An Exploratory Study of RFID Adoption in Retail Sector

Abstract

While several large retailers have mandated RFID deployment across their value chain, the case for RFID adoption among several other retailers still remains more uncertain. In this paper, we use an exploratory methodology, content analysis, to quantitatively analyze benefits, RFID applicable value chain activities, and business processes. We found that the most significant retailer benefits are better management of inventory, improved security, and increased operational efficiency. However, to realize these benefits retailers must situate their RFID implementation choices within a business context. To assist in this endeavor, we identify RFID-applicable business processes and value chain activities currently perceived as highly influencing retailer benefits. We find that while retailer benefits are strongly linked to RFID-applicable business processes, they are not strongly correlated across value chain activities. In addition, retailer benefits for RFID-applicable business processes and value chain activities do not show a strong association. We reflect on possible reasons for these results.

Keywords: RFID, retail, value chains, new technology adoption, content analysis

Introduction

The development of Radio Frequency Identification (RFID) technology dates back to early 1920s with the birth of radar systems and was further developed for detection of enemy aircraft during the World War II (AIM, 2001). Starting from the 1980s through early 2000s, the technology was silently deployed in a wide range of applications where wireless non-line-of-sight data capture could be used to advantage, such as highway and bridge tolls, livestock identification, tracking nuclear inventories, and automated vehicle identification systems (Jacob *et al.*, 2004; Capone *et al.*, 2004). Currently RFID technologies are generally used to identify, capture, and transmit information from tagged objects to enterprise systems. These objects may be manufacturing equipment, products, or even hospital patients. However, integrating this captured data into existing business practices to improve business effectiveness is proving to be a complex undertaking.

Industries with the greatest opportunity to use RFID are retail, aerospace, defense, health care, logistics, and pharmaceuticals. Since the benefits of RFID can vary from industry to industry, we select the retail industry for our initial study as it is one of the most aggressive supporters of the technology. Frost & Sullivan reported that the revenue in the RFID retail market was $400.2 million in 2004, and expected to grow to $4,169 million by 2011 (Bacheldor, 2006). Mandates from giant retailers (e.g., Wal-Mart, Target, Albertson) and government agencies (e.g., Department of Defense, Department of Homeland Security) have increased RFID awareness and driven many suppliers to implement it. On the other hand, according to a recent survey sponsored by NCR, only 9% of the participating retailers have an RFID implementation timeline as compared to 44% of the participating manufacturers (NPN News, 2006). This raises the question of why retailers (other than large ones such as Wal-mart) are not adopting RFID

technology as rapidly as expected. One answer could be retailers prefer to wait until the technology matures to accurately assess potential benefits (Jabjiniak & Gilbert, 2004). These retailers may have some skepticism about the eventual benefits of implementing the technology, given the uncertain state of return on investment (ROI) measures and the need for a huge investment up front (Michael & McCaithe, 2005).

In this paper, we examine the benefits, business processes and the value chain activities that are influenced by the use of RFID for the retail industry. We also investigate the correlation between the retailer benefits separately with RFID applicable and value chain activities and business processes which further has managerial implications. To achieve our research objectives, we employ content analysis on a combined set of trade and academic articles, many of which are the results of various pilot studies or actual implementations. To guide our investigation and analysis, we use the following research questions:

- What are the major benefits from RFID usage by retailers?
- Which retail value chain activities show benefits from using RFID?
- Which retail business processes show benefits from using RFID?
- Are there correlations between value chain activities, RFID-applicable business processes, and retailer benefits associated with RFID?

Our paper is organized as follows. We first discuss our research methodology and related research work. Next, we present and discuss our content analysis results and related statistical analyses. Finally we conclude with study implications.

Research Methodology

Due to the fact that the use of RFID for operational and value chain improvement is a rather new area it became clear during the research planning phase that that the methodology

must be suitable for the analysis of data as it could not be expected to find a representative sample of participants for empirical survey. Therefore a combination of secondary and primary data sources will provide data for this research work. We use a research methodology called *content analysis* to guide our reference search, data collection, and analysis. Content analysis has been widely used in informatics, library science, and social science research (Krippendorff, 1980). The methodology is exploratory, yet allows researchers to capture and quantify information based upon the presence of words or concepts within a set of text and has been used previously to study RFID adoption (Michael & McCathie, 2005; Johnston, 2005). It is defined as the detailed and systematic examination of the contents of a particular body of materials for the purpose of identifying patterns, themes or biases (Leedy and Ormrod 2005, p. 143). There are four major functions of content analysis: confirmation of what is believed, correction of the existing illusions of specialists, settling disagreements among specialists and finally formulating and testing hypotheses about symbols. The methodology is both qualitative and quantitative in nature (Leedy and Ormrod 2005, p. 143). The reason is that content analysis counts the frequency of occurrence of particular words in the text and provides means for statistical analysis, thus making it quantitative. It also allows establishing relationships between themes making it qualitative as well. Since this is an emerging rather than an established technology, the texts selected for our content analysis include not only journal or conference papers but also press releases and industry white papers. Our study consists of three major phases: (1) reference identification and search, (2) theme and research issues identification, and (3) data analysis and interpretation. Figure 1 shows the pictorial representation of how the content analysis methodology is applied in our work.

Phase 1: Reference identification and search. In this phase, we identify the possible sources as the targets for our extensive search for relevant references. Our search covers popular on-line sources such as RFID Journal, RFID Gazette, TechRepublic, and major academic on-line databases such as ABI INFORM, ACM Digital library, and IEEE Explore. We use different versions of the keyword containing "RFID" and "Retail" such as "RFID in retail", "RFID and retail", and "RFID and retailers" and collect all relevant articles. We conducted our search between October 2006 – May 2008. 470 relevant articles were found and retrieved. Out of the total 470 references, there are 35 published journal articles, 40 conference proceedings, 49 academic magazines, 4 academic theses, 138 industry white papers, and 204 news releases. The majority of these articles were published anywhere between the year 2002 and 2007.

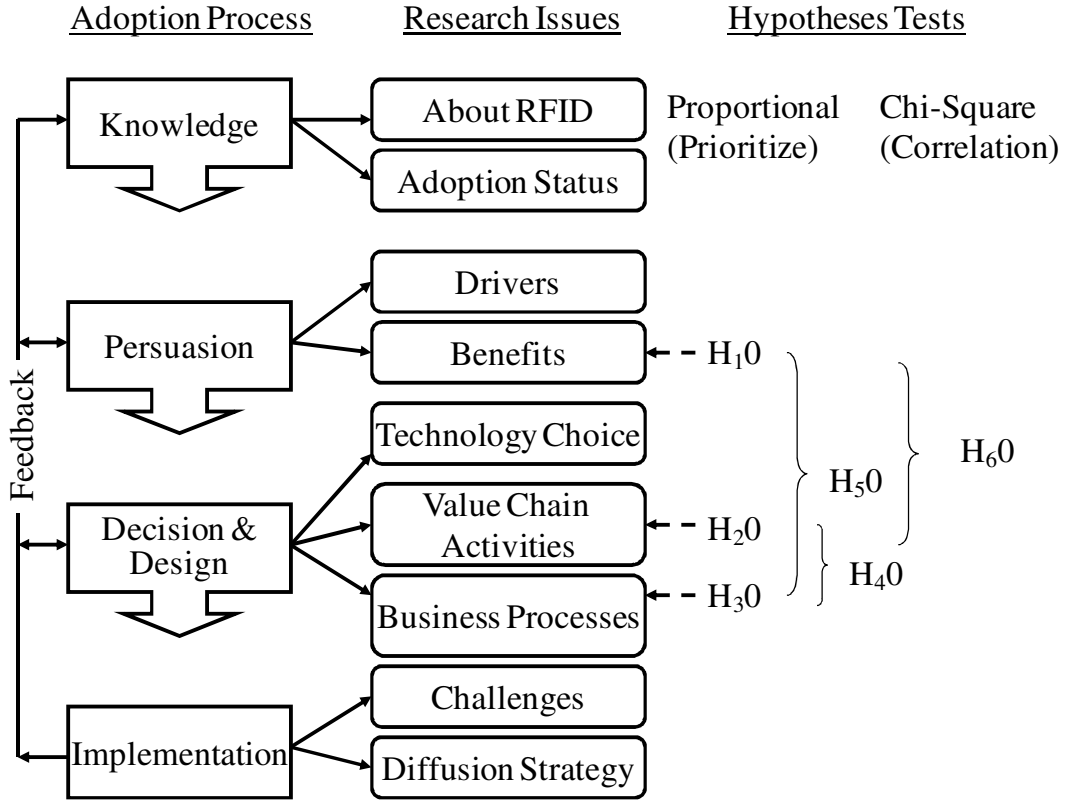

FIG 1. Content analysis process

Phase 2: Classification. We classify and sort the textual data based upon the themes that emerged and associate each theme with a stage in our RFID diffusion model adapted from Rogers (Rogers, 1995). The various themes that emerged are adoption drivers, potential benefits, value chain activities that could be influenced by RFID, RFID applicable business processes, RFID technology choices in terms of frequency, standards, and tagging levels, and finally adoption challenges. We focus on potential benefits, value chain activities, and business processes in this paper.

The *knowledge stage* of the diffusion model involves enhancing the required knowledge about the various aspects of the technology. Thus issues such as RFID adoption pros and cons, retail domain characteristics and current RFID adoption status are associated with this stage. The *persuasion stage* of the diffusion model maps to RFID-adoption drivers, including the key driver and benefits. The *decision and design stage* incorporates activities that lead to deciding to adopt or reject a particular RFID solution, and includes identifying potential value chain activities, RFID-applicable business processes, and RFID technology choice (in terms of RFID frequency, standards, case/pallet level of tagging and so on). Finally, in the *implementation stage*, knowledge about issues such as adoption challenges and diffusion model can significantly improve the technology implementation process. Each stage of the adoption model informs every other stage, and in this paper, we particularly look at selected aspects of the persuasion and design and decision stages. We investigate the synergistic effects between the persuasion stage and the decision and design stage by considering possible correlations between benefits separately with business processes and value chain activities. The knowledge and implementation phases are beyond the scope of this paper. Also adoption driver issues of the persuasion stage and technology choice issues within the design stage have not been investigated

in this paper. In order to ensure the reliability of the data coding we revisited the dataset multiple times during the coding process and the coding scheme was generated as an iterative process. We used manual coding techniques so that no piece of relevant information is ignored.

Phase 3: Data analysis and interpretation. From these RFID adoption issues, we develop several hypotheses regarding their impact on the RFID adoption process in retail sector, which we test using the quantitative results from our content analysis. To do this, we tally the frequency of the articles that support each sub-issue.

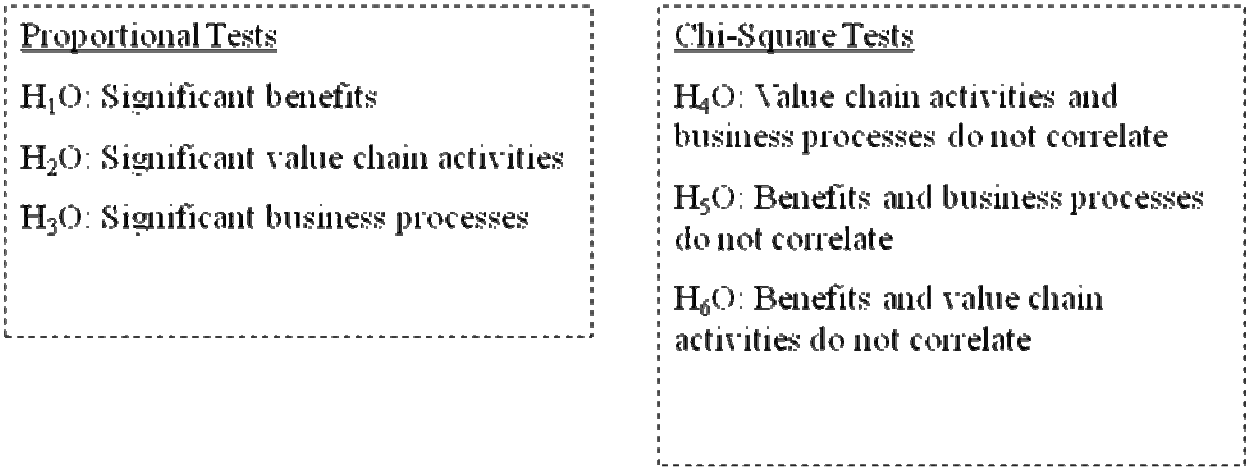

FIG 2. List of hypotheses tests

We apply proportional hypotheses tests (Zou *et al.,* 2003) to the numerical data to identify the most significant factors amongst benefits, value chain activities, and business processes. We apply chi-square analysis to analyze and identify correlations between retailer benefits and value chain activities, between RFID benefits and business processes, and between RFID-applicable business processes and value chain activities. These results can be used by retailers to spotlight key RFID implementation areas with the potential to maximize benefits.

See Figure 2 for a list of our hypotheses categorized by the statistical hypotheses test used. Detailed discussion of our hypotheses is provided in the analytical discussion and result section of the paper.

Related Research Work

Studies of RFID technology and its applications cover a wide range of RFID adoption characteristics, industry sectors, and geographical regions. Table 1 summarizes and contrasts this related work according to these features. Note that while our content analysis includes industry articles, in this section, we discuss only relevant academic articles.

Faber (2002) claimed that RFID can lead to savings when used for managing records. He also discussed the issues and challenges faced in RFID implementation. Karkkainen (2003) conducted an analysis of the benefits of RFID obtained by increasing the supply chain efficiency for short shelf-life products. Mortensen & Pederson (2004) focused on the implementation of RFID in construction logistics. Larsson & Qviberg (2004) conducted a similar research on the justification of RFID implementation in the retail sector. Angeles (2005) argued that RFID technology has the potential to provide process freedom (thus reducing labor requirements) and real time visibility across the supply chain especially in retailing and logistics. Bose & Pal (2005) claimed that the significant benefits achieved from RFID technology implementation are improved visibility across the supply chain and full or semi- automation of rote operations. They also claimed that the challenges to overcome are cost of tags, item level vs. pallet level tagging, multiple frequencies, data management, and privacy issues. Similarly Metras (2005) claimed that future challenges for RFID technology are privacy issues, the handling of massive data, and technological issues. Prater & Frazier (2005) examined the impact of RFID technology on electronic supply chains and specifically in grocery retailing. Their work focused on the market drivers leading to RFID implementation in grocery retailing. Johansson (2005) identified the factors that influenced RFID implementation in the automotive and pharmaceutical industries.

Jones *et al.* (2004, 2005a, b) presented potential benefits and challenges of RFID across the retail supply chain in the United Kingdom (UK).

Michael & McCathie (2005) attempted to identify the pros and cons of RFID in supply chain management; however, their work is geared toward RFID adoption in general, whereas our focus in this paper is to look specifically at the retail sector. Koh *et al*. (2006) surveyed the issues and critical factors of RFID in the retail sector; but their focus is on currently perceived benefits, which may be limiting due to the evolving nature of the RFID technology. The most significant benefits identified in their work are improved inventory management, improved in-store operations, an integrated business model, and velocity of the retail cycle. Vijayaraman & Osyk (2006) conducted an empirical study of RFID implementation in the warehousing sector. Want (2006) claimed that the most important challenges hampering RFID adoption are privacy concerns, cost of tags, and technical reliability. Engels *et al.* (2007) analyzed RFID applications in the Department of Defense (DOD) supply chain. They identified the requirements of the DOD supply chain (readiness, long span, variety of items, unstable demand, moving end points, priority, and equipment reliability and maintenance) along with the ability of RFID to address them. However, most studies only considered a few aspects of RFID adoption, whereas our paper includes seven of the eleven aspects listed. In particular, our study is the only one that examines the RFID-applicable business processes and specific integrated value chain activities with the potential to be influenced by the RFID technology. We also establish statistical relationships between value chain activities and business processes; value chain activities and retailer benefits; and business processes and retailer benefits.

Analytical Results and Discussion

Our analytic results and discussion are framed according to the stage in which they occur in our RFID adoption model. We start with the persuasion stage and identify key RFID retail benefits and assess their significance using the proportional hypothesis test. To address the decision & design phase, we identify the most significant RFID-applicable retailer business processes and value chain activities, and their relationship to retailer benefits.

Retailer Benefits of Adopting RFID (H_10)

Starting with the entire set of RFID related articles, we narrow this set down to 338 that mention one or more specific RFID retailer benefits. These are shown in Table 1. For some retailer benefits, such as better management of inventory, we found we could further divide the benefits into sub-categories such as reduced out of stock, reduced inventory and reduced shrinkage. Our hypothesis H_10 concerns the significance of these specific retailer benefits and uses the proportional test to assess whether each benefit contributes to at least one eighth (8 categories of benefits) or more to the total article frequency of 338 at 5% significance level. As shown in Table 1, better management of inventory is the most significant benefit (p-value = 0), followed by improved security (p-value = 0.019). While improved efficiency/throughput (p-value = 0.067) is not significant at 5% significance level, it comes close. The rest of the benefits are not significant. We see from Table 1 that the impact of better inventory management on retailer benefits comes primarily from reduced out of stock, rather than reduced inventory or reduced shrinkage. Since 8-12% of items in stores are out of stock at any one time, reducing out of stock can clearly have a big impact on retailer profits. The retailer benefits derived from improved security benefits appear to be split almost equally across reducing in-store theft and fraud and reducing supply chain theft and fraud. However, simply increasing security is not a

panacea and requires retailers to trade off customer privacy issues carefully, which we discuss in the challenges section. Lastly, for benefits related to operational efficiency/improved throughput, we see that improving business processes and supply chain velocity are the key factors. In later sections, we further explore these connections by explicitly correlating retailer benefits with specific business processes and value chain activities.

TABLE 1. Benefits from RFID implementation in the retail sector

Benefits	Frequency	Percentage	p-value
Better management of inventory	77	22.78	0.000*
- Reduced out of stock	52	15.38	
- Reduced inventory	13	3.85	
- Reduced shrinkage	12	3.55	
Improved Security	56	16.57	0.017*
- Security against theft/fraud	29	8.58	
- Improved supply chain security	27	7.99	
Operational Efficiency/Improved Throughput	52	15.38	0.067
- Accuracy, speed and efficiency of process/ Improved supply chain velocity	33	9.76	
- Improved efficiency of store operations	12	3.55	
- Improved labor productivity	4	1.18	
- Streamlined process achievement	3	0.89	
Improved Visibility	45	13.31	0.349
- Real-time visibility	25	7.40	
- Improved visibility of orders and inventory	20	5.92	
Reduced Cost	37	10.95	0.827
- Reduced labor requirements/costs	21	6.21	
- Reduced overall cost	16	4.73	
Better Information Accuracy	31	9.17	0.977
- Improved packing and shipment accuracy	12	3.55	
- Business Intelligence	19	5.62	
Improved Customer Service Levels	29	8.58	0.991
Increased Sales	11	3.25	1.000
Total	338	100	

* Statistically significant (5% significance level)

The currently insignificant benefits are improved visibility, reduced costs, better information accuracy, improved customer service levels and increased sales. Improved visibility can help achieve a tighter, integrated supply chain, but appears to benefit manufacturers more

than retailers (Bhattacharya *et al.*, 2008). Reducing costs appears to rely on two main sub-effects, namely reduced labor costs and overall costs. One possible explanation for the lower significance of reduced costs is that when significant labor cost savings are possible, retailers (and manufacturers) have most likely already installed bar codes. Thus, any additional savings from RFID will be less than if RFID were a completely new automation technology. As for reducing overall costs, it may be that since RFID implementation costs are non-trivial in the short run, impact of RFID on operational cost savings are not as great as they might otherwise be.

The lack of significant benefits for better information accuracy and increased customer service levels may be due to the complexity of implementing systems to achieve those benefits. Thus, to truly acquire better business intelligence means knowing what RFID data to capture and how to use it intelligently to achieve business goals, which is no easy task. Similarly, while customer service might be increased by technologies such as smart shelves in the long run, in the short run this technology remains immature. An additional possibility is that customer privacy concerns are slowing the development of such data gathering systems.

Lastly, since many of these benefits have the potential to influence each other, some benefits may not show up as primary benefits since they are achieved indirectly. For example, implementing better inventory management and improved security throughout the value chain will eventually contribute to reducing cost and improving information accuracy and visibility. It will also improve customer services due to better availability of consumer products (i.e., no stock outs) and lower prices. Retailers should not overlook this dependence when determining benefits. We intend to further explore the effects of interrelated benefits in future research.

Where RFID has been Used in Retailer's Value Chains (H_20)

A value chain is a chain of activities. Products pass through all activities of the chain in order and at each activity, the product gains some value. The chain of activities gives the products more added value than the sum of added values of all activities. The value chain categorizes the generic value-adding activities of an organization. The concept has been extended beyond individual organizations. It can apply to whole supply chains and distribution networks. Typically major retailers have business alliances with multiple tiers of suppliers, manufacturers, and distributors across the supply chain, so that a retail value chain consists of one or more of each of these entities: suppliers, manufacturers, distributors, retailers, and consumers [Sikander, 2005]. Most companies today rank value chain management as their key priority for gaining competitive advantage.

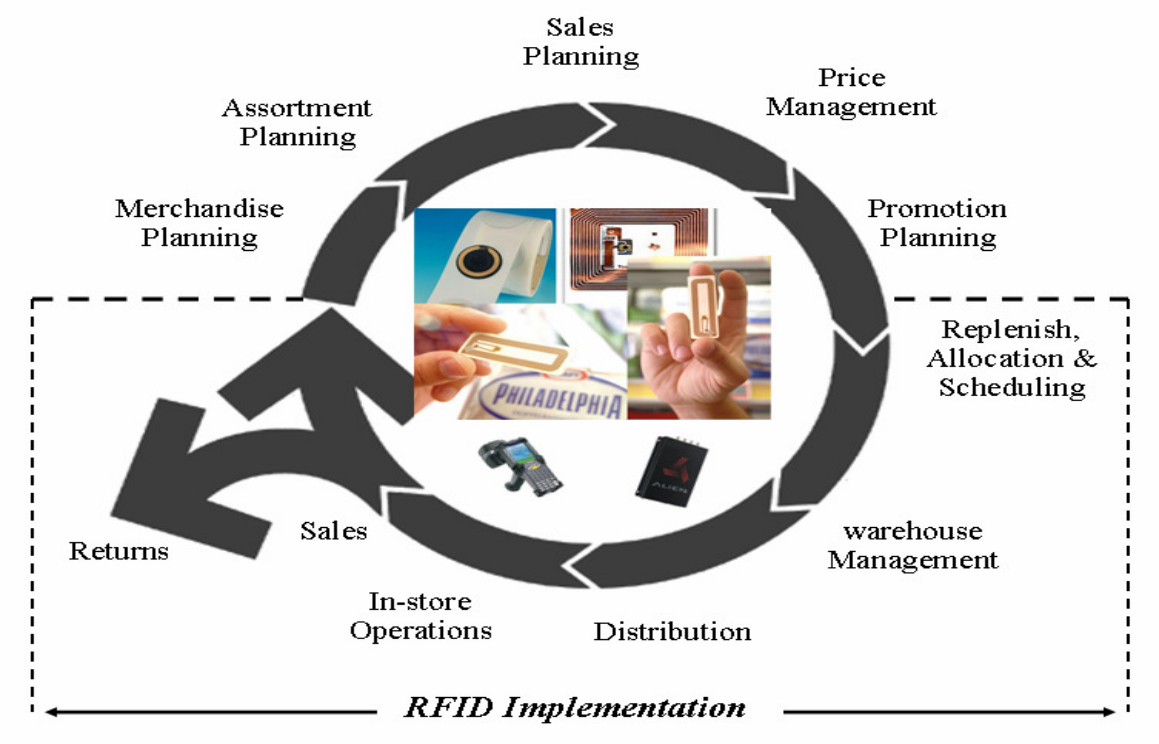

FIG 3. Framework of an integrated retail value chain (Adapted from Callana, 2006)

The benefits of RFID within the retail sector primarily revolve around allowing for improved value chain management. For example, improved visibility can help achieve a tighter, integrated value chain. In this section, we consider integrated retail value chains, which focus on merging retailer constraints into manufacturer and distributor schedules. A typical integrated retail value chain has the following major elements shown in Figure 3 (Vargus, 2007b), where many of these elements may be common to other types of value chains as well:

1. *Merchandise planning*: focuses on planning and maintaining a balance between sales and inventory.
2. *Assortment Planning*: involves the planning and proper selection of merchandise to meet a variety of customer needs.
3. *Sales planning*: helps plan routes and distribution channels to reach target customers.
4. *Price management*: concerns the understanding, managing, and improving pricing decisions based on predictions and forecast data.
5. *Promotion planning*: involves planning and managing promotions and is highly dependent on the quality of forecast data.
6. *Replenish, allocation, and scheduling*: involves managing resources and product delivery to avoid out-of-stock events.
7. *Warehouse management*: involves the management and coordination of diverse warehouse facilities to achieve improved distribution of products across different distributors, retailers, and customers.
8. *Distribution*: process of distributing the right product accurately to the right destination at the right time.

9. *In-store operation*: involves the management of various store operations, such as receiving, shelf stocking, and product ordering for store replenishment.
10. *Sales*: revenue generation.
11. *Return*: manages return of merchandise. The goal is to streamline reverse logistics.

Since the benefits of RFID adoption can spread throughout value chain activities, in this section we correlate specific retailer benefits to particular value chain activities. Table 2 shows the frequency and percentage of articles related to retailers using or expecting to use RFID in value chain activities along with the results of the proportional hypothesis tests. Here we assume that each value chain activity contributes to at least one tenth or more (10 categories of relevant value chain activities) of the 526 value chain articles found to be significant contributors (our hypothesis H_20). The most dominant value chain activity turns out to be replenishment followed by in-store operations, warehouse management, and returns/recalls.

TABLE 2. Retailer value chain activities

Value chain activities	Frequency	Percentage%	p-values
Replenish, allocation and scheduling	208	39.54	0.000*
In-store operations	99	18.82	0.000*
Warehouse management	82	15.59	0.000*
Returns / recalls	74	14.07	0.002*
Distribution	32	6.08	0.999
Merchandise planning	19	3.61	1.000
Promotion planning	6	1.14	1.000
Price management	5	0.95	1.000
Sales planning	1	0.19	1.000
Assortment planning	0	0.00	1.000
Total	526	100.00	

* Statistically significant (significance level 5%)

We can see from Table 2 and Figure 3 that except for distribution, the dominant RFID benefits cluster into the more tradition activities at the lower end of the value chain rather than

among the newer integrated value chain concepts, such as merchandise planning. While activities such as merchandise planning allow manufactures to adjust their production schedules well in advance resulting in potential cost savings and reduced product delivery delays for retailers, the integration of RFID data and resultant business forecasting may simply not yet be incorporated into standard value chains.

Which RFID-applicable Business Processes can be used? (H_30)

We have identified eight broad business processes where RFID can be used in retail applications. While these processes are not necessarily exclusive to retailers, they are crucial for retail operations and can be improved by implementing RFID. Table 3 shows the frequency, percentage and the results of the proportional hypotheses tests for each business process. We assume that each process category that contributes to at least one eighth or more (total of 8 categories of business processes) out of the total article frequency of 812 is a significant contributor (our hypothesis: H_30). As shown, inventory management, tracking and tracing, and security against theft/fraud, are the most dominant RFID-applicable business processes. One possible explanation for the lack of relevance of the other business processes may be that they rely on other technologies or processes to mature. For example, inventory management captures basic information about assets, while asset management builds on inventory management to include lifecycle and financial management aspects. Thus, asset management implicitly requires inventory management be in place. Another possibility for processes such as tracking shopping behavior is that they raise important social questions about shopper's privacy rights that have yet to be addressed satisfactorily.

TABLE 3. RFID-applicable business processes

Business Processes	Frequency	Percentage%	p-values
Inventory management	173	21.31	0.000*
Tracking and tracing	161	19.83	0.000*
Security against theft/fraud	133	16.38	0.001*
Automated shipping/receiving	96	11.82	0.735
Returns/recall management	71	8.74	1.000
Asset management	70	8.62	1.000
Acquire business intelligence	67	8.25	1.000
Tracking shopping behavior	41	5.05	1.000
Total	812	100	

* Statistically significant (5% significance level)

Interaction between Benefits, Value Chain Activities and Business Processes

A retailer planning to invest in RFID technology wants to know which business processes and value chain activities will provide the greatest return on investment. For example, Wamba *et al.* (2006) have pointed out that the use of RFID by retailers for tracking and tracing products can lead to reduced inventory and better collaboration among value chain participants. In this section, we discuss potential correlations between benefits, integrated value chain activities and RFID-applicable business processes. These correlations can assist retailers in judiciously applying RFID technology and help to identify specific kinds of benefits they can expect. Helping to reduce the uncertainty involved in RFID investment decisions could eventually lead to broader diffusion of the technology.

Table 4 shows our three hypotheses H_40, H_50, and H_60 concerning potential interrelationships between retailer benefits, value chain activities and business processes. To test each hypothesis, we encode and compile the frequency of the articles that correspond to that hypothesis and then apply chi-square analysis to test their correlations. However, while Table 4 shows the significance of the overall relationship, it does not address the potential correlation of a specific retailer benefit (e.g., better inventory management) with a specific value chain activity

(e.g., merchandise planning) or specific business process (e.g., tracking and tracing). To address this, we also test for pair-wise relationships between specific benefits, activities, and processes using proportional tests. For hypotheses H_40 and H_60, we eliminate value chain activities with very low frequency as they are not significant in our data. The eliminated activities were sales planning, assortment planning, price management, and promotion planning. We discuss the chi-squared test results and follow-up proportional tests for each hypothesis in the sub-sections below.

Correlation between value chain activities and business processes (H_40)

Hypothesis H_40 concerns the correlation between retailer-based value chain activities and RFID-applicable business processes. The calculated chi-square value in Table 4 is equal to 44.76 with 35 degrees of freedom. Since this value is less than the critical value 49.80 (i.e., chi square value corresponding to a tail probability of 0.05 with 35 DF), we cannot reject the null hypothesis H_40 and conclude that overall value chain activities and business processes are not correlated at 5% significance level.

TABLE 4. Correlation analysis using Chi-square test

Hypothesis	DF	Chi-Square Value	Critical Chi-Square Value	Result
H_40: Value chain activities and RFID-applicable business processes are not correlated.	35	44.76	49.80	Accept
H_50: RFID benefits and business processes are not correlated.	49	80.831	66.34	Reject
H_60: RFID benefits and value chain activities are not correlated.	35	22.702	49.80	Accept

To test whether specific value chain activities and business process might be strongly related, we follow up with 48 proportional hypotheses tests to identify any relatively significant relationships for each pair of activities and processes. Table 5 shows the individual frequency and the calculated p-values for each proportion test. From the frequency and the p-values we observe that the value chain activity of replenish, allocation, and scheduling is strongly related to inventory management and tracking and tracing. Warehouse management and distribution are strongly correlated with the tracking and tracing. Finally, and not surprisingly, returns/recall management is strongly related with the value chain activity returns/recall.

Correlation between RFID benefits and business process (H_50)

Hypothesis H_50 concerns the correlation between retailer benefits and RFID-applicable business processes. The calculated chi-square value in Table 4 is equal to 80.831 with 49 DF. Since this value is greater than the cut off value of 66.34, we conclude that RFID benefits and RFID applicable business processes are strongly correlated at 5% significance level. After identifying the overall correlation between benefits and business processes, we performed 64 proportional hypotheses tests to gauge the relative strength for specific benefit-process pair relationships. Table 6 shows the individual frequency and the calculated p-values for each of the tests. As shown, the benefit of better management of inventory is strongly related to all of the RFID-applicable business processes except acquiring business intelligence and tracking shopping behavior. Next, the benefit of improved security is strongly related to business processes ensuring security against theft & fraud, returns & recalls, and inventory management. Operational efficiency benefits are strongly related to the business processes of tracking & tracing and automated shipping & receiving.

TABLE 5. Correlation between activities/business processes

Business Process / Value Chain Activity	Frequency / (p-values)								
	Tracking and tracing	Security against theft/ fraud	Automated shipping and receiving	Acquiring business intelligence	Asset management	Returns / recall management	Tracking shopping behavior	Inventory management	Total
Merchandise planning	2 (0.496)	3 (0.216)	1 (0.824)	2 (0.496)	1 (0.824)	1 (0.824)	1 (0.824)	2 (0.496)	13
Replenish, allocation & scheduling	28 (0.002*)	17 (0.434)	14 (0.742)	10 (0.966)	11 (0.936)	9 (0.984)	8 (0.993)	31 (0.000*)	128
Warehouse management	18 (0.001*)	8 (0.593)	8 (0.593)	2 (0.998)	11 (0.197)	7 (0.733)	2 (0.998)	10 (0.308)	66
Distribution	8 (0.033*)	2 (0.914)	6 (0.184)	2 (0.914)	3 (0.762)	3 (0.762)	2 (0.914)	5 (0.345)	31
In-store operations	12 (0.053)	10 (0.183)	6 (0.748)	7 (0.599)	2 (0.996)	4 (0.942)	7 (0.599)	10 (0.183)	58
Returns / recalls	10 (0.088)	9 (0.166)	4 (0.886)	2 (0.990)	4 (0.886)	14 (0.003*)	1 (0.999)	6 (0.607)	50
Total	78	49	39	25	32	38	21	64	346

* Statistically significant (5% significance level)

Achieving better information accuracy is strongly related to the task of acquiring business intelligence. However, while Table 5 shows that better management of inventory, improved security, and operational efficiency are the three major benefits strongly associated with the specific RFID-applicable business processes, it is clear that most retailer benefits are reasonably widely scattered across different business processes and this helps account for hypothesis H_50's stronger overall correlation between generic benefits and processes.

TABLE 6. Correlation between benefits/ business processes

RFID Benefits / Business Process	Frequency / (p-values)								Total
	Better management of inventory	Increased operational efficiency	Improved visibility	Reduced cost	Improved security	Improved customer service	Better information accuracy	Increased sales	
Tracking/tracing	36 (0.000*)	29 (0.022*)	25 (0.128)	17 (0.779)	27 (0.057)	8 (0.999)	11 (0.991)	5 (1.000)	158
Security against theft/fraud	31 (0.000*)	13 (0.798)	12 (0.870)	11 (0.923)	37 (0.000)*	10 (0.958)	9 (0.980)	2 (1.000)	125
Automated shipping/ receiving	19 (0.013*)	18 (0.026*)	8 (0.881)	12 (0.437)	14 (0.218)	5 (0.990)	12 (0.437)	1 (1.000)	89
Acquiring business intelligence	12 (0.159)	12 (0.159)	5 (0.948)	6 (0.885)	11 (0.255)	5 (0.948)	18 (0.002*)	1 (1.000)	70
Asset management	22 (0.000*)	11 (0.286)	6 (0.900)	13 (0.109)	9 (0.553)	3 (0.996)	6 (0.900)	2 (1.000)	72
Returns/recalls management	14 (0.015*)	7 (0.636)	8 (0.480)	8 (0.480)	13 (0.032*)	5 (0.884)	3 (0.985)	2 (0.997)	60
Tracking shopping behavior	8 (0.133)	4 (0.771)	4 (0.771)	1 (0.996)	6 (0.407)	6 (0.407)	7 (0.247)	5 (0.594)	41
Inventory management	44 (0.000*)	25 (0.156)	20 (0.559)	18 (0.738)	29 (0.029*)	9 (0.999)	14 (0.952)	3 (1.000)	162
Total	186	119	88	86	146	51	80	21	777

* Statistically significant (5% significance level)

Correlation between RFID benefits and value chain activities (H_60)

Hypothesis H_60 concerns the correlation between retailer benefits and value chain activities. The calculated chi-square value in Table 4 is equal to 22.702 with 35 DF. Since this value is less than the cut off value 49.80, we conclude that RFID retailer benefits and value chain activities are not strongly related. After identifying the overall relationship between benefits and value chain activities, we performed 48 proportional hypotheses tests to identify the relative

strength of the sub-category relationships. Table 7 shows the individual frequency and the calculated p-values for each of the tests.

TABLE 7. Correlation between benefits/activities

RFID Benefits / Value Chain Activities	Frequency / (p-values)								Total
	Better management of inventory	Increased operational efficiency	Improved visibility	Reduced cost	Improved security	Improved customer service	Better information accuracy	Increased sales	
Merchandise planning	3 (0.359)	3 (0.359)	1 (0.897)	2 (0.646)	5 (0.052)	1 (0.897)	2 (0.646)	0 (1.000)	17
Replenish, allocation & scheduling	59 (0.000*)	34 (0.076)	26 (0.572)	21 (0.897)	31 (0.201)	19 (0.957)	16 (0.992)	6 (1.000)	212
Warehouse management	17 (0.019*)	17 (0.019*)	14 (0.121)	11 (0.417)	12 (0.295)	3 (0.998)	5 (0.978)	1 (1.000)	80
Distribution	8 (0.018*)	3 (0.698)	3 (0.698)	2 (0.881)	4 (0.471)	3 (0.698)	4 (0.471)	1 (0.976)	28
In-store operations	22 (0.006*)	16 (0.191)	13 (0.500)	7 (0.975)	20 (0.024*)	12 (0.619)	7 (0.975)	4 (0.999)	101
Returns / recalls	14 (0.015*)	7 (0.636)	7 (0.636)	9 (0.333)	13 (0.032*)	5 (0.884)	3 (0.985)	2 (0.997)	60
Total	123	80	64	52	85	43	37	14	498

* Statistically significant (significance 5% level)

The benefit of better management of inventory is strongly related to almost all of the included value chain activities except merchandise planning. Improved security is strongly related to in-store operations and returns/recalls. Increased operational efficiency is strongly related to warehouse management. None of the other relationships is statistically significant and these results provide evidence that better management of inventory is a key reason why RFID is currently being deployed in retailer value chains.

Implications for Decision Support

Using the data from Table 4, which shows key retailer-based value chain activities, and the analytical results obtained from hypotheses H_40, H_50, and H_60, we can provide initial guidance for RFID retailer implementation concerns. Thus, if a retailer is considering implementing RFID for replenish, allocation, and scheduling operations, we can identify the business processes that can make use of the RFID data using Table 5 (i.e., inventory management, tracking and tracing, security against theft/ fraud, and automated shipping and receiving).

Similarly, we can advance guidelines to predict expected benefits from implementing a particular RFID business process. For example, in Table 6, if a retailer implements RFID for inventory management, the top five expected benefits in order include better management of inventory, improved security, increased operational efficiency, improved visibility, and reduced costs.

From Table 7, we can derive the main expected benefits as better management of inventory, increased operational efficiency, improved security, improved visibility, and reduced cost. Using this guidance, a retailer could tailor their return on investment (ROI) analyses more constructively.

Conclusions and Implications

In this paper, we use content analysis to study the benefits, RFID applicable value chain activities, and business processes in the retail sector. We derive quantitative results based on our content analysis data using proportional and chi-square tests, and frame our research questions

based on our adapted version of Roger's technology adoption model. We conclude that key RFID retailer benefits that emerged in our study are better management of inventory, improved security, increased operational efficiency, increased visibility, and reduced cost. We plan to further investigate dependencies and correlations between these retailer benefits to provide a better framework for evaluating the ROI of RFID.

Key RFID-applicable business processes emerged to be inventory management, tracking and tracing, security against theft and fraud, automated shipping and receiving, and acquiring business intelligence. Key value chain activities emerged as replenishment, in-store operations, warehouse management, return/recall handling, and distribution. Although not yet a significant activity, merchandise planning appears to be gaining interest among retailers. The other possible activities such as promotional planning, price management, sales planning, and assortment planning have potential value in retailer value chains but do not seem to be currently explored.

We discover strong relationships between retailer benefits and RFID-applicable business processes. The relationship between retailer benefits and integrated value chain activities came out to be insignificant, as did business processes and value chain activities. This suggests that in order to fully reap retailer RFID benefits we may need to consider a more comprehensive analysis.

This research contributes toward clarifying some uncertainties associated with RFID technology adoption. These uncertainties may impede the adoption progress and acceptance in the retail world despite its immense potential. To help reduce this uncertainty, we take a novel integrated approach to investigating retailer RFID adoption by investigating relationships between specific retailer benefits, business processes, and integrated value chain activities. By applying content analysis in a rigorous way, we can identify statistically significant correlations

across value chain activities, business processes, and benefits. These correlations can then be used by retailers to develop RFID implementation strategies. This same approach can be further extended to analyze the RFID status of other sectors or industries. To validate and refine our results with real world data, we intend to design a survey instrument based on our present analyses and compare the results.

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