

May 2005

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Recommended Citation

Jones, Michael A.; Wyld, David C.; and Totten, Jeff W. (2005) "The Adoption of RFID Technology in the Retail Supply Chain," *The Coastal Business Journal*: Vol. 4 : No. 1 , Article 4.

Available at: <https://digitalcommons.coastal.edu/cbj/vol4/iss1/4>

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THE ADOPTION OF RFID TECHNOLOGY IN THE RETAIL SUPPLY CHAIN

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ABSTRACT

This article examines current developments regarding the adoption of RFID technology in the retail supply chain. An explanation is provided of what Radio Frequency Technology (RFID) is and how it works. The benefits of this technology to retailers are outlined in contrast to Bar Coding. Though the technology offers promise for retailers, it does present a number of concerns, which are outlined. Lastly, the article identifies research needs with regard to the new technology.

INTRODUCTION

Radio Frequency Identification (RFID) technology is poised to experience widespread adoption in the world's supply chain over the next decade. The technology presents a compelling value proposition to retailers due to its ability to deliver substantial benefits over the bar code system for tracking and identifying inventory (Friedman, 2003; Quinn, 2002). Though not a new technology, a recent announcement by Wal-Mart has pushed retail suppliers into rapid-paced adoption of RFID systems. In November 2003 Wal-Mart informed its largest 100 vendors that they would be required to start using RFID tags on pallets by January of 2005.

The appeal of RFID technology lies in its capability to allow retailers to know the exact location and quantity of inventory without conducting time consuming counts (DeHoratius, 2004; Dunne & Lusch, 2005, p. 306). Retailers seek to fulfill customer demand by ensuring that inventory is at the right place at the right time in the right amount (Fisher, Ananth & McClelland, 2000). Achieving this objective is difficult, and the operational complexity that retailers face has increased for a variety of reasons, including increasing product assortments, larger store sizes, and information requirements (Buzzell & Ortmeier, 1995). For example, Home Depot went from having an assortment of 12,000 different items in 1979 to 45,000 in 1998 (Johnson, 1998). Wal-Mart obtains merchandise from over 3,200 vendors to fill the shelves of its forty departments (Sack, 2001). DeHoratius and Raman (2001) argue that most retailers are not able to identify the number of units of a given stock-keeping unit available at a particular store due to inaccurate inventory records. A study of one large retailer found that 65 percent of a store's SKU's had inaccurate inventory counts. (Worthen, 2003). The 30-year-old bar coding system simply can't "store the kind of information that retailers and vendors say they need to better track merchandise as it flows from factories to warehouses to stores" (Landy, 2004, p. 1F). Another problem retailers have been faced with is that "the physical exchange of goods, i.e., the visual counting and inspection of goods, remains a tedious and expensive process" (Food Marketing Institute's Information Technology Committee [FMI I/T], 2004, p. 3). "The physical goods

receiving function today is still labor intensive and prone to errors, both at the distribution center (DC) and retail store levels” which can affect profitability (FMI I/T, 2004, p. 4).

This article examines the adoption of RFID technology in the retail supply chain. It outlines potential benefits of RFID as compared to bar codes. A brief explanation of the technology and how it works is provided, along with a discussion of issues and social concerns surrounding the adoption of the technology. These issues include the cost of the technology, invasion of consumer privacy, potential for illegal misuse of the technology for theft, and the increased market power RFID may afford to large retailers. A number of research questions are raised. Though RFID technology has been given little attention in retailing or marketing literature, numerous articles appear in trade publications on RFID, the appearance of which exploded following the Wal-Mart/DOD announcements.

The Wal-Mart and DOD Announcements

On October 23, 2003, the U.S. Department of Defense announced a new policy mandating that its 43,000 suppliers use RFID tags by January 2005. Just over ten days later, on November 4, Wal-Mart called its top 100 suppliers to Bentonville for a summit. At that meeting, Wal-Mart announced that RFID tags would be required on shipments, also beginning in January 2005. Both had actually made their intention known in June 2003, but with the pronouncements, the drive towards widespread use of RFID in retailing has begun in earnest (Albright, 2003; Duris, 2003). Target stores have followed suit with a similar announcement (Hickey, 2004). CVS and Rite Aid recently announced an experiment collaborating with several large drug manufacturers and distributors to test RFID on containers and/or bottles of prescription drugs (Stackpole, 2003). In the United Kingdom, Marks and Spencer and Tesco have conducted trials of the technology (Best, 2004a). Wal-Mart tested the technology in Dallas-area stores and distribution centers in the spring of 2004, and expects all domestic suppliers to be using RFID by 2006 (Coupe, 2004e, 2004f). Albertsons announced the launch of its RFID program in March 2004 and expects its top 100 suppliers to be participating by April 2005 (Coupe, 2004d).

WHAT IS RFID?

What is RFID? In brief, Radio Frequency Identification (RFID) uses a semiconductor (microchip) in a tag or label to store data. Data is transmitted from, or written to the tag or label when it is exposed to radio waves of the correct frequency and with the correct communications protocols from an RFID reader. Tags can be either *active* (using a battery to broadcast a locating signal) or *passive* (using power from the RFID reader for location). A firm may use a combination of fixed and hand-held readers for reading RFID tags to gain as complete a picture as has ever been possible on exactly what is in their store and where it is. For a detailed explanation of the technology, see McFarlane, (2002) and Kambil & Brooks, (2002).

Because the tag sends an electronic signal, it can transmit information when buried under several layers of products and shipping material, through concrete walls or even underwater (Arner, 2003). With this degree of visibility, it is possible to electronically read an entire pallet or truckload of material in seconds by passing the products through an RFID reader. Tags also

can withstand dirt or moisture better than printed barcodes. Reading and writing distances range up to 100 feet, and tags can be read at high speeds (Booth-Thomas, 2003).

RFID technology has been used in a numerous applications in recent years, much of which has not been retailing. Toll road collection systems utilize RFID to read tags on cars identifying prepaid customers (Burnell, 2003). Another common application for the technology has been in security and inventory control for books in libraries (Dorman, 2003). Burlington Northern Sante Fe has been using an earlier generation for years to track its cars, and Delta Airlines tested RFID to track passenger baggage in 2003 (Fuquay, 2004). RFID has been widely used for remote keyless entry systems for automobiles, and the USDA is evaluating the implantation of RFID tags into U.S. livestock as a solution to the tracking of “Mad Cow” disease (Sullivan, 2004a).

Current Retail Applications

Today, RFID applications are already being seen in the retail environment. Removable tags are used in retailing now to for theft prevention in applications such as apparel retailing. These devices are added by and removed by the retailer, as opposed to being built into the product, and are expensive on a per item basis. In 1997, Exxon Mobil introduced “Speedpass,” an RFID based system that allowed customers to make credit gasoline purchases by waving a tiny transponder in front of the gas pump. The company estimates that about six million drivers were using it in 2004 (Fuquay, 2004). Mastercard introduced “a contact-free RFID payment chip called PayPass that will be available in credit cards and Nokia cellphones” (Garskof, 2004). Some Dallas-area restaurants plan to use RFID technology in “smart cards” to develop their customer loyalty programs (Coupe, 2003).

Among retail organizations that are evaluating and experimenting with RFID technology, a notable case is The Metro Group of Germany, which is the world’s 5th largest grocery chain, and a world-leader in retail technology development. Last year in Rheinburg, Germany, Metro opened the “store of the future,” which has RFID technology installed for checkout and for replenishment of store shelves (Collins, 2004). Shoppers log into the system by scanning a customer ID card into the touch screen, according to (“Metro Opens,” 2003). The device lets them scan bar coded goods as they place them in a grocery cart, which then sends the prices to checkout through the wireless network. This eliminates scanning at checkout. Smart shelves also alert staff to expired perishable products such as milk or yogurt. However, the cost of the technology is reportedly too high for implementation into the 2,600 Metro stores the organization has world- wide. Metro has faced a mounted resistance from German consumers in the form of organized protest and boycott over rights-of-privacy issues (See <http://www.spsychips.com>; Best, 2004c).

BENEFITS OF RFID VS. BAR CODES

The advantages of RFID over bar code technology are summarized in Table 1. RFID tags have been described as being a “quantum leap” over bar codes. *Inc. Magazine* characterized RFID versus bar codes as “like going from the telegraph to the Internet.”(Valentine, 2003, n.p.).

According to Tirschwell (2004), “a main benefit of RFID is that handling costs are reduced because boxes do not have to be manually staged to obtain the line of sight necessary for bar-code reading.” Another major advantage is that the RFID tag can carry more information than the bar code system, meaning that it can uniquely identify a single item rather than an SKU only (Mitchell & Chappell, 2003; Booth-Thomas, 2003). Electronic tags can carry important information such as lot number, date the product was manufactured (or in the case of fruit when it was first picked), customer information, or a wealth of other data that the manufacturer wishes to store on the tag. A major distinction between tags and bar codes is the tag’s ability to both transmit and store new data, meaning that updates can be written to the tag/item as it moves through the distribution process (Freidman, 2003). These features of RFID systems appear to offer value to several retail functions, which are discussed below.

TABLE 1 – RFID versus Bar Code Technology

Bar Codes	RFID Tags
• Bar Codes require line of sight to be read	• RFID tags can be read or updated without line of sight
• Bar Codes can only be read individually	• Multiple RFID tags can be read simultaneously
• Bar Codes cannot be read if they become dirty or damaged	• RFID tags are able to cope with harsh and dirty environments
• Bar Codes must be visible to be logged	• RFID tags are ultra thin, and they can be read even when concealed within an item
• Bar Codes can only identify the type of item	• RFID tags can identify a specific item
• Bar Code information cannot be updated	• Electronic information can be overwritten repeatedly on RFID tags
• Bar Codes must be manually tracked for item identification, making human error an issue	• RFID tags can be automatically tracked, eliminating human error

Store and Shelf Replenishment

The process of retail store inventory replenishment is complex and labor-intensive, and one which affords itself to errors and inaccuracies. RFID is expected to yield reduced handling cost, increased inventory accuracy, reduced inventory costs, and increased “real time” tracking capabilities (Trebilcock, 2002). “Retail analysts at Sanford C. Bernstein estimate that Wal-Mart could save \$8.35 billion annually by using RFID--mostly in labor costs from not having to manually scan the bar codes of incoming goods” (Boyle, 2003, n.p.). In another study conducted by the Grocery Manufacturers of America, A.T. Kearney Inc. estimates that retailers and manufacturers each lose \$2 million for every \$1 billion in sales due to bad data. They predict that eliminating bad data could save \$10 billion per year (Scheraga, 2003). Kurt Salmon

Associates estimate that if only attached to pallets and cases, RFID will cut warehouse and distribution costs by 3 to 5 percent (Wrolstad, 2004). According to a study by grocery consultant IGD, 68% “of food and grocery retailers think the technology will deliver benefits to the industry – including better tracking and greater efficiency in the supply chain – and only two per cent of them are in the dark about RFID” (Best, 2004d).

Gillette has announced the most ambitious use of an RFID system in an effort to lead the rest of the world in implementing new inventory technology (Fontanella, 2003). A key component of Gillette’s RFID system will be the use “smart-shelves” with built-in RFID readers. These smart shelves are designed to send messages when the shelf needs to be restocked or when there are suspected theft. According to Gillette, this type of system could potentially save substantially through better inventory control and management – savings that could be passed onto the customer.

Customer Service

The Metro Group “store of the future,” mentioned earlier, worked with NCR to develop a system called “Fastlane” checkout. RFID tags on products eliminate the need for scanning each bar code in self checkout. According to information released from the Metro Group, customers are able to check out without emptying their grocery cart. This service was recently suspended however, due to protests from privacy groups. Other customer service contributions of RFID are reduced stock shortages and more responsive stocking of shelves (Violino, 2004).

Dating Received/Date Sold and Product Perishability

A core capability of RFID, which barcodes do not offer, is the ability to link date-received of an item to date-sold. By implementing RFID readers at the receiving docks and at the point-of-sale, retailers can know when specific items arrived at the store, and when they are sold (Rutner, Waller & Mentzer, 2004). For perishable products such as food, this allows the reduction of losses due to spoilage. By positioning RFID scanners within the store, retailers can better understand which products are selling from which locations within. For example, batteries might be found in three locations within a store, but bar codes would not allow knowledge of which in store location accounted for most sales.

Security and Loss Prevention

One of the most costly problems in retailing is loss due to employee theft or shoplifting of merchandise. The industry wide net loss in 2002 was \$31.3 billion (Dunne & Lusch, 2005, p. 319). A 2003 retail security survey report indicated that employee theft accounted for 47% of retailers’ inventory shrinkage that year, down from 48% in 2002. Statistics for the remaining three major sources of shrinkage were: shoplifting, 32% (no change); administrative error, 15% (no change); and vendor fraud, 6% (up from 5% in 2002) (Hollinger & Langton, 2004, p. 5). Armed with more accurate information about what is on the shelves, what is in storerooms, and what is on its way from distribution centers, retailers can better determine sources of loss

(Levinson, 2003). High-priced goods such as consumer electronics, apparel and pharmaceuticals are more suited to RFID systems, and firms retailing such items are experimenting with the tags.

Prada, the Italian fashion retailer is using RFID in its Epicenter Store in New York as a security measure (Violino, 2004). When a tagged item nears a reader near the door or in the dressing rooms, the tag triggers an interactive display showing the particular product the customer has possession of. The Gap is using tags to track jeans from a distribution center to a store in Atlanta equipped with readers. The real-time visibility offered by RFID for tracking an item can monitor shoplifting almost as it happens through wireless communications to a hand-held wireless personal digital assistant (PDA), which a manager could be carrying (Laudisio, 2003). Gillette's Mach III razor is reportedly the most shoplifted product in the U.S. For their European market, Gillette plans to put a half-billion RFID tags on individual packages of its razors to track them from the manufacturer to the point where the consumer purchases them.

Authentication Protection Against Counterfeiting of Merchandise

A problem in the distribution of some products such as designer apparel or pharmaceuticals is counterfeiting. The pharmaceutical industry estimates that between 2 percent and 7 percent of the drugs sold globally are counterfeit (Whiting, 2004). Lipitor, Zocor and Viagra are among a number of commonly counterfeited products that have been sold through U.S. pharmacies. In February 2004, the FDA issued a recommendation to the pharmacy industry that RFID technology be implemented in the supply chain due to the ability of technology to verify the pedigree of a product. Wal-Mart is currently testing RFID with its pharmaceutical suppliers, as is Rite Aid and CVS (Sullivan, 2004b). Another potential benefit of the RFID tags in pharmaceutical distribution is the reduction of mistakes in the administration of medication. Special tags being tested now can record when a container was last opened and send a signal to readers notifying them of inventory changes and updates in the contents (Zaino, 2003).

In summary, academicians, consultants and industry executives alike espouse the promise of RFID in the retail supply chain. Dr. Henry Chesbrough, executive director of the Center of Technology Strategy and Management at UC—Berkeley, commented, “if the retailers can engineer their inventory control systems, supplier coordination systems, and even customer checkout systems to incorporate RFIDs, there could be tremendous improvements in inventory turns, lower stock-outs, lower customer wait times, and so forth” (Coupe, 2004a). Kathryn Cullen, a principal with Kurt Salmon Associates, offered this advice to small-and-mid-sized retailers: “While it may be premature for a mid-size retailer to move to an RFID pilot right now, they should plan for RFID by forming and involving cross-functional teams. RFID touches most functions, from product development to returns. Working with a larger, diverse group, including DC, merchandising, and accounting associates, will help identify potential applications and required changes (Coupe, 2004c). The Food Marketing Institute's Information Technology Committee called for manufacturers and retailers to work together, and sees that “the greatest opportunity involves building financial and accounting systems based on the actual value of physical products rather than paper invoice representations of value” (FMI I/T, 2004, p. 7; also

see Davis & Luehlfling, 2004 for an assessment of RFID's impact on accounting). However, others offer caution for RFID's use, which are discussed below.

CONCERNS OVER RFID TECHNOLOGY

The Cost of RFID

A major concern over installation of a RFID system is the cost, which is only partially understood (Fontanella, 2003). Four of the major costs are the tags, the readers, the software and the integration of the software into existing systems (Levinson 2003). Individual RFID tags can vary in price from as much as \$100 to as little as 10 cents based upon their capability. Investments in computing capabilities and software architecture may be required for some retailers to handle the added data delivered by RFID systems, as well as additional employee training (Levinson, 2003). Limited Brands CTO Kathleen Starkoff suggests that RFID will generate an "avalanche of data," forcing CIO's to rethink their warehouse strategies.

For the near term, the price of the tag is a key barrier to more widespread adoption of RFID for certain retail operations and products, particularly for tagging individual products (Roberti, 2003a). For RFID tags to be cost-effective at the consumer level, industry analysts have held that the price of the tags must fall to 5 cents each or lower to make individual item tagging at all practicable. This is considered to be the "Holy Grail" by the industry (Fuquay, 2004, p. 4F). Many of the largest technology providers are actively developing RFID applications for the retailing industry, including recent announcements from Accenture, Texas Instruments, Phillips, IBM and NCR (Anonymous, 2004). The ARC Advisory Group, a Massachusetts research firm, announced that, based on survey findings, the average price of a passive UHF tag will only drop to 16 cents by 2008, and passive HF tag prices will only reach 30 cents or so (down from 57 cents and 91 cents, respectively, in 2003). In addition to tag cost being a factor in the adoption process, a related concern is that there is no justifiable "business case" at present (e.g., can personnel costs really be reduced, in order to offset the tag costs?) (Ward, 2004).

Lack of Standards

Another major issue is standardization of the technology (Guillory, 2002; Roberti, 2003b). A spokesperson from UPS recently stated, "the biggest stumbling block for the technology is a lack of standards." Companies experimenting with this technology have developed their own standards with regard to tag language and the frequency at which they operate. When tags are attached to products that pass through the supply chain, the lack of standardization creates havoc for organizations. "Data compatibility will also be key to the industry's preparation for RFID" (Landy, 2004, p. 4F). Currently, there are hundreds of standards being developed by those interested in RFID. This problem can be compared to developments in barcodes and WLAN's (Burnell, 2003). In these cases, it was not until international standards were adopted that both systems achieved widespread acceptance. The Food Marketing Institute's Information Technology Committee has called for national and international formal standards to be developed (FMI I/T, 2004, p. 6).

Privacy

Privacy is another major concern about RFID applications in retailing (Bednarz, 2003; Albrecht, 2002). The attainment of information by unauthorized parties is a concern for businesses as well as consumers, and both could be exposed through RFID (Quinn, 2003). A reader in a supermarket could identify items in a consumer's purse or coat pocket, whether shoplifted from a store or not (Electronic Privacy Information Center, 2003). Competitors could potentially read what is in a truck or warehouse, while potential burglars could read what is in a business or home (Evans, 2003). The American Civil Liberties Union is worried that RFID technology could be used by the government to track and control citizens' movements (Geewax, 2004; also see Lewis, 2004). Yet, according to a Cap Gemini Ernst & Young study, 42% had a positive attitude towards RFID and 48% had no opinion. Only 25% or thereabouts of those surveyed had even heard of the technology (Coupe, 2004b).

A national grass-roots consumer group was formed in 1999 to address the potential abuse of information collected by supermarkets and other retailers (Quinn, 2003). Consumers Against Supermarket Privacy Invasion and Numbering (CASPIAN; www.spsychips.com), has quickly attacked RFID as another form of 'big brother' unnecessarily monitoring consumer purchases and habits. What makes RFID particularly concerning to groups like CASPIAN is the potential to track the product after the purchase. For many products tags will be built into the product or its packaging, meaning that tags are not removed when the product leaves the retail store. This makes it possible for others to retrieve information from an active or passive tag without the customer's knowledge. Until retailers adopt a policy of "killing" tags once they leave the store, these tags could be read and updated by any RFID scanner within range of the tag (Evans, 2003). Developers have argued that it would be better if the chips were switched from "non-private" to "private" once they left the store, instead of being "killed." This would allow reactivation should the merchandise be returned to the store (Best, 2004b). The power of consumer activists groups directed against this issue was experienced by Wal-Mart when they tested RFID tags in a store in New Jersey in 2003. After only a few months Wal-Mart abandoned the experiment due to aggressive protests. A bill, to set privacy standards for RFID use in California, was defeated in committee in July 2004 (Coupe, 2004g).

Increased Power for Large Retailers

Yet another concern is that RFID will provide large retailers with even more market power. Rutner et.al. (2004) argue that the increased information available to retailers through RFID systems will provide added leverage in dealing with suppliers. More knowledge could become available on issues of in store product-rotation, spoilage, or consumer shopping behavior. Large retailers are able to afford their own R & D to test the system, as well as the capital investments in hardware, software systems, and training needed to put RFID in place. It is estimated that Wal-Mart's top 125 suppliers will spend \$502,000,000 in achieving compliance to the requirements, according to Bear, Stearns & Co. (Jackson, 2004). Will smaller retailers and small suppliers be pushed further out of the supply chain if they cannot justify the purchase of RFID technology?

CONCLUSIONS

Not all involved agree on the value and use of RFID in retailing. Sears and J.C. Penny's stores are waiting and watching developments (Hickey, 2004). Some analysts are wary of the "hype" created by recent developments, and argue that it is too early to determine the practical value of the technology. It seems apparent, however, that retailers and their suppliers face eminent decisions regarding investment into of RFID systems.

A concern for managers facing this decision to install RFID is the lack of objective, "third-party" research and public information regarding the value and cost of the technology. Much of the information available today is provided by marketers of the technology through seminars and "white papers" touting the benefits of RFID technology. One quasi-public research center is the Auto ID Center at Massachusetts Institute of Technology, which has been conducting research and publishing findings for several years. Though this organization has published a number of in depth reports on RFID technology, this initiative is funded by a coalition of firms interested in promoting the technology. While large retailers can conduct in-house tests, smaller retail organizations appear to be at the mercy of marketers of RFID products and services for information on which to make adoption decisions.

Academic researchers appear therefore to have an opportunity to contribute to the outcome of the situation by addressing the many questions being raised:

- Will RFID deliver on its value proposition?
- Will the technology deliver the cost savings promised?
- Will the bar code disappear, and when, or, will there be dual systems allowing either technology?
- Will RFID end up on low-cost items that are bought in the grocery stores daily?
- Will small retailers be forced to make changes in their systems and technology?
- What will become of the privacy issue?
- Can one supplier and/or retailer use RFID in an unethical way to determine the contents of a competitor's warehouse, or what merchandise is being shipped to a competitor in trucks?
- Will the technology reduce or eliminate employee theft and/or shoplifting?
- Will there be international standards for RFID technology?
- Will large retailers grow more powerful armed with new information?
- Will consumers benefit in the end?

Thus, the application of RFID technology in the retail supply chain is an issue that is fertile for research.

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