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An exploratory study of RFID adoption in the retail sector

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Abstract We use a search procedure called *content analysis* to determine the benefits of RFID in the retail sector. Content analysis classifies textual material, such as academic articles, and reduces them to manageable data. We find that the key RFID retailer benefits are better management of inventory, improved security, better operational efficiency, and reduced cost. We also find the key RFID business processes to deal with, for example, tracking and tracing. Through hypothesis testing and correlations, we discover strong relationships between retailer benefits and RFID business processes, and that better management of inventory is a reason why RFID is being used by retailers.

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1 Introduction

The development of Radio Frequency Identification (RFID) dates back to the early 1920s with the birth of radar systems. It was further developed for detection of enemy aircraft during World War II (AIM 2001). Starting from the 1980s through the early 2000s, the technology was deployed in a wide range of applications where wireless non-line-of-sight data 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). Currently RFID technologies are used to identify, capture, and transmit information from tagged objects to enterprise systems (Reyes and Frazier 2007; Visich et al. 2009). The objects could be manufacturing equipment, products, or hospital patients. However, integrating this captured data into existing business practices to improve effectiveness is proving to be a complex undertaking.

Industries, such as retail, aerospace, defense, health care, logistics, and pharmaceuticals can benefit from RFID. Since the benefits vary from industry to industry, we select the retail industry for our study, as it is one of the most aggressive supporters of the technology. For on the one hand, requirements from giant retailers and government agencies have increased awareness and driven many suppliers to implement it. But on the other hand, only 9% of the retailers in a recent NCR study had 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 Walmart, are not adopting RFID rapidly. One answer could

be that most retailers may be skeptical about the benefits of implementing the technology, given the need for a huge investment up front (Michael and McCathie 2005) and the uncertain return on investment (ROI).

In this paper, we examine the benefits, business processes and the value chain activities that are influenced by the use of RFID in the retail industry. We also capture the correlations between the retailer benefits, value chain activities, and business processes. To achieve our research objective of better understanding the impact of RFID on retail, we employ content analysis of a combined set of trade and academic articles, many of which are *pilot studies or actual implementations*. To guide our investigation and analysis, we adopt the following research questions:

- What are the major benefits from RFID use 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 RFID retailer benefits, value chain activities, and business processes?

Our paper is organized as follows. We first discuss our research methodology and the related research work. Next, we present our content analysis together with a related statistical analysis. This is then followed by implications for decision support and by conclusions.

2 Research methodology

Since the use of RFID for operational and value chain improvement is new, it was clear that our methodology must be suitable for the analysis of the data, as it could not be expected to find a representative sample of participants for an empirical survey. Therefore a combination of secondary and primary sources provided data for our research, and we used *content analysis* to guide our 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 text; it has been used to study RFID adoption (Michael and McCathie). The methodology is both qualitative and quantitative (Leedy and Ormrod 2005, p. 143), because content analysis counts the frequency of particular words in a text. It also allows for establishing relationships. But since content analysis is emerging rather than an established procedure, the texts we selected included not only journal or conference papers, but also press releases and industry white papers. Content analysis is a form of semiotics or hermeneutics like conversation analysis and discourse analysis (Krippendorff 1980). Like hermeneutics, semiotics is an underlying philosophy and a mode of analysis. (Liebenau and Backhouse 1990) demonstrated the applicability of semiotics in information systems (IS) research. Lee's (1994) work on electronic mail as a medium for rich communication using hermeneutic interpretation showed the potential of this exploratory mode of analysis. Wynn's (1991) is an example of the use of conversation analysis in IS research whereas (Klein and Truex 1995) work shows the use of discourse analysis in IS. Our study consisted of three major phases as shown in Fig. 1.

Phase 1: Reference identification and search In this phase, we identified the possible sources as targets for our search. Our search covered 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 used different versions of the keyword containing "*RFID*" and "*Retail*" and collected all relevant articles. We did our search between October 2006—Oct 2008 and found 470 articles: 35 published journal articles, 40 conference proceedings, 49 academic magazines, 4 academic theses, 138 industry white papers, and 204 news releases. We made sure that we eliminated duplication. For the news releases, the majority consisted of insights from pilot studies or actual RFID implementations or views from experts in light of empirical investigations and are thus equally reliable and equally important as academic articles.

Phase 2: Classification In Phase 2, we classified the textual data by major RFID adoption category and associated each research issue with a stage in an RFID diffusion model adapted from Rogers (1995). The idea was to extend the Rogers model into RFID implementation. It also allowed us to encapsulate the research problems. The various issues that emerged in this classification phase were the following: 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 focused on potential benefits, value chain activities, and business processes. The knowledge stage of our adopted diffusion model involved enhancing the required information 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 linked with this stage. The persuasion stage of the diffusion model maps unto RFID-adoption drivers and key benefits, and the decision and design stage incorporated activities that led to deciding whether to adopt or reject a particular RFID solution. The latter included identifying potential value chain activities, RFID-applicable business

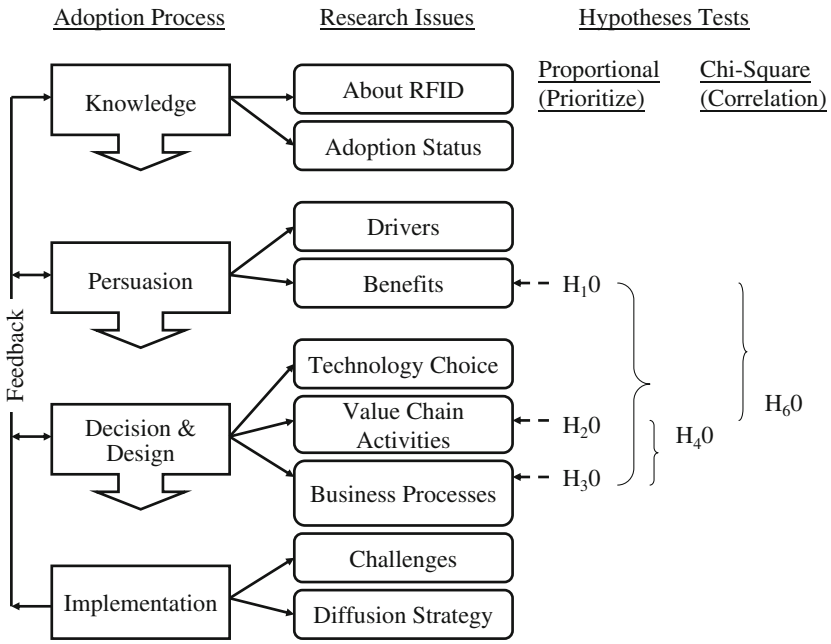

Fig. 1 Research model

processes, and RFID technology choice (in terms of RFID frequency, standards, case/pallet level of tagging, and so on).

Coding reliability In order to ensure the reliability of data coding, we revisited the dataset multiple times during the coding process and thus the coding scheme was generated iteratively. We used manual coding techniques, so that no piece of relevant information was ignored. We also used an open source tool textStat to do reliability test of our coding. Holsti's (1969) formula for reliability is used among the original coding and the textStat coding. We randomly selected 10% of the total number of articles (which is 47 articles) and fed them to textStat to generate word frequency lists. We used this word frequency list to compare with our actual primary coding schema and treated it as secondary coder. After comparing codes we calculated the level of coding agreement.

Based on the following formula, the coding reliability was found to be at 99.21%.

$$\text{Reliability} = 2(OA)/N1 + N2$$

OA Observed Agreement
N1 No. of coding decisions made by the primary coder
N2 No. of coding decisions made by the secondary coder

$$\begin{aligned}\text{Reliability} &= 2^*(252)/(252+256)\\ &= (2^*252)/(252+256) = 504/508\\ &= 0.992126 = 99.21\%\end{aligned}$$

Phase 3: Data analysis and interpretation From the RFID adoption issues identified in Phase 2, we developed several hypotheses regarding the impact of these issues on the RFID adoption in retail, and we tested these hypotheses using the quantitative results from our content analysis. We applied proportional hypothesis tests (Zou et al. 2003) to the numerical data to identify the most significant factors amongst benefits, value chain activities, and business processes. We used 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 could then be used by retailers to identify key RFID implementation areas. See Fig. 2 for the list of hypotheses tests.

3 Related research

Studies of RFID and its applications cover a wide range of adoption characteristics, industry sectors, and geographical regions. Note that while our content analysis includes industry articles, in this section we discuss only academic articles.

Faber (2002) claimed that RFID can lead to savings when used for managing records. He also examined the challenges 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. Angeles (2005) argued that RFID had the potential to provide process freedom (thus reducing labor requirements) and real time visibility across the supply

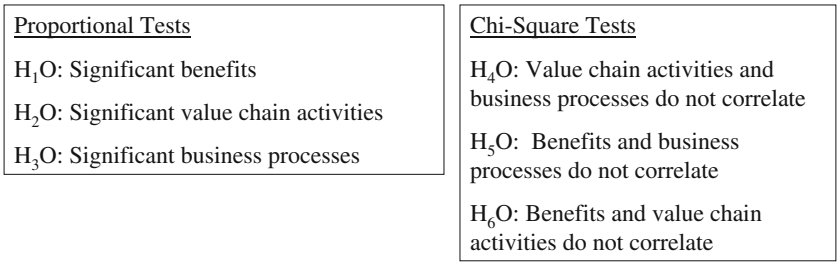

Fig. 2 List of hypotheses

chain, especially in retailing and logistics. Bose and Pal (2005) claimed that the significant benefits achieved from RFID implementation are improved visibility across the supply chain and full or semi-automation of repetitive operations. They also claimed that the challenges are the cost of tags, item level vs. pallet level tagging, multiple frequencies, data management, and privacy issues. Prater et al. (2005) examined the impact of RFID on electronic supply chains and specifically in grocery retailing. Their work focused on the market drivers leading to RFID implementation in grocery retailing. Jones et al. (2004, 2005) presented potential benefits and challenges of RFID across the retail supply chain in the United Kingdom.

Michael and McCathie attempted to identify the pros and cons of RFID in supply chain management; however, their work was geared toward RFID adoption, whereas our focus is to look specifically at the retail sector. Koh et al. (2006) surveyed the critical factors of RFID in the retail sector; but their focus was on short-term benefits, which may be limiting due to the evolving nature of the RFID technology. Reyes et al. (2007) also conducted an empirical study of RFID adoption and barriers for successful implementation. Engels et al. (2007) analyzed RFID applications in the Department of Defense (DOD) and identified the requirements of the DOD supply chain along with the ability of RFID to address them. But most of these studies usually considered only single aspects of RFID adoption, whereas our paper covers seven of them (see Table 1). In particular, our study is the only one that examines the RFID-applicable business processes and integrated value chain activities influenced by RFID. We also establish statistical relationships between

- value chain activities and business processes,
- value chain activities and retailer benefits, and
- business processes and retailer benefits.

4 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 and design phase, we identify the most significant RFID-applicable retailer business processes and value chain activities and their relationship to retailer benefits.

4.1 Retailer benefits of adopting RFID (Hypothesis H_10)

Starting with the set of RFID 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 stockouts, reduced inventory, and reduced shrinkage. The hypothesis H_10 concerns the significance of these specific retailer benefits; it 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. 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 the 5% significance level, it comes close. The rest of the benefits are not statistically significant. We see from Table 1 that the impact of better inventory management on retailer benefits comes primarily from reduced stockouts, rather than reduced inventory or reduced shrinkage. The retailer benefits derived from improved security in terms of theft and fraud appear to be split almost equally between reducing the store and the supply chain. Finally, for benefits related to operational efficiency/improved throughput, we see that improving business processes and supply chain velocity are the key factors.

The statistically insignificant benefits are improved visibility, reduced cost, better information accuracy, improved customer service levels, and increased sales. Improved visibility helps achieve a tighter, integrated supply chain, but appears to benefit manufacturers more than retailers (Bhattacharya et al. 2008). Reducing cost appears to rely on two main sub-effects, 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

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)

completely new automation. As for reducing overall costs, it may be that since RFID implementation costs are non-trivial in the short run, the impact of RFID on the 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. Similarly, while customer service might be improved in the long run by technologies, such as smart shelves, in the short run this technology remains immature. An additional possibility is that customer privacy concerns are slowing the development of data gathering systems.

Lastly, since many of these benefits have the potential to influence each other, some benefits may not show up as primary, since they are achieved indirectly. For example, implementing better inventory management and improved security throughout the value chain would eventually contribute to reducing cost and improving information accuracy and visibility. It would also improve customer service due to better availability of products (i.e., no stockouts) and lower prices.

4.2 Where RFID has been used in retail value chains (Hypothesis H_20)

A value chain is a series of connected activities. Products pass through all activities of the chain in order and at each activity, the product gains value. The chain of activities gives the products more added value than the sum of added values of the parts. Typically major retailers have business alliances with multiple tiers of suppliers, manufacturers, and distributors, 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.

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. A typical integrated retail value chain has the major elements shown in Fig. 3, where many of these elements may be common to other types of value chains as well:

1) *Merchandise planning*: Planning and maintaining a balance between sales and inventory.
2) *Assortment Planning*: Planning and proper selection of merchandise.
3) *Sales planning*: Planning routes and distribution channels to reach target customers.
4) *Price management*: Concerns understanding and improving pricing decisions based on forecast data.
5) *Promotion planning*: Planning and managing promotions.

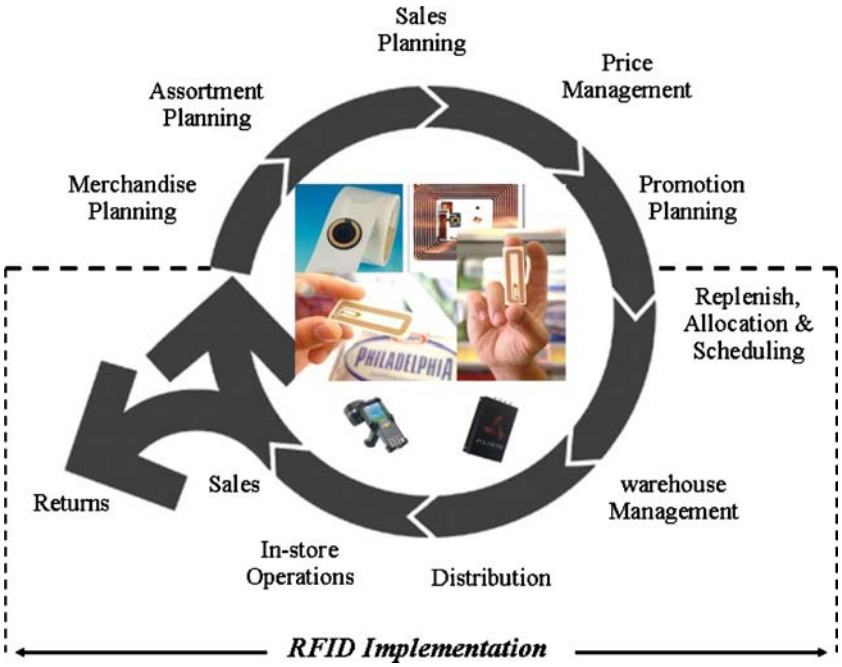

Fig. 3 Framework of an integrated retail value chain (Adapted from Callana 2006)

6) *Replenishment, allocation, and scheduling*: Managing resources and product delivery to avoid stockouts.
7) *Warehouse management*: Management and coordination of warehouse facilities.
8) *Distribution*: Distributing the right product to the right destination at the right time.
9) *In-store operation*: Management of various store operations.
10) *Sales*: Revenue generation.
11) *Returns*: Manages return of merchandise.

Since the benefits of RFID adoption can spread throughout the value chain, 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 along with the results of the proportional hypothesis tests. In Table 2, we assume that each value chain activity contrib-utes 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

Table 2 Retailer value chain activities

Value chain activities	Frequency	Percentage	*p*-values
Replenishment, 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%)

value chain activity turns out to be replenishment followed by in-store operations, warehouse management, and returns/recalls. We see that most of the dominant RFID benefits cluster into the more traditional activities at the lower end of the value chain, rather than among the newer integrated value chain concepts, such as merchandise planning.

4.3 Which RFID-applicable business processes can be used? (Hypothesis $H_3 0$)

We have identified eight broad business processes where RFID can be used in retail applications. These processes are not necessarily exclusive to retailers, but 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 hypothesis tests for each business process. We assume that each process category that contributes to at least one eighth or more out of the total article frequency of 812 is a significant contributor (our hypothesis $H_3 0$). 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.

4.4 Interaction between benefits, value chain activities and business processes

A retailer planning to invest in RFID wants to know which business processes and value chain activities would 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 and help to identify specific 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 the three hypotheses $H_4 0$, $H_5 0$, and $H_6 0$ concerning 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.

But whereas 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 a specific business process (e.g., tracking and tracing). To address this, we also test for pairwise relationships between specific benefits, activities, and processes using proportional tests. For hypotheses $H_4 0$ and $H_6 0$, we eliminate those value chain activities with low frequencies as they are not significant. The eliminated activities were sales planning, assortment planning, price management, and promotion planning.

4.4.1 Correlation between value chain activities and business processes (Hypothesis $H_4 0$)

Hypothesis $H_4 0$ concerns the correlation between value chain activities and RFID business processes. The calculated chi-square value for this hypothesis in Table 4 is 44.76 with 35 degrees of freedom, and thus the *p*-value is 0.125; hence, we conclude that value chain activities and business processes are not correlated.

To test whether specific value chain activities and business processes might be strongly related, we follow up with 48 proportional hypothesis tests to identify any significant relationship for each pair of activities and processes. Table 5 shows the individual frequencies and

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)

Table 4 Correlation analysis using Chi-square test

Hypothesis	DF	Chi-Square value	*p*-value	Result
$H_4 0$: Value chain activities and RFID-applicable business processes are not correlated.	35	44.76	0.125	Accept
$H_5 0$: RFID benefits and business processes are not correlated.	49	80.83	0.003	Reject
$H_6 0$: RFID benefits and value chain activities are not correlated.	35	22.70	0.946	Accept

Table 5 Correlation between activities/business processes

Business process	Frequency / (*p*-values)								
Value chain activity	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
Replenishment, allocation & scheduling	28 (0.002[a])	17 (0.434)	14 (0.742)	10 (0.966)	11 (0.936)	9 (0.984)	8 (0.993)	31 (0.000[a])	128
Warehouse management	18 (0.001[a])	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[a])	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[a])	1 (0.999)	6 (0.607)	50
Total	78	49	39	25	32	38	21	64	346

[a] Statistically significant (5% significance level)

p-values for each proportion test. From the frequencies and the *p*-values, we observe that the value chain activity of replenishment, allocation, and scheduling is strongly related to inventory management and tracking and tracing. Warehouse management and distribution are strongly correlated with tracking and tracing. And not surprisingly, returns/recall management is strongly related to the value chain activity returns/recall.

4.4.2 Correlation between RFID benefits and business processes (Hypothesis $H_5 0$)

Hypothesis $H_5 0$ concerns the correlation between retailer benefits and RFID-applicable business processes. For this hypothesis, the calculated chi-square value in Table 4 is 80.83 with 49 DF; the *p*-value is then 0.003, and we conclude that RFID benefits and RFID applicable business processes are strongly correlated. After identifying the overall correlation between benefits and business processes, we performed 64 proportional hypothesis tests to gauge the relative strength for specific benefit-process pairs, and Table 6 shows the frequencies and the calculated *p*-values for each of the tests. As seen, the benefit of better management of inventory is strongly related to all of the RFID-applicable business processes, except for acquiring business intelligence and tracking shopping behavior. Next, the benefit of improved security is strongly related to the three business processes of 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.

Achieving better information accuracy is strongly related to the task of acquiring business intelligence. However, while Table 5 shows that better management of inventory,

Table 6 Correlation between benefits/ business processes

RFID benefits	Frequency / (*p*-values)								
Business process	Better management of inventory	Increased operational efficiency	Improved visibility	Reduced cost	Improved security	Improved customer service	Better information accuracy	Increased sales	Total
Tracking/tracing	36 (0.000[a])	29 (0.022[a])	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[a])	13 (0.798)	12 (0.870)	11 (0.923)	37 (0.000)[a]	10 (0.958)	9 (0.980)	2 (1.000)	125
Automated shipping/receiving	19 (0.013[a])	18 (0.026[a])	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[a])	1 (1.000)	70
Asset management	22 (0.000[a])	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[a])	7 (0.636)	8 (0.480)	8 (0.480)	13 (0.032[a])	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[a])	25 (0.156)	20 (0.559)	18 (0.738)	29 (0.029[a])	9 (0.999)	14 (0.952)	3 (1.000)	162
Total	186	119	88	86	146	51	80	21	777

[a] Statistically significant (5% significance level)

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, which accounts for hypothesis $H_5 0$'s stronger overall correlation between generic benefits and processes.

4.4.3 Correlation between RFID benefits and value chain activities (Hypothesis $H_6 0$)

Hypothesis $H_6 0$ concerns the correlation between retailer benefits and value chain activities. The calculated chi-square value in Table 4 is 22.70 with 35 DF; hence, the *p*-value is 0.946. Therefore, we conclude that RFID retailer benefits and value chain activities are not 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 frequencies and the calculated *p*-values for each of the tests.

We find that the benefit of better management of inventory is strongly related to almost all of the 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 retail value chains.

5 Implications for decision support

Using the results in Table 4 and from hypotheses $H_4 0$, $H_5 0$, and $H_6 0$, we can provide some suggestions for retailer RFID retailer implementation. Thus, if a retailer is considering implementing RFID for replenishment, allocation, and scheduling, we can, using Table 5, identify the corresponding business processes. These would be inventory management, tracking and tracing, security against theft/fraud, and automated shipping and receiving.

Similarly, we can suggest guidelines to predict expected benefits from implementing a particular RFID business process. For example, if a retailer implements RFID for inventory management, the top five expected benefits (Table 6) would be better management of inventory, improved security, increased operational efficiency, improved visibility, and reduced costs. From Table 7, we can elicit the expected benefits as better management of inventory, increased operational efficiency, improved security, improved visibility, and reduced cost.

6 Conclusions

We use content analysis to study the benefits, the RFID value chain activities, and the 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 Rogers' technology adoption model. We conclude that key RFID retailer benefits are better management of inventory, improved security, increased operational efficiency, increased visibility, and reduced cost.

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 were replenishment, in-store operations, warehouse management, return/recall handling, and distribution. And although not a statistically significant activity, merchandise

Table 7 Correlation between benefits/activities

RFID benefits	Frequency / (*p*-values)								
Value chain activities	Better management of inventory	Increased operational efficiency	Improved visibility	Reduced cost	Improved security	Improved customer service	Better information accuracy	Increased sales	Total
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[a])	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[a])	17 (0.019[a])	14 (0.121)	11 (0.417)	12 (0.295)	3 (0.998)	5 (0.978)	1 (1.000)	80
Distribution	8 (0.018[a])	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[a])	16 (0.191)	13 (0.500)	7 (0.975)	20 (0.024[a])	12 (0.619)	7 (0.975)	4 (0.999)	101
Returns / recalls	14 (0.015[a])	7 (0.636)	7 (0.636)	9 (0.333)	13 (0.032[a])	5 (0.884)	3 (0.985)	2 (0.997)	60
Total	123	80	64	52	85	43	37	14	498

[a] Statistically significant (significance 5% level)

planning appears to be gaining interest among retailers. We discovered 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 research contributes toward clarifying some uncertainties associated with RFID adoption, uncertainties that may impede acceptance in the retail world. To help reduce this uncertainty, we take an integrated approach to investigating retailer RFID adoption by investigating relationships between specific retailer benefits, business processes, and value chain activities. By applying content analysis, we identified statistically significant correlations across value chain activities, business processes, and benefits. These correlations can then be used by retailers to develop RFID implementation strategies.

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