The Impact of RFID in Retail Industry: Issues and Critical Success Factors

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By focusing on the retail industry, this study explores Radio Frequency Identification (RFID) and postulates a structural causal relationship among its intrinsic attributes, perceptions, and impact on business performance. A focus group of select industry experts was used to develop and corroborate the research model. Based on findings from the focus group and a literature review, a survey instrument was developed to empirically validate the research model. Data collected from seventy industry executives and managers using exploratory factor analysis, confirmatory factor analysis, and structural equation modeling were analyzed. Four major categories of RFID benefits were identified: (a) improved inventory management, (b) velocity of retail cycle, (c) integrated business model, and (d) efficiency of store operation. In addition, three major risk factors were recognized: (a) lack of technical expertise, (b) complexity of the technology, and (c) uncertainty of the technology. From the structural causal relationship analysis, a significant relationship was found between intrinsic attributes and benefits of RFID, but the connection between intrinsic attributes and risks of RFID was not substantiated. The structural equation model also suggests a significant relationship between benefits of RFID and the strategic impact on business performance. In particular, two RFID benefit factors, velocity of retail cycle and improved inventory management, seem to have a strong effect on business.

Advances in Information Technology are constantly transforming competitive dynamics in marketplace. One of these advances is RFID, which is a technology that uses a special tag or label embedded with a computer chip and an antenna that allows it to communicate with a reader or transponder. It is far more than an extension of the widely used bar code system because the RFID tag can store data and can even have processing capability. Potential benefits of RFID are numerous for all stakeholders in retailing industries. Some of these benefits include reduced labor costs, simplified business processes, improved inventory control, increased sales, and reduced shrinkage. In fact, many retailers and suppliers have already initiated various projects to utilize the technology, such as Wal-Mart, which has mandated its top suppliers to start using RFID on cases and pallets. Studies have shown that most companies are intensely interested in the technology as a means to improve operation and gain competitiveness in the market. A recent study, commissioned by Wal-Mart, empirically demonstrated that RFID improves inventory management by significantly reducing downtime from stock turnover (Hardgrave, 2005). It is predicted that the global RFID market will reach $3.0 billion by 2008, with a minimum annual growth rate of 23% (Chen, 2004).

For the retail industry, bar codes have long been an important technology for Quick Response (QR) by helping the industry save production costs, hold inventories low, and prevent overstocking (Fiorito, et. al., 1998; Hill, 2004; Ko & Koncade, 1997; Sweeney, 1995). Recently, apparel retailers such as Benetton and Prada have considered RFID as a new technology to reinvigorate the trend of "quick-response" (Shim, 2003). Retail chains, such as Marks & Spencer, are expected to benefit the most from

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the technology because it could support the industry's increasing demand for speed, frequent delivery, and collaborative planning along the value chain (Store, 2005). The technology can be particularly beneficial to high velocity retailers, because it can revolutionize and accelerate the way products are designed, manufactured, transported, and inventoried. To maximize the benefit and minimize the risk associated with RFID, retailers need to identify critical success factors for increasing competitive advantage through the use of the technology, and assess the challenges and issues that it poses.

Technological Innovation in Retail Industry

Today, the retail industry is facing a serious challenge due to rapidly changing market conditions, fueled by increasing global competition, higher performance expectations by customers and the market, and ever evolving technologies (Lin et al., 2002). During the past three decades, the industry has grown significantly due to technological innovations, and by adopting supply-chain management techniques, such as QR, which combines technologies, modular layouts, process reengineering, total quality management, and employee involvement (Fiorito, et. al., 1998; Kincade, 1995; Ko & Kincade, 1997). While QR has been a successful initiative for the retail industry, there is a growing need for a new technology to sustain and revive its vitality in order to deal with the increasing market pressure and customer demand. The industry welcomes RFID as a possible solution to this challenge, although it is not clear what the limits of the technology and how to harness it to maximize its benefits while controlling its risks. Accordingly, there is demand for a comprehensive framework of RFID that can be used as a roadmap for researchers as well as practitioners.

Benefits of RFID for Retailing

The RFID technology is being touted as a tool to revolutionize the way business gets done because of its broad impact on manufacturing, logistics, material handling, inventory tracking and management, safety and security, cashless payment, and customer service (Chen, 2004; TIBCO, 2005). With RFID technology, a retail business can provide better customer service along with improvements in store layout, adjacencies, fitting rooms, and customer amenities (Leob, 2003). For instance, RFID can help retail businesses track stock more efficiently by beaming out a product identity code, plus the type, size, and color when prompted by a radio signal from a nearby RFID reader (Hogan, 2003). In other cases, specialty apparel retailers, such as Zara and Prada in Europe, enhance their ability to design, manufacture, and stock the latest products in disposable chic fashions that change almost weekly by monitoring and responding to consumer preferences more effectively and promptly (RFID Journal, 2004; Store, 2005).

For retailing, RFID technology has numerous advantages over the prevailing bar code technology, for suppliers, retailers, and consumers. Some of these benefits include: (a) improved accuracy in managing inventory; (b) improved visibility of orders and inventory; (c) reduced costs for logistical operation; (d) improved efficiency of store operation; (e) shorter retail cycle of designing, manufacturing and stocking

the latest products; (f) improved sales floor planning for desired styles, sizes, and colors; (g) improved customer service; and (h) improved security, among others. RFID promises many benefits, and as such, it is not hard to understand why retailers are eager to integrate the technology. However, it is imperative to recognize that RFID has limitations, which must be addressed and resolved, before technologist benefits can be realized.

Exploratory Analysis of RFID Applications

Due to the lack of a comprehensive framework of RFID technology, this preliminary and exploratory study was conducted to identify as many issues and concerns related to the technology as possible. We searched ABI Index for all articles with the keyword "RFID." ABI Index is one of the most comprehensive indexing systems available for business-oriented publications. The search returned 1,177 articles published between 1985 and the first half of 2004. For each article returned, we recorded all keywords used to describe the article by the index, which resulted in 113 substantially distinct keywords. Table 1 shows the top ten keywords and the count of articles in which each keyword was covered by year. Notably, most of the top ten keywords in the table (e.g., inventory, retail, supply chain, logistics, and market) provide support for a commonly held contention that RFID has the most profound impact on supply chain and inventory management, particularly in retail. This exploratory study provided a comprehensive "vocabulary" and a roadmap for this study.

Research Objectives and Research Model

This study explores critical success factors of RFID technology for the retail industry using qualitative and quantitative approaches. As illustrated by the research model in Figure 1, the qualitative phase of the research focuses on an exploratory analysis of RFID attributes related to technology and business, perceived benefits, and risks beyond those identified from the literature review. On the other hand, the quantitative phase focuses on the impact of RFID on strategic business performance for the retail industry. Specifically, two objectives were established for the research:

1. To identify underlying dimensions of perceived RFID benefits and risks for the retail industry.
2. To estimate a structural equation model for examining the relationships among RFID intrinsic attributes, perceptions of RFID (e.g., benefits, risks), and its strategic impact on business performance.

Table 1

Top 10 Keywords that Appeared Most in Articles Published on RFID from 1985 to 2004

Meta keyword	1985	1986	1987	1988	1989	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
1. Technology	1	1	1		2		4	1	4	6	1	6	16*	13*	13*	36**	84†	43
2. Inventory	3				1		2	2		2	2		9	6	21*	32**	112††	25
3. Retail							1		1	1	1	2	3	3	4	21*	102††	51
4. Supply chain											1	1	3	4	10*	24*	92†	44
5. Industries & markets					1	1	1	3	2	5		8	13*	6	10*	17*	65†	28
6. Identification	1	1	1		1		5	2	3	8	10*	12*	44**	19*	17*	2	6	
7. Logistics				1	1			1	1		1	1	6	10*	13*	19*	50†	9
8. Security							2		4	5	4	5	15*	6	7	11*	21*	12
9. Products					1		1			3	3	1	16*	6	6	6	17*	10
10. Market					1							1	6	5	2	5	32**	16

Note. The numbers in table indicate the count of article in which the keyword appeared. The study was conducted in August 2004 and includes articles published up to June 2004. * 10 to 24. ** 25 to 49. † 50 to 99. †† Over 100.

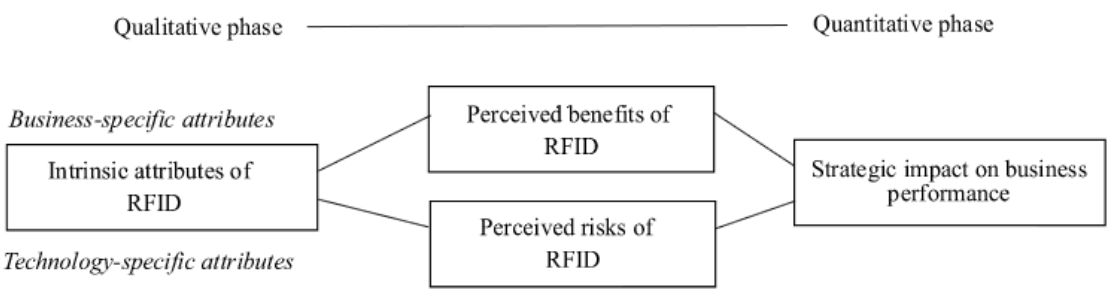

Figure 1. Research model for the impact of RFID technology on the retail industry

Methods

Qualitative Phase - Focus Group Interview

As a preliminary step toward developing a quantitative data collection instrument to be used in the next phase of the research, we conducted a focus group interview with a panel of six industry experts who served on the Advisory Board of the School of Merchandising and Hospitality Management at the University of North Texas. To guide the focus group interview we organized the session in the following semi-structured sequence: (a) introduction; (b) general exploratory discussion (e.g., level of experience, familiarity and perception of RFID); (c) detailed discussion (e.g., intrinsic attributes, perceived benefits and risks, and implementation strategies); and (d) closing. The panel was asked to discuss their perceptions about RFID and strategies to implement the technology in retail systems. One of the authors served as the moderator. The session was audio recorded and additional notes were taken to capture subtle contexts. The entire session was transcribed into a script for further analysis. Qualitative content analysis was used to analyze the verbal data collected from the focus group. From this analysis, 31 RFID attributes were recognized, along with six dimensions of benefits and one dimension of risks. Some of these included visibility, velocity, revenue enhancement, employee productivity, store operation, customer service, standardization, and security. The findings from the focus group and the preliminary literature review were incorporated into the survey instrument used in the following quantitative research phase.

Quantitative Phase - Survey

Based on the findings from the literature and the focus group interview, a self-administered survey questionnaire was developed with multi-item scales. The instrument consists of items to measure the RFID variables in the proposed research model, including intrinsic attributes, benefits and risks, and strategic impact on business performance. It also includes questions about the level of familiarity with the technology and the stage and intention of RFID implementation. In addition, general demographics of respondents and their firms (e.g., position and work experience, annual sales volume, and number of employees) are included.

RFID intrinsic attributes. Measurements were taken of the level of importance of RFID as perceived by the respondent for each of the intrinsic attributes considered crucial for successful implementation. These attributes encompass both technological and business aspects. Examples of the items used to measure these attributes include data accuracy, EPC standards, cost of hardware, and middleware. Each item was measured using a 5-point rating scale, with 1 being “very unimportant,” and 5 being “very important.”

Perceptions of RFID. To measure perceptions of RFID, including benefits and risks, a multi-item scale was derived from the literature (Hill, 2004) and the focus group. Examples of items used to measure benefits of RFID include reduced labor cost, reduced items out of stock, reduced time to market, and improved visibility. Examples of risk items include cost of technology, lack of return on investment, lack of expertise, security, and privacy. Respondents were asked to answer these questions using the 5-point rating scale.

Strategic impact on business performance. Strategic impact of RFID technology on business performance was measured as the likelihood of the technology to have an impact on various aspects of business. The scale items were designed to measure perceived levels of impact on areas such as merchandising strategy, distribution and supplier networks, customer service, and marketing strategy. Each item was measured by asking questions using the 5-point rating scale.

Sampling and Data Collection

A survey was conducted in January 2006 with a sample of 1,195 executives and managers working in retail industries. The sample was derived from three sources of potential participants: (a) a mailing list of 1,120 top executives working for major retailers in the U.S. compiled and provided by a retail consulting organization, (b) a list of 31 executives who serve on the Advisory Board of the School of Merchandising and Hospitality Management at the University of North Texas, and a group of professionals enrolled in two MBA marketing and logistics classes at the University of North Texas. To make the survey more convenient and to increase the response rate, it was distributed in both hardcopy and electronic format. The printed version of the self-administered questionnaire was mailed or personally delivered. Two weeks later, a postcard was sent to remind the mangers of the survey, and to encourage them to participate, and inform them that the survey was available online and provided the web address. About a week later, an e-mail reminder was sent to 592 managers whose e-mail addresses were available to the researchers, from which 81 responses were received, of which 70 were deemed usable. Excluding 23 mailings that were returned as undeliverable from the sample, the response rate to the survey was about 6.9%.

The majority of the survey participants were senior executives and managers of retail firms, and their self-reported titles or positions include: (a) Chairman, Chief Economic Officer, President, Owner, or Principal (18%); (b) Senior Vice President (18%); (c) Distribution Manager or Team Leader (8.1%); Store Manager (4.9%); and Other (50.8%). The average work experience reported with the current organization was 8.5 years. The participating firms represent a broad range of sizes as measured by the number of employees with the following breakdown: (a) 100 or less (11.3%), (b) 101 to 500 (20.9%), (c) 501 to 1,000 (15.2%), (d) 1,000 to 5,000 (19.0%), (e) 5,000 to 10,000 (11.4%), (f) and more than 10,000 (22.8%). They also encompass a wide range of sizes in terms of annual gross revenue, from $1.7 million to over $ 50 billion, with the mean of $3.16 billion.

Data analysis. An exploratory factor analysis was conducted to identify major dimensions of intrinsic attributes, perceived benefits, and risks of RFID. The validity of the measures was assessed with confirmatory factor analysis using maximum likelihood and used Cronbach's alpha to establish inter-item reliability. To examine relationships among RFID intrinsic attributes, perceptions of benefits and risks and strategic impact on business performance, AMOS 4.0 was used to perform Structural Equation Modeling (SEM) based on a correlation matrix with the maximum likelihood. Overall fit of the model was assessed by various statistical indexes such as Chi-square (χ^2), Comparative Fit Index (CFI), Incremental Fit Index (IFI), Normed Fit Index (NFI), and Root Mean Square Error of Approximation (RMSEA).

Findings and Discussion

Retailers' Perceptions of RFID Technology

Intrinsic attributes of RFID. An exploratory factor analysis revealed three major factors of intrinsic attributes of RFID: (a) technical attributes, (b) business attributes, and (c) data attributes. These three factors accounted for 81.1% of the total variance. Specific factor items and factor loadings are shown in Table 2.

Table 2
Factor Analysis of RFID Intrinsic Attributes

Factors and items	Factor loadings	Eigenvalue	% of variance
Technical attributes (α = .92)		3.56	32.36
Middleware	.83		(32.36)
Tagging at the item level	.80		
Item label data via EPC	.79		
EPC standards	.77		
Mass availability of UFH tags and readers	.71		
Business attributes (α = .87)		2.69	24.52
Business process management	.84		(56.88)
Business activity monitoring	.83		
Web service and service oriented architectures	.77		
Data attributes (α =.90)		2.66	24.22
Data read and write capability	.85		(81.10)
Data accuracy	.80		
System automation	.77		

Perceived RFID benefits. The initial 25 items of RFID benefits were analyzed using principal component factor analysis with varimax rotation. Three items were eliminated due to low loadings less than 0.50. Four factors with eigenvalue above 1.0 were found to account for 73.9% of the total variance.

Cronbach's alphas were high, ranging from 0.85 to 0.96, suggesting a high level of internal consistency of items within each factor. Perceived benefits of RFID consist of four major factors: (a) improved inventory management, (b) velocity of retail cycle, (c) integrated business model, and (d) efficient store operation. Table 3 summarizes these four factors identified from the factor analysis.

Table 3
Factor Analysis of Perceived RFID Benefits

Factors and items	Factor loadings	Eigenvalue	% of Variance
Improved inventory management (α = .96)		5.87	26.69
Reduced stock-out	.85		(26.69)
Reduced shrinkage	.83		
Improved inventory data collection	.83		
Real-time inventory	.81		
Reduced complexity in inventory	.79		
Improved inventory control	.77		
Better integration of order and warehouse management	.71		
Velocity of retail cycle (α = .89)		3.92	17.85
Faster fashion cycle	.80		(44.54)
Increased purchase assortment	.75		
Better sales floor design	.73		
More accurate pricing	.73		
Improved fashion trend forecasting	.62		
More production information for customers	.55		
Integrated business model (α = .86)		3.60	16.36
Creation of new business models	.76		(60.90)
Merging the online and offline channels	.70		
Competitive differentiation	.61		
Streamlined transaction processing	.61		
Closer connection between retailers and suppliers	.59		
Efficiency of store operation (α = .85)		2.86	13.04
Improved visibility of order	.70		(73.94)
Moving merchandise closer to the sales floor	.69		
Less time spent on the stock	.64		
Improved efficiency of store operation	.63		

The data indicates that the respondents regard improved inventory management as the most important benefit of RFID, followed by efficiency of store operation, integrated business model, and velocity of retail cycle as shown in Figure 2.

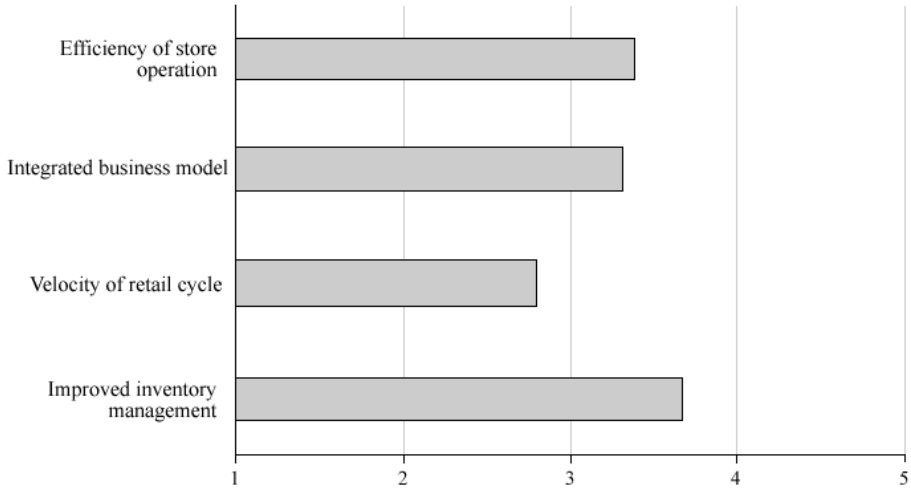

Figure 2. Perceived RFID benefit factors for retail industry

Note. The scale in the chart indicates the level of likelihood of each factor to be a benefit of RFID to retail industry from 1 (very unlikely) to 5 (very likely).

Perceived RFID risks. Factor analysis was performed on the initial list of 17 items used to measure perceived risks associated with RFID. Three items were removed due to low factor loadings, and the analysis revealed three major factors with eigenvalue above 1, which accounted for 74.5% of the total variance. High Cronbach's alphas suggest that the instrument was reliable with high levels of internal consistency. As shown in Table 4, the three major RFID risk factors include: (a) lack of expertise, (b) complexity of the technology, and (c) uncertainty of the technology. The respondents viewed the uncertainty and lack of standards as the most serious risks for implementing RFID (see Figure 3).

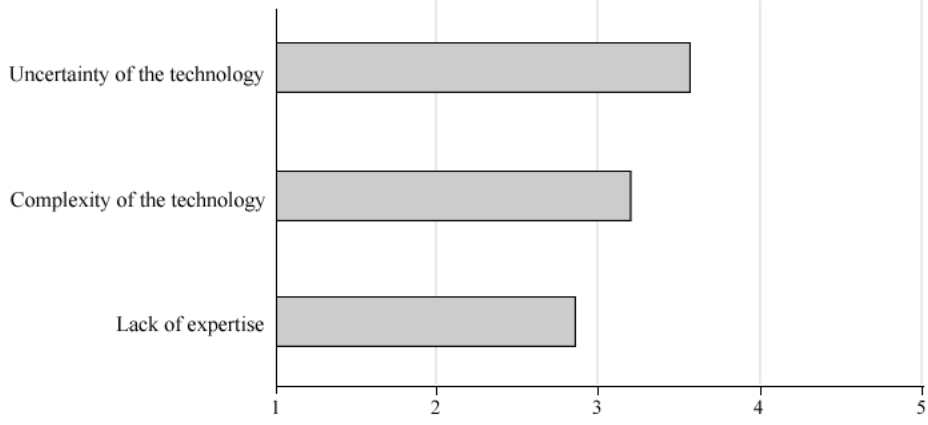

Figure 3. Perceived RFID risk factors for retail industry

Note. The scale in the chart indicates the level of likelihood of each factor to cause RFID project to fail from 1 (very unlikely) to 5 (very likely).

Table 4

Factor Analysis of Perceived RFID Risk

Factors and items	Factor loadings	Eigenvalue	% of variance
Lack of expertise (α = .92)		4.10	29.31
Lack of training time	.95		(29.31)
Lack of experts	.89		
Cost of employee training	.89		
Management reluctance to new technology	.81		
Lack of information about RFID	.76		
Complexity of the technology (α = .90)		3.35	23.99
Complexity of technology	.82		(53.30)
Increased manageability required	.79		
Immaturity of RFID technology	.78		
Lack of reliability	.75		
Poor interoperability	.73		
Uncertainty of the technology (α = .84)		2.96	21.19
Uncertainty about standards	.80		(74.49)
Lack of standards	.77		
No clear ROI	.76		
Inaccurate date reads	.76		

Structural Equation Model

The research model that hypothesized causal relationships among RFID intrinsic attributes, perceived RFID benefits and risks, and strategic impact on business performance for retailing (see Figure 1) using Structural Equation Modeling (SEM) analysis was examined. AMOS 4.0 was used for the analysis with simultaneous estimation of structural and measurement models. The hypothesized structural model incorporated one exogenous construct of RFID intrinsic attributes, and five endogenous constructs — the first two factors of perceived RFID benefits, the first two factors of RFID risks, and one construct of strategic impact on business performance.

Measurement model results. The measurement model assesses the latent constructs measured in terms of observed indicators and describes the validity and reliability of the measurements. Before testing the structural equation model, multiple indicators of each construct were grouped together in order to equalize measurement weight across indicators (Byrne, 2001). Next, 21 indicators were used to measure six latent constructs by removing items due to low factor loadings through confirmatory factor analysis. The goodness of model fit for confirmation factor analysis was high with chi-square value of 241.147 ($df = 172$, $p < 0.001$), CFI of 0.940, IFI of 0.942 and NFI of 0.823. In addition, the RMSEA value of 0.076 was also within the recommended range between 0.05 and 0.08 (Byrne, 2001).

Table 5 summarizes the results of the measurement model, including the factor loadings, standard errors, construct reliability, and proportion of variance extracted for each construct. All items loaded significantly on their corresponding latent constructs, suggesting convergent validity was established. It is suggested that the reliability and variance extracted for a latent construct must be computed separately for each multiple indicator construct in the model using indicator standardized loadings and measurement errors (Hair, et al., 1998). Construct reliability for all constructs exceeded .74 with an exception of Strategic Business Performance with .65. While the generally agreed upon lower limit construct reliability is .70, a lower range between .60 and .69 is considered acceptable (Hair, et al., 1998; Robinson, et al., 1991).

Table 5

Results of Measurement Model

Construct/Indicator	*S.F.L* [a]	*SE*	*t*-value	*Construct reliability*[b]	*Extracted variance*[c]
RFID intrinsic attributes (ξ_1)				.74	.80
X1: Middleware	.810	-[a]	-		
X2: Business process management	.863	.170	7.486		
X3: Data read and write capability	.614	.145	5.138		
Perceived RFID benefits				.82	.85
Velocity for retail cycle (η_1)					
Y1: Improved fashion trend forecasting	.879	-[a]	-		
Y2: Faster fashion cycle	.893	.103	8.953		
Y3: Increased product assortment	.693	.118	6.487		
Improved inventory management (η_2)				.91	.94
Y4: Real time inventory	.963	-[a]	-		
Y5: Improved inventory data collection	.967	.051	20.343		
Y6: Reduced stock-out	.916	.062	15.558		
Y7: Reduced shrinkage	.799	.088	10.153		
Perceived RFID risks				.85	.87
Complexity of RFID technology (η_3)					
Y8: Complexity of technology	.790	-[a]	-		
Y9: Increased manageability required	.969	.146	8.070		
Y10: Immaturity of RFID technology	.752	.140	6.957		
Lack of expertise (η_4)				.89	.93
Y11: Cost of employee training	.993	-[a]	-		
Y12: Lack of expert	.962	.063	15.174		
Y13: Lack of training time	.888	.060	14.556		
Y14: Management reluctance of new technology	.746	.085	9.168		

Note. $\chi^2 = 241.147$ ($df = 172$, p-value <.001); CFI = .940, IFI = .942, NFI = .823 and RMSEA = .076.

[a] Standardized factor loading; the first item for each construct was set to 1.

[b] Calculated as [$\sum$(std. loading)^2] / [$\sum$(std. loading)^2 + $\sum\xi i$]. [c] calculated as [$\sum$std. loading]^2 / [$\sum$std. loading^2 + $\sum\xi i$].

Table 5 (*continued*)

Construct/Indicator	*S.F.L* [a]	*SE*	*t*-value	*Construct reliability*[b]	*Extracted variance*[c]
Strategic impact on business performance (η_5)					
Y15: Customer service	.724	-[a]	-		
Y16: Merchandising strategy	.852	.197	6.434	.85	.87
Y17: Distribution and supplier network	.769	.196	5.924		
Y18: Marketing strategy	.645	.185	5.002		

Note. $\chi^2 = 241.147$ (df = 172, *p*-value <.001); CFI = .940, IFI = .942, NFI = .823 and RMSEA = .076.
[a] Standardized factor loading; the first item for each construct was set to 1. [b] Calculated as [$\sum$(std. loading)^2] / [$\sum$(std. loading)^2 + $\sum\xi i$]. [c] calculated as [$\sum$std. loading]^2 / [$\sum$std. loading^2 + $\sum\xi i$].

The variance extracted measure, a complementary measure to the construct reliability value (Hair et al., 1998), exceeded .80. Discriminant validity is supported when the Average Variance Extracted (AVE) between each pair of constructs is greater than Φ^2 (i.e., the squared correlation between two constructs). This criterion is considered the most stringent test of discriminant validity (Maxham & Richard, 2002). As shown in Table 6, Φ^2 never exceeded AVE between each pair of constructs. This proves that our measurements are valid and reliable for testing structural model.

Table 6
Correlation and Φ^2 of Constructs

Construct	1	2	3	4	5	6
RFID intrinsic attributes	1	.158	.626	.000	0.009	.278
Velocity of retail cycle	.397	1	.194	.000	045	.426
Improved inventory management	.791	.441	1	.005	.003	.256
Complexity of RFID technology	.010	-.010	.070	1	.163	.001
Lack of expertise	.093	.213	.050	.409	1	.001
Strategic impact on business	.527	.653	.506	-.037	-.023	1

Note. The lower diagonal represents for correlation between each construct, and the upper represents for Φ^2,

Structural model result. Structural equation modeling was used to determine the causal effect of intrinsic attributes of RFID on the benefits, risks, and the strategic impact on business performance. Overall model fit of the hypothesized model was not acceptable due to the small sample size *(n* = 70) with the chi-square value of 278.96 (*df* = 181, $p < .001$). In order to improve the model fit, three indicators (e.g., Y7: Reduced shrinkage, Y13: Lack of training time, and Y14: Management reluctance of new technology) with low factor loadings were deleted. As shown in Figure 4, this modification resulted in the model with the chi-square value of 161.199 for eighteen indicators (*df* = 124, $p < .05$) acceptable by Hair et al.'s (1998) recommended level. Other fit statistics were also within acceptable ranges (CFI = .95; IFI = .96; NFI = .83; RMSEA = .06).

The difference in chi-square value between the hypothesized model and the modified model was statistically significant ($\Delta\chi^2$ (57) = 117.76, $p < .001$), implying that the modified model was acceptable (Bagozzi & Yi, 1989).

By examining causal relationships among all constructs, it was found that two constructs of perceived RFID risks were not significantly related to intrinsic attributes ($\gamma 31 = .08$, t-value = 0.56, $p = .57$; $\gamma 41 = .16$, t-value = 1.18, $p = .23$) and strategic impact on business performance ($\beta 53 = -.01$, t-value = -0.03, $p = .97$; $\beta 53 = -.12$, t-value = -1.05, $p = .29$). Thus, the two constructs of perceived RFID risks and the hypothesized paths were excluded from the model.

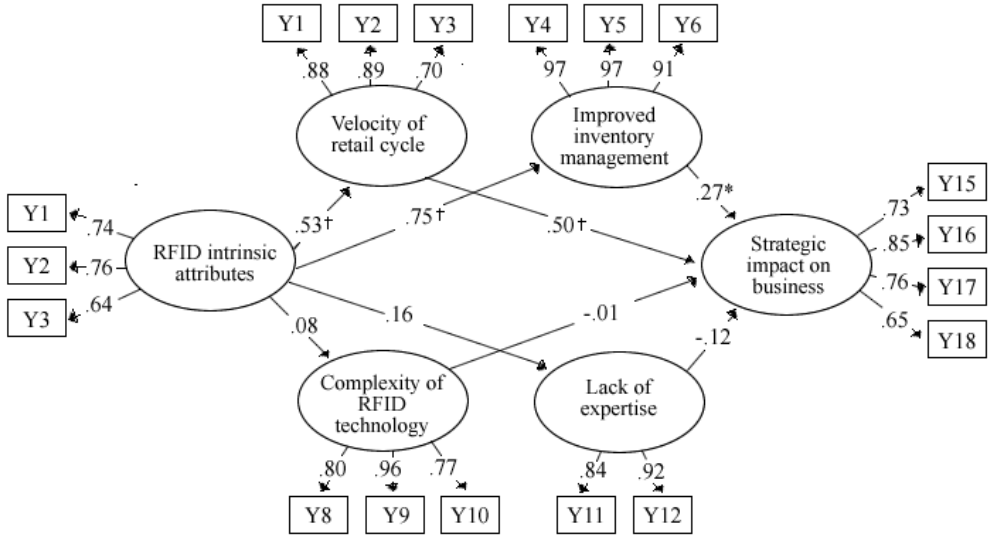

Figure 4. Structural model for the impact of RFID benefits and risks in retail industry.

Note. Model fit statistics: $\chi^2 = 169.886$ ($df = 126$; $p < .01$), CFI = .946, IFI =.948, NFI = .824, RMSEA = .071.
*$p < .05$, † $p < .001$

The final revised structural model indicated an improved fit with a chi-square of 67.59 ($df = 60$; $p = .24$). Other fit indexes (e.g., CFI of .99, IFI of .99, NFI of .90 and RMSEA of .04) were also improved. Comparison of the final model to the prior one shows a significant change in χ^2 relative to the difference in degree of freedom ($\Delta\chi^2$ (64) = 93.609, $p < .01$) suggesting that the modified model is acceptable. The final revised model explains 27.6% of the variance of velocity benefit, 56.6% of inventory benefit, and 50.0% of strategic impact on business. Figure 5 depicts the final structural equation model in terms of standardized factor loadings of indicators for measurement model and significant path coefficients for standardized path coefficients for each relationship.

The structural model suggests that intrinsic attributes of RFID had a significant effect on velocity of retail cycle ($\gamma 11 = 0.53$, $p < .001$) and inventory management ($\gamma 21 = 0.75$, $p < .001$). The model also indicates a strong relationship between strategic impact on business performance and velocity of retail cycle ($\beta 31 = .55$, $p < .001$) and improvement of inventory management ($\beta 32 = .27$, $p < .05$). The structural model provides empirical evidence for the common belief that various benefits of RFID can provide a means to improve inventory control and supply chain management (Hardgrave, 2005; Jones, et al., 2004).

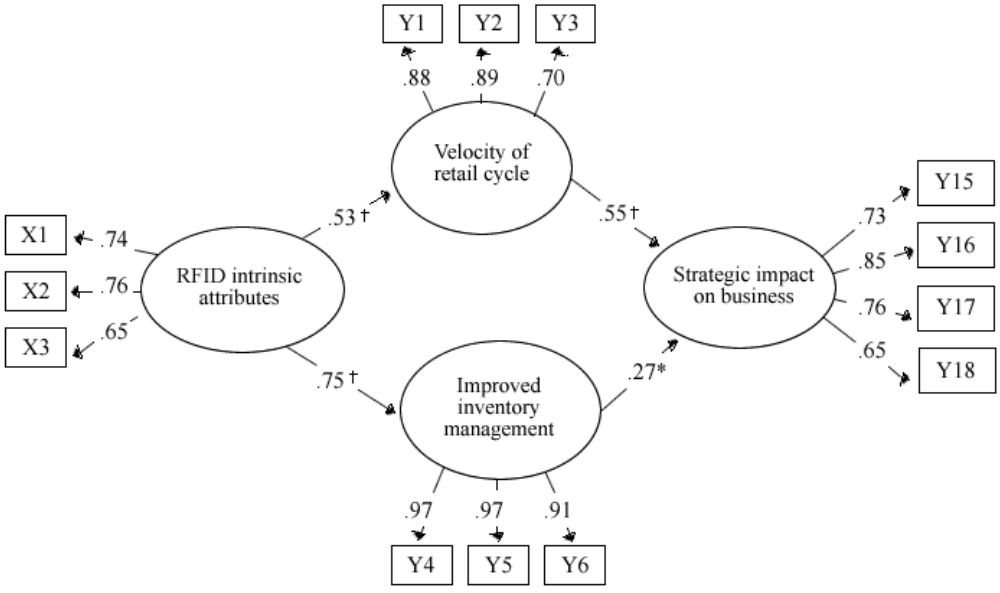

Figure 5. Structural model for the impact of RFID benefits in retail industry

Note. Model fit statistics: $\chi^2 = 68.259$ ($df = 61$; $p = .244$), CFI = .988, IFI = 0.988, NFI = .898, RMSEA = .042.
*$p < .05$, † $p < .001$

Conclusions and Implications

RFID has been heralded as a technology that can revolutionize the retail industry. Numerous benefits of the technology have been suggested and an increasing number of firms are either testing or implementing various RFID applications. However, there is no study that systematically investigates this important technology and offers a comprehensive framework to guide researchers and practitioners in the retail industry. This study proposed and empirically tested such a framework to help the retail industry maximize the benefits of RFID while controlling risks associated with the technology.

Four major benefits of RFID were recognized, which provide empirical evidence for various anecdotal claims of the benefits of for retailers: (a) improved inventory management, (b) velocity of retail cycle, (c) integrated business model for inventory and supply chain management, and (d) improved store operation. Additionally, three critical risk factors for implementing RFID in the retail industry were determined, which include: (a) lack of expertise, (b) complexity of technology, and (c) uncertainty of technology. These risk factors echo the anxiety that the industry has been experiencing with the technology and the pressing demand to establish a clear path and strategy to implement the technology.

This study also found support for the potential of RFID technology to impact business performance in areas such as customer service, merchandising strategy, distribution and supplier network, and marketing strategy. One of the surprising findings of the study is that the risk factors associated with RFID did not fit into the comprehensive RFID implementation model developed in this study. It is premature to offer any conclusive explanation for this counter-intuitive finding. It can be speculated that it reflects the fact that the technology is too young for managers to make a rational assessment of its risks. Subsequently, the immaturity of the technology is a limiting factor for this study, and as such, the interpretations of results of this study are compromised. Additional limitations include the small sample size ($N = 70$) and the assessment of key constructs (e.g., benefits, risks, and business impact), based primarily on respondents' self-reported perceptions.

Hopefully, as RFID matures, and our understanding of the technology improves, more studies with rigorous design and methods will contribute insight on many questions unanswered by this study. Although the technology is believed to help firms improve business in many different ways, it was confirmed that the retail industry believes RFID has the most potential to offer in streamlining the value chain management as suggested by industry experts (Christopher & Gattorna, 2005; Roy et al., 2004). This finding implies that the industry may be unable to recognize and capitalize on many other benefits that RFID technology has to offer in the long run. Accordingly, there is a need for an industry-wide effort to establish technical and business standards, identify and publicize business models, and educate all stakeholders on the potential and peril of the technology.

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