Production, Manufacturing and Logistics

Determinants of RFID adoption stage and perceived benefits

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A B S T R A C T

This study identifies the determinants of radio frequency identification (RFID) adoption stage and explores the perceived benefits from RFID adoption. RFID adoption is divided into three stages, starting from not considering the adoption (Stage 1), to begin considering the adoption (Stage 2) and to finally implementing RFID (Stage 3). It is argued that a firm's RFID adoption stage is influenced by the following factors: Drivers (Internal Drivers and External Drivers), Management Leadership (Top Management Leadership and Middle-level Management Leadership), and Barriers (Cost Issues, Lack of Understanding, Technical Issues and Privacy Issues). The RFID adoption stage will in turn impact the level of perceived Benefits from RFID implementation. Benefits we measure are Customer Service, Productivity, Asset Management and Communication.

Through an on-line survey we collected data from 175 organizations and we used an ordered probit regression model to test the factors influencing RFID adoption stage. Business sector and firm size were entered as control variables. The results show that internal drivers, top management leadership, cost barrier and firm size are significant determinants of the stage of RFID adoption. In addition, two-factor ANOVA were conducted to investigate the impact of RFID adoption stage/firm size on perceived benefits. The findings show that RFID adoption stage has a significant positive impact on each perceived benefit. The results also show that firm size has a significant impact on perceived customer service and productivity benefits. Our results offer new insights into RFID adoption factors and broaden our understanding of RFID technology in the supply chain.

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1. Introduction

In late 2003, both Wal-Mart and the U.S. Department of Defense (DOD) sparked massive interest in radio frequency identification (RFID) technology when they announced plans to issue mandates to their suppliers to use RFID in order to improve customer service and help automate inventory replenishment systems. We refer to these announcements as the *big bang of RFID* because many firms around the world followed their lead. These announcements ignited hype and predictions of a possible RFID revolution that would significantly improve supply chain operations by reducing costs and increasing sales.

Not long after the *big bang of RFID*, reports of Wal-Mart easing back on its mandate (due to a number of reasons including

supplier resistance) suggested RFID as a failing technology. While Wal-Mart may have scaled back on its initiative, it did not infer that the 600 Wal-Mart suppliers already tagging shipments were going to stop (McWilliams, 2007). For example, rival retailer Metro of Germany has continued their pilot testing with RFID applications, recently at apparel subsidiary Galeria Kaufhof (Thiesse, Al-kassab, & Fleisch, 2009).

Since the *big bang of RFID*, a number of empirical studies have been conducted to investigate the adoption, benefits and challenges of RFID implementation. However, because of the early stage of RFID implementation, those studies suffered a few problems such as a limited sample size and a low percentage of respondents who had actually implemented or were pilot testing RFID (Visich, Li, Khumawala, & Reyes, 2009). For example, only 14.2 percent (30 out of 211) of the respondents to a survey by Vijayaraman and Osyk (2006) on RFID implementation by members of the Warehousing Education and Research Council had any hands-on experience with RFID. Similarly, the Reyes, Frazier, Prater, and Cannon (2007) survey of Institute of Supply Management members had 10.1 percent (67 out of 663) with experience, while 12.2 per-

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cent (6 out of 49) of the respondents to Li, Godon, and Visich (2010) survey of APICS members had experience. Whitaker, Mithas, and Krishnan (2007) utilized two *Information Week* surveys and data from financial databases to address both RFID adoption and business value. However, the use of cross-sectional data does not imply causality in their results.

While the above survey papers had a low percentage of respondents with actual RFID experience, two studies identified differences between the respondents based on their stage of RFID adoption. Vijayaraman and Osyk (2006) compared two groups: those considering implementing RFID (group 1) and those pilot testing or implementing RFID (group 2). They found that group 1 was statistically more optimistic than group 2 about several factors where RFID cost savings would come. These factors were reduced labor cost dues to less material handling, optimization of assets employed, and minimized inventory loses. Interestingly, group 2 rated sales increases and out-of-stock higher than group 1, but these differences were not significant. In regards to reasons for deploying RFID, the Wal-Mart mandate was the highest rated factor for group 2 and statistically different than for group 1. But, group 1 rated six deployment factors as significantly more applicable than group 2. These factors included cost reduction, security and asset tracking. The study by Li et al. (2010) found that firms who were pilot testing, implementing or had implemented RFID rated the issues (barriers) lower and the motivations (benefits) higher when compared to firms that were considering RFID implementation within two years. However, statistical differences between the two groups were not calculated.

Most studies in RFID are focused on respondents' perception on RFID Implementation, not actual RFID implementers. For example, Angeles (2007) identified critical success factors for RFID implementation through a survey distributed to members of the Council of Supply Chain Management Professionals. Bhattacharya (2015) conducted a Delphi study to explore opinions of experts in order to gain insights for the factors that influence the RFID adoption; namely knowledge, persuasion, design and decision, and implementation. However, none of the Delphi study participants had implemented RFID and a significant majority of the respondents (68.9 percent) were from the service sector. Bendoly, Citurs, and Konsynski (2007) investigated the effect of infrastructural capabilities on perceptions of RFID benefits and commitment to actually adopt by matching three levels of management at the same firm. The target firms were limited to only those firms that had implemented an ERP system and hence excluded non-ERP firms that might have been under external pressure to adopt RFID. A survey of Logistics Council of Taiwan members was conducted by Lin (2008) to identify factors affecting the adoption of RFID, however the relationships between these factors is not tested and most of the respondents were small and medium size business. Angeles (2009) conducted a survey of members of the Council of Supply Chain Management Professionals on their perceptions of the importance of absorptive capacity attributes in RFID implementation in the supply chain in order to create operational efficiency and capture market knowledge. This study was limited in that it focused only on those firms intending to adopt RFID and the data was drawn from a convenience sample instead of from a representative sample.

The above review indicates a lack of valid constructs that could be used to study RFID implementation. Hence, the purpose of this study is to develop a valid instrument in studying RFID adoption and test a causal model in understanding drivers, management leadership, barriers, adoption stage and benefits in the implementation of RFID. In this research we close several gaps in the RFID supply chain literature. First, we conceptualize and develop major dimensions of RFID implementation (Drivers, Barriers, and Benefits). Second, we use a bigger sample size (175 respondents) cov-

ering various industries. This sample has a higher percentage of organizations that have actual experience with RFID (~32 percent) than previous studies and about 27 percent of the respondents are considering implementation within next two years. Third, we consider RFID adoption as a stage (from not considering, considering, and implementing) and empirically test the relationships between the RFID adoption stage, the determinants of RFID adoption and the perceived benefits.

The reminder of this paper is organized as follows. We first review previous literature for developing our constructs and framework. Next, we describe our methodology and data collection followed by our validation of the constructs. We then present our data analysis. Finally, we discuss the implications of our research, followed by the limitations of this study and we offer suggestions for future research.

2. Research framework

The RFID adoption framework developed in this research is shown in Fig. 1. It is proposed that a firm's RFID adoption stage is influenced by the factors including Drivers (Internal Driver and External Drivers), Management Leadership (Top Management Leadership and Middle-level Management Leadership), and Barriers (Cost Issues, lack of Understanding, Technical Issues and Privacy Issues). The RFID adoption stage will in turn impact perceived benefits from RFID implementation (Customer Service, Productivity, Asset Management and Communication). Bendoly et al. (2007) noted "*the relatively underinvestigated nature of RFID adoption*" (p. 430) and looked to the practitioner research for cues on the development of their scale items. In the development of our research framework and scale items we utilized more recent empirical survey research and academic articles based on practitioner implementations.

The focus of our research is on the development and validation of constructs for the adoption of RFID in the supply chain. For literature reviews on RFID see Ngai, Moon, Riggins, and Yi (2008), Visich et al. (2009) and Fescioglu-unver, Choi, Sheen, and Kumara (2015). For health care Fosso Wamba, Ananda, and Carter (2013) conducted a very comprehensive literature review, while Reyes, Li, and Visich (2012) and Yazici (2014) investigated the adoption of RFID in health care. In this section we discuss our research model which is comprised of the constructs adoption stage, drivers, management leadership, barriers, and benefits, and we present our research hypothesis. In Table 1 we list these dimensions, their definitions and supporting literature.

2.1. RFID adoption stage

We consider RFID adoption as three stages starting from not considering the adoption within two years (Stage 1), to considering the adoption within the next two years (Stage 2), and to implementing RFID (Stage 3). Stage 3 is comprised of reporting firms with actual RFID experience who are either pilot testing, are in the process of implementing or have already completed implementation of RFID. We combined these three categories of pilot testing, in the process of implementing and already completed implementation into Stage 3 due to the small sample sizes from previous studies. For example, the study of Li et al. (2010) found that out of 49 respondents to their RFID adoption survey, one was pilot testing, one was in the process of implementing and four had completed an RFID implementation. This results in a response rate of 12.2 percent with actual experience with RFID. Visich, Reyes, and Li (2012) had similar results, with 14.8 percent of respondents having RFID experience. In this research, 32 percent of the respondents have RFID experience; more than double the Visich et al. (2012) percentage.