressed RFID's application specific characteristics such as the ability to allow intelligent processes [25] or process freedom [26], and more importantly, the inter-organizational nature of RFID technology [22,27]. Therefore, the present study theoretically contributes to adopt the revised TAM model by considering the RFID specific application characteristics to examine RFID's adoption in IDCs.

Some quantitative variables like cost and timesaving that could affect the acceptance of RFID are also discussed herein. Thus, the stated preference method is used to gather consumers' preference information to calibrate the binary Logit model, in order to estimate the possible RFID adoption rate for IDCs' operations. This study also contributes to establish an initial effort towards bridging the revised TAM model with the logit model to estimate the RFID adoption rate in IDCs' operation. The advantage of our practical approach is to derive the latent variable from the revised TAM model and to use this latent variable to incorporate it into the discrete choice model to predict RFID's adoption rate in IDCs' operation.

This study is organized as follows. Section 2 describes the TAM model, research hypotheses. Section 3 presents the modeling approach and Section 4 offers the data collection, questionnaire design, and sampling processes. Section 5 describes the empirical result of SEM and the binary Logit model. The discussion and conclusions are included in the final section.

2. Technology Acceptance Model (TAM) and research hypotheses

A number of papers already exists using the DOI theory or TAM model to assess RFID [19,20] and [21–24]. Brown and Russell [19] investigated the influence of technological factors, organizational factors, and external factors on RFID's adoption in the South African retail sector. Leimeister et al. [20] conducted a cross-national comparison of perceived strategic importance of RFID for CIOs in Germany and Italy by examining the influence of the main construct such as company size, RFID experience, and perceived potentials of RFID on strategic importance and on the willingness to invest. This study demonstrates that perceived potentials of RFID have a significant impact on perceived strategic importance of RFID, and cultural difference analysis is also examined.

Schmitt et al. [21] identified factors with a top-down approach that fosters the adoption and the diffusion of RFID in an automotive industry. Wamba et al. [22] developed a contingency model for creating value from RFID supply chain projects in logistics and manufacturing environments based on the framework postulating a positive relationship between the level of organization transformation effected by the use of information technology and the level of business benefits realized from IT. Wamba et al. [23] also identified the decision factors to adopt RFID technology by conducting a large survey of 133 RFID journal readers. The results indicate that the most important factors to invest in RFID are: (1) the benefits that RFID offers in terms of improved data quality, reliability, and timeliness; (2) the amount of top management commitment by senior managers to provide resources that will support investment in RFID; and (3) improved alignment of information between suppliers and customers. Lee [24] adopted the extended TAM model with factors such as security trust, employee knowledge, partner influence, and service provider trust to examine the RFID acceptance of South Korean companies registered in South Korea's RFID society.

There are relatively few literature studies focusing on RFID's adoption under the consideration of RFID's application specific characteristics such as intelligent processes and inter-organizational system's characteristics. Therefore, this study theoretically contributes to examine RFID adoption in IDCs by using the revised TAM model to address the specific characteristics of RFID adoption in the supply chain.

The TAM was proposed by Davis [32] and Davis [18] as an extension of the TRA, where an individual's performance in a specific behavior is determined by his behavioral intention. TAM replaces TRA's attitudinal determinants with a set of two factors, including perceived ease of use and perceived usefulness, which are derived separately for each behavior and employed in many computer technology acceptance contexts [31]. TAM can explain and predict much of the variance in new information technology acceptance [18]. Davis [18] adapted Fishbein and Ajzen's [32] TRA on information system acceptance intention. The original TAM