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An Exploratory Study of RFID Implementation in the Supply Chain

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Abstract

Purpose - The purpose of this study is to investigate the barriers and motivations for adopting RFID, the level of RFID implementation, the processes RFID is utilized in, and issues in the deployment of RFID.

Design/methodology/approach - a survey instrument was developed based on a literature review. The survey was then distributed to the members of the Association for Operations Management (APICS) Rhode Island and Boston chapters. The results were then analyzed.

Findings - It was found that the majority of the surveyed firms are not considering RFID implementation. Lack of a business case and lack of understanding were cited as their main concerns. For firms considering RFID implementation and firms that had implemented RFID, better inventory management, obtaining competitive advantage and cost reduction were the three most important motivations for adopting RFID. Financial concerns and the lack of a business case were the most prevalent issues. In addition, product tracking (pallets, cases and items) in shipping was the most cited RFID application. It was also found that considering firms are facing less pressure from customers to adopt RFID and reported a much higher degree of apprehension regarding potential issues than implementing firms reported for actual difficulties faced.

Research limitations - One of the limitations was the small sample size (n=49) which may limit the generalizability of the results.

Originality/value - By identifying barriers, motivations, and issues in the implementation of RFID, this study further educates practitioners on the challenges and opportunities of RFID, as well as provides direction to academicians for further research on this area.

Keywords: Radio Frequency Identification, Auto-ID, RFID Adoption, Supply Chain Management, Survey Research

Paper type: Research paper

1. Introduction

Due to today's rapidly changing global environment, it is essential for businesses to constantly adapt and continually improve operational efficiency in order to remain competitive and enter new markets. Radio Frequency Identification (RFID) has received a great deal of attention lately because of the benefits it could potentially have within the supply chain, in the manufacturing environment, and in the healthcare industry, among other areas. Potential benefits for the supply chain include: increased inventory and asset visibility; reduced inventory levels; improved customer satisfaction; reduced stock-outs; improved efficiency; reduced labor costs; increased collaboration and planning; improved information sharing; increased sales revenue; and improved security (Li and Visich, 2006). Despite the potential for this technology in the supply chain, many firms have been reluctant to implement, or even consider implementation. As with any new technology or new use of an old technology, RFID has its drawbacks. Some critical issues regarding this technology within the supply chain include (but are not limited to): high cost of implementation; low or unknown return on investment; data synchronization and

management; potential difficult system integration; potential reader problems; a lack of global standards; RFID vendor / consultant infancy; security, privacy, and environmental concerns (Li and Visich, 2006).

The majority of issues regarding RFID technology are due to a lack of published knowledge on how to build the business case for implementation and how to deploy RFID in business processes. This lack of knowledge regarding RFID, specifically in the supply chain, is at many levels including the consumer, business process manager, and top management level. A lack of academic research and general universal understanding of the technology is hindering the potential for vast supply chain improvements. The purpose of this study is to determine through a survey methodology the status of RFID implementation, barriers/motivations for RFID implementation, the level of RFID implementation, the processes RFID is utilized in, and issues in the deployment of RFID. It is hoped that this study will further educate practitioners on the challenges and opportunities of RFID, as well as provide direction to academicians for further research on the areas of RFID that are most pertinent to practitioners.

The flow of the paper is as follows: we first present a literature review on RFID implementation in the supply chain. We next discuss our research methodology, followed by a discussion of our results. We conclude our paper with a summary of our findings and make suggestions for future empirical research on RFID in the supply chain.

2. Literature review

The recent academic interest in RFID has generated a rapidly growing body of RFID and related literature. Therefore, in this section we review the RFID literature with a focus on those papers that are most relevant to the supply chain. We classify the literature of RFID in the supply chain into three areas: RFID general overview, analytical studies and empirical studies.

Most literature in RFID provides a general overview in this field. Major topics include RFID technology and its applications in the supply chain (Spekman and Sweeney, 2006; and Reyes and Frazier, 2007); benefits (McFarlane and Sheffi, 2003); business values (Riemenschneider *et al.*, 2007), managerial guidelines (Angeles, 2005); implementation challenges and strategies (Li and Visich, 2006), the impact of RFID on competitive advantage (Tajima, 2007); RFID in closed-loop supply chains (Visich *et al.*, 2007); and the impact of RFID on supply chain facilities (Twist, 2005) and others.

In addition, recent literature includes a rapidly growing number of modeling papers in the areas of finance, inventory and manufacturing. For example, financial studies include the cost and benefits of item-level tagging, (Hou and Huang, 2006), cash flow and risk (Ozelkan and Galambose, 2008), the expected costs and benefits in three-echelon supply chains (Bottani and Rizzi, 2008; Ustundag and Tanyas, 2009). Inventory models are presented for time-sensitive products (Chande *et al.*, 2005), inventory record inaccuracy (Heese, 2007; Uckun *et al.*, 2008), item-level tagging (Gaukler *et al.*, 2007), information visibility and inventory decisions in the reverse channel (Karaer and Lee, 2007), the use of RFID tagged inventory to map supply networks (Bi and Lin, 2009) and others. Manufacturing models include the use of RFID for mixed-model automotive assembly (Gaukler and Hausman, 2008) and for data collection, shop floor control and lot splitting (Hozak and Collier, 2008).

Empirical studies of RFID are dominated by case studies in big retailers or distributors such as UK retailer Sainsbury's (Kärkkäinen, 2003), Wal-Mart (Hardgrave *et al.*, 2008a; Hardgrave, *et al.*, 2008b), Metro Group (Loebbecke, 2007), and GENCO (Chow *et al.*, 2006; Langer *et al.*, 2007), while Delen *et al.* (2007) provide a detailed description of a product moving through a

distribution center to the retail store shelf. Other case studies include Volvo's supply chain flow (Holmqvist and Stefansson, 2006), an RFID-based traceability system at a Hong Kong aircraft engineering company (Ngai *et al.*, 2007), an RFID system to improve supply chain visibility for a medium sized third party logistics company (Choy *et al.*, 2007), the use of a RFID-based logistics system by Korean third-party logistics provider CJ-Global Logistics Service (Kim *et al.*, 2008), and a container tracking study of a large packaging company and its logistics service providers (Pålsson, 2008).

Survey papers have mainly focused on the commitment to adopt RFID, and on the benefits and challenges of RFID implementations. Bendoly *et al.* (2007) investigated the transparency of infrastructural capabilities of the firm and subsequently perceptions of RFID benefits and actual commitment to adopt. Whitaker *et al.* (2007) utilized two *InformationWeek* surveys to address both RFID adoption and business value. Exploratory surveys were conducted by Vijayaraman and Osyk (2006) for the implementation of RFID in the warehouse industry, Reyes *et al.* (2007) to determine the extent of RFID adoption in industry, Angeles (2007) to identify critical success factors, and Lin (2008) for factors influencing adoption by logistics providers in Taiwan.

Extending previous empirical studies in RFID, the purpose of our research was to develop an understanding of practitioners' attitudes and most prevalent concerns regarding RFID technology. We sought to discover the reasons firms are reluctant to implement RFID. This study also sought to uncover the driving motives of practitioners who are considering implementation or are implementing RFID. We also explored the level of RFID implementation and the processes RFID is utilized in firms. Finally, we were interested in comparing the different sentiments between the groups in respect to expectations and actual experiences.

3. Research methodology

We developed the survey instrument using the published literature and the work of Reyes *et al.* (2007) as a guideline. This survey was distributed to a MBA level Supply Chain Management class to critique, and after incorporating the feedback of the graduate school students the instrument was finalized. The survey was then formatted for online administration in order to increase the response rate by making the survey as convenient as possible for the potential respondents.

We initially distributed the survey to approximately 300 members of the Association for Operations Management (APICS) Rhode Island chapter via email. From this distribution we received only eight responses as of March 25, 2007. This is about a 2.6% response rate. In order to obtain more responses, the survey was resent a second time. At the same time the survey was also distributed to full-time MBA students of one of the authors. This simultaneous distribution is a limitation of our research since it did not allow for the stratification of the sample. After the second wave of distribution we received an additional 27 responses for a total of 35 responses. Our goal was to obtain 60 responses, so we extended the sample to the Boston APICS chapter. We received a total of 14 responses from Boston APICS, yielding a grand total of 49 responses which will be the basis of analysis for this paper.

4. Research results

4.1 Demographics

Of the 49 respondents, the majority (58%) are at the managerial level, while the next largest category was director at 16%. Recipients were asked to mark all of the job functions under their scope of duties. 86% of the respondents work in the manufacturing or supply chain division of

their firm. More than 1/3 (39%), specifically have inventory and/or supply chain management duties. The manufacturing industry was represented by 70% of respondents. Over half (53%) of the firms participating in this study conduct only business-to-business (B2B) transactions, 16% conduct business-to-consumer (B2C) transactions, and 31% conduct both B2B and B2C business transactions. Large firms (> 1000 employees) made up the majority 40% of the mix, while medium sized firms (101 to 1000 employees) accounted for 38% of the sample, and finally small firms (\leq 100 employees) composed 22% of the respondents. An overwhelming majority (72%) of the firms conduct business internationally basis.

4.2 Status of RFID implementation

Table 1 shows that the majority of the firms surveyed (61%) indicated that they are not considering RFID deployment within the next two years. Another 13 respondents (27%) said that they were considering deployment within a two-year period. Finally, a total of six firms (12%) are currently pilot testing, are in the process of implementing, or have already completed implementation. Due to the low response rate, we will combine the later three groups in the later analysis and will refer to the combination as: pilot/implementing/completed (PIC).

Table 1. Current status of RFID

Current Status	# Respondents	Percentage
Not considering within next 2 years	30	61 %
Are considering within next 2 years	13	27%
Currently pilot testing	1	2%
In the process of implementing	1	2%
Already completed implementation	4	8%
Total	49	

4.3 Barriers for RFID implementation

The 30 firms not considering implementation were asked to indicate from a list of 19 responses as many reasons for not considering RFID as pertained to their firm. We then grouped these responses into four categories: lack of a business case, lack of understanding, financial issues, and technology issues. Table 2 shows that the major reasons for not considering RFID are lack of a business case and a lack of understanding. Financial issues have a moderate impact and technology issues have the least impact on the adoption of RFID for firms not considering RFID. Table 2 also shows that the top five barriers for not considering RFID implementation are return on investment unclear (47%), not applicable in our business (37%), expected benefits are not enough (23%), other projects have higher priority (23%), and lack of understanding of the benefits (23%). This finding is in consistent with previous literature which considers lack of knowledge as the major barrier for RFID implementation.

Table 2 Barriers for RFID implementation

Barrier	# Respondents	Percentage
Lack of a Business Case		
Not applicable in our business	11	37%
Return on investment too low	2	7%
Lack of a business case to benchmark against	2	7%
Expected benefits are not enough	7	23%
Our system works fine	3	10%
Other projects have higher priority	7	23%
Lack of Understanding		
Return on investment unclear	13	43%
Payback period unclear	4	13%
Lack of understanding of the costs	3	10%
Lack of understanding of the benefits	7	23%
Lack of top management understanding of RFID	6	20%
Lack of top management buy-in	5	17%
Financial		
Initial deployment costs are too high	6	20%
Costs of maintaining the system are too high	3	10%
Lack of funds	4	13%
Technology		
Technology is too new	1	3%
System reliability issues	1	3%
Lack of standards	1	3%
Integration issues with existing technology	1	3%

4.4 Motivations for RFID implementation

For the firms in the considering and PIC group, we asked them rank from 1 to 5 (1 = least importance & 5 = most importance) 30 factors for considering implementation and then grouped the items into six categories, including customer pressure, competitive decision, inventory management, process improvement, cost reduction in processes, and customer service and collaboration. The results are shown in Table 3.

Table 3. Comparison of considering vs. PIC motives

Motive	Considering Group	PIC Group	Difference
Customer Pressure	2.46	3.50	1.04
To comply with a retailer mandate	2.46	3.00	0.54
To comply with a U.S. DoD mandate	2.85	3.83	0.98
Pressure from customers	2.62	3.67	1.05
Competitive Decision	3.46	3.92	0.46
Strategic initiative	3.46	3.67	0.21
Competitive advantage	3.46	4.17	0.71
Inventory Management	3.59	3.89	0.30
Increased inventory visibility	3.69	3.83	0.14
Better inventory tracking and tracing	3.92	4.33	0.41
Inventory reduction	3.15	3.50	0.35
Process Improvement	3.22	3.62	0.40
Lead time reduction	3.15	3.83	0.68
Improved efficiency in operations	3.69	3.67	-0.02
Improved labor efficiency	3.38	3.83	0.45
Quality control	3.23	3.67	0.44
Better ability to trace defects	3.15	3.33	0.18
Improved level of process automation	3.62	4.00	0.38
Improved accuracy in shipping & receiving	3.77	4.33	0.56
Claims reduction	2.62	3.17	0.55
Minimize inventory loses due to theft	2.38	2.67	0.29
Cost Reduction in Processes	3.27	3.78	0.51
Reduced cost of labor for material handling	3.23	3.83	0.6
Reduced overall internal operating costs	3.46	3.33	-0.13
Improved return on internal assets	3.31	3.33	0.02
Reduced cost in the supply chain	3.15	4.17	1.02
Reduced overall supply chain costs	3.23	4.17	0.94
Improved return on supply chain assets	3.23	3.83	0.6
Customer Service / Collaboration	2.97	3.64	0.67
Reduction in out-of-stocks	2.69	3.00	0.31
Improved store sales	2.08	2.67	0.59
Improved store shelf inventory	2.23	3.00	0.77
Improved customer service	3.62	4.50	0.88
Improved response time to customer inquires	3.46	4.17	0.71
Increased collaboration and planning	3.23	4.00	0.77
Improved supply chain information sharing	3.46	4.17	0.71

For the considering group, inventory management, competitive decision, and cost reduction in processes were rated as the three most important motivations, with an average score of 3.59, 3.46 and 3.27 respectively. For the PIC group, the top three motivations are the same as for the considering group but in a slightly different order. Competitive decision was rated as the most important with an average score of 3.92, with inventory management was next at 3.89 followed by cost reduction in processes (3.78). Interestingly, customer pressure had the lowest rank for both groups. This finding is in contrast with literature indicating firms are adopting RFID due to the pressure from customers, such as Wal-Mart mandate.

Table 3 shows that the PIC group rated all six categories higher than the considering group, indicating that the PIC group has stronger motivations to implement RFID and perceive higher benefits of RFID. The difference column in Table 3 also shows that the largest mean difference between the two groups is customer pressure. It can be inferred that the PIC group is under a higher customer pressure/mandate to implement RFID.

4.5 Level of RFID implementation and processes RFID utilized

The respondents were asked to indicate the level of RFID implementation and the processes RFID is utilized in. The results are shown in Table 4. For the considering group, item level tracking was the most frequently cited response, at a frequency of 54%, followed by pallet level tracking (39%), case level tracking (31%), asset tracking internally (31%), work-in-process tracking (15.4%), employee tracking (15.4%), container tracking for parts (7.7%) and reusable assets tracking in the supply chain (7.7%). For the PIC group, the top three most cited levels for RFID implementation are pallet level tracking (83%), case level tracking (67%), item level tracking (33%) and work in process tracking (33%). Asset tracking internally, reusable assets tracking in the supply chain and employee tracking have not been implemented by any company in the PIC group. It can be seen that product tracking in the supply chain (pallets, cases and items) was the most frequently cited response for both groups.

Interestingly, there was only 1 response (8%) in the considering group indicating a future plan for the tracking of reusable assets in the supply chain. None of the 6 respondents in the PIC group indicated a use of RFID to the tracking of reusable assets in the supply chain. A study by Visich *et al.* (2007) found a high degree of reusable assets tracking in the supply chain using RFID, with clear benefits from the implementation.

Regarding processes RFID is utilized in, shipping, order put-away, and logistics were the three most cited responses for the Considering group, at a percentage of 62%, 46% and 39% respectively. Promotions at retail did not generate any responses. For the PIC group, the top three are shipping (83%), receiving (50%), and order picking (33%). It can be seen that shipping is the most cited process RFID utilized for both groups.

Table 4. Comparison of considering vs. PIC level of implementation and processes utilized

Level of RFID Implementation	Considering group		PIC group	
	Frequency	%	Frequency	%
Item level tracking	7	53.8%	2	33.3%
Case level tracking	4	30.8%	4	66.7%
Pallet level tracking	5	38.5%	5	83.3%
Container tracking for parts	1	7.7%	1	16.7%
Work-in-process tracking	2	15.4%	2	33.3%
Asset tracking internally	4	30.8%	0	0.0%
Reusable assets tracking in the supply chain	1	7.7%	0	0.0%
Employee tracking	2	15.4%	0	0.0%
Processes RFID Utilized				
Receiving	2	15.4%	3	50.0%
Order put-away	6	46.2%	1	16.7%
Order picking	4	30.8%	2	33.3%
Shipping	8	61.5%	5	83.3%
Inventory replenishment for manufacturing operations	3	23.1%	1	16.7%
Monitor inventory usage	3	23.1%	1	16.7%
Conduct inventory counts of items in storage	4	30.8%	0	0.0%
Logistics	5	38.5%	1	16.7%
Promotions at retail	0	0.0%	1	16.7%

4.6 Issues in RFID implementation

We also asked firms to indicate on a scale of 1 to 5 (1 = not an issue, 5 = significant issue) the potential of 23 factors that could be issues in the deployment of RFID. These factors were then grouped into the categories of financial, lack of a business case, technology, and other. Table 5 shows the results. For the Considering group, financial issues ranked the highest concern with an average score of 3.29, followed by lack of a business case (2.83), technology (2.82), and other (1.97). The other category was comprised of privacy issues (2.3) and environmental issues (1.6). The PIC group ranked Financial issues first with an average score of (2.75) followed by lack of a business case (2.39), technology (2.37), and other (1.50). These rankings are the same as for the Considering group, except that the average scores for the PIC group are all lower, indicating that the Considering firms reported a much higher degree of apprehension regarding potential issues than implementing firms reported for actual hardships faced.

It can be seen that environmental issues was the lowest ranked of all 23 factors for the Considering and PIC group. Of the 13 firms considering deployment, 9 of them export to Europe, and all 6 firms in the PIC group export to Europe. Due to laws and regulations set forth by the European Union Directive 2002/96/EC on waste electrical and electronic equipment (WEEE), producers are made responsible for taking back and recycling electrical and electronic

equipment. Although it was not specifically mentioned in the legislation, RFID tags most likely fall under Category 3 IT and Telecommunications Equipment (Visich *et al.*, 2005).

Table 5. Comparison of considering vs. PIC implementation issues

Issues in RFID Implementation	Considering group	PIC group	Difference
Financial	3.29	2.75	0.54
Deployment costs too high	4.15	3.50	0.65
Return on investment too low	3.69	3.50	0.19
Payback period too long	3.46	3.00	0.46
Costs of maintaining the system too high	3.23	2.83	0.40
Costs to deploy incorrect	2.55	2.00	0.55
Funding not adequate	2.67	1.67	1.00
Lack of a Business Case	2.83	2.39	0.44
Business case not feasible	3.08	2.33	0.75
Benefits not observable	2.75	2.33	0.42
Lack of top management understanding of RFID	2.58	1.50	1.08
Lack of top management buy-in	2.50	2.33	0.17
Other projects a higher priority	3.42	3.17	0.25
RFID vendor / consultant infancy	2.67	2.67	0.00
Technology	2.82	2.37	0.45
Integration problems with existing technology	3.42	2.50	0.92
Security of sensitive information	2.33	2.00	0.33
System reliability problems	2.50	2.00	0.50
Reader problems	2.00	1.67	0.33
Lack of standards	3.00	2.00	1.00
Internal system integration	3.00	3.00	0.00
Supply chain integration	2.92	2.67	0.25
Data synchronization	3.08	2.83	0.25
Data management	3.17	2.67	0.50
Other	1.97	1.50	0.47
Privacy of consumers	2.33	1.67	0.67
Environmental impact	1.62	1.33	0.28

5. Conclusions and Future Research

This final section of the paper will begin by discussing the limitations of the research. Next, we discuss the implications of our results for practitioners and academics. Finally, we will offer suggestions for future research on RFID technology in the supply chain.

One of the limitations we encountered in this study was the small sample size (n=49) spread out over 5 status levels of RFID implementation. In addition, the low response rate indicated

many survey recipients were reluctant to take part in the study and the survey was focused in a narrow geographic area. A future study can validate the findings of this research by using a larger sample across a wider geographic area with a higher response rate.

The results of our research indicate a lack of knowledge as the main reason firms are not considering RFID implementation in the near future. Firms with little knowledge of RFID are reluctant to pursue RFID technology because the initial deployment stage can be costly and the exact benefits are not clear. The issues for those considering and the actual issues incurred by those who have started the process are similar. However, the firms in the PIC group ranked the motivations higher and the issues lower, indicating a deeper understanding of RFID technology by the PIC group.

Currently, there is a lack of detailed published case studies on the implementation of RFID in the supply chain. Best practices and applications need to be identified in order to educate practitioners and help them build the business case for RFID deployment. The survey questions and categories used in our research can be extended to develop structural models that identify those best practices that have the most impact on performance. Specific supply chain areas of research include the integration of RFID information between supply chain partners, applications in the perishable and pharmaceutical supply chains, the use of RFID for closed-loop applications, and import/export issues.

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