RFID in the Retail Supply Chain

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RFID is a technology that has existed for many years. Recently RFID received much fanfare about its application into retail supply chains. Consumers were first introduced to RFID at hotels and in employee ID cards. Soon, as RFID can be read by anyone with a reader, privacy concerns pushed customers away from RFID. Next, Wal-Mart said it would mandate its suppliers begin tagging shipments with RFID, later Wal-Mart would reverse course. Perhaps RFID should be used at the store level rather than the distribution level. This paper looks to explore new applications for RFID in the retail supply chain.

INTRODUCTION to RFID

In today's information age new technologies are susceptible to hype and implementation solely because they are new. Further, pressures can be placed on companies to implement technology for the sake of being progressive or staying current. From an operations management perspective costs of additional technology must be weighed against the benefits. Whether these benefits are hard dollar savings or soft dollar improvements RFID is a technology that has received significant media attention but has resulted in relatively small implementation.

RFID stands for radio-frequency identification. There are two types of RFID tags, active and passive. Active tags have an on-board battery that allows these tags to transmit their signal. Passive tags rely on the radio energy transmitted wirelessly from a tag reader. This difference allows passive tags to be both smaller and cheaper than active tags (Violino, 2005). Passive tags have short read ranges. Both types consist of an integrated circuit, a modulating signal device, and an antenna (Violino, 2005). RFID operates in a frequency range expressed in mega-hertz (MHz). Lower frequencies function better in metal environments but have shorter read ranges, while higher frequencies travel farther but are more susceptible to metallic backscatter. Metallic backscatter is the interference created by metal near the tag antenna. For example, 13.56 MHz tags have a maximum read range, between tag and reader, of about 3 feet. Tags in the 915 MHz range have a maximum read range of about 60 feet (Brewin, 2004).

Created more than 70 years ago, RFID technology is just coming into mainstream use. "According to Bill Allen, marketing manager for Texas Instruments RFid Systems, the technology first was used in the 1940s to identify ships and airplanes as friend or foe (Levinson, 2013)". This identify friend or foe (IFF) was important as radar use increased and weapons systems effective distances extended. Ship captains and aircraft pilots needed the ability to know if the radar blip they were witnessing was friendly or hostile significantly before visual confirmation could be ascertained.

Like most new technology the initial price of RFID was high and power requirements large. All early IFF systems employed active RFID. As time progressed RFID devices became physically smaller, capable of storing more data, and requiring less, or in some cases no, power to operate. As the technology improved and became less costly interest grew in using it in retail applications. Companies 2 began to envision a price point at which it would be feasible to tag pallets of merchandise with passive tags. In 2003 passive RFID tags cost about $0.40 each. Wal-Mart believed tags could be economically feasible at a cost of $0.05 each, and would reach this point by 2005. In reality 2015's tags begin at a cost of $0.07 and range to about $0.15 each (RFID Journal, 2015).

Besides tracking and pallets that identify themselves, a central promise of RFID tagging has been the replacement of barcodes. Barcodes, while effective, require line of sight visibility and rely on a human operator to scan the tag. In today's grocery store one must unload items from their cart as a cashier scans the bar codes, and a bagger repacks the cart. In the RFID enabled store of the future a customer could roll their cart into RFID reader territory and nearly instantly a RFID reader could read, invoice, and total all items. All grocery lanes then become express lanes. The customer benefits through reduced wait times and no human error induced double scanning of items. The store benefits from reduced staffing requirements, more space freed from line queues, and increased customer turnover per hour.

Like all new technology, adoption before a standard protocol is created limits implementation and is a risky expenditure. RFID standardization is important so that benefits from implementation are in the entire supply chain, from supplier to retailer. The same tag needs to be able to share data as the products pass from one entity to another. In 1999, to facilitate standardization, the Uniform Code Council, Gillette, and Proctor & Gamble funded the Auto-ID Center at the Massachusetts Institute of Technology (Violino, 2005). The Auto-ID Center was critical to standard creation and later handed off standard development to a non-profit called EPC_global. EPC_global worked to develop worldwide integration and later created the EPC_global Network to facilitate data sharing.

Consumer Introduction

At the consumer level individuals are becoming familiar with RFID in hotels, company issued employee ID cards, automotive toll passes, and the ExxonMobil SpeedPass. Hotel chains moved from traditional door keys, susceptible to physical copying, to rolling code RFID readers. This allowed doors to be coded with one code and rolled to another when that guest checked out adding security to rooms. Soon after, toll road authorities moved to in-car active RFID tags to allow automated toll payments. This allowed commuters to bypass toll booths and instead electronically self-report toll use by passing under RFID readers at high speeds. This simultaneously increased commuter happiness while reducing toll booth staffing expense.

Privacy

Privacy concerns focus on three main areas. First, the purchaser of an item may not necessarily be aware of the presence of an RFID tag, and even if they are aware of its presence they may lack the ability to remove it, leaving them vulnerable to privacy breaches. Second, RFID tags can be read at a distance without the knowledge of the individual. Third, if a tagged item is paid for via credit card or in conjunction with a loyalty card, it is then possible to tie the unique ID of that item to the identity of the purchaser (Ahson and Mohammand, 2008).

Applying these concerns to the EPC_global system, using tags with globally unique serial numbers enables both tracking of the product and the consumer globally with this technology. While the question of "so what?" remains, privacy advocates have not always used the moral high ground to prove a need to said privacy. The earlier mentioned toll tags have lead to judgments in both divorce and criminal cases. In one case a cheating spouse claimed to be in New York while the toll pass reported him in New Jersey. Bob Barr, former Republican Congressman from Georgia has said, "People are foolish to buy into these systems without thinking, just because they want to save 20 seconds of time going through a toll booth (Newmarker, 2007)." Out of 24 states, 12 share toll identification with the court system in all cases, while the other 12 share data only in criminal cases.

An upstanding citizen may find little sympathy for adulterers and criminals, but carrying this argument further Orwellian, tracking peoples every move for government purposes could soon be on the horizon. Will "double-speak" and "the thought police" follow? The government could implant RFID tags into humans at birth. Many people already "chip" their dogs and cats, and the FDA has cleared a specially designed RFID tag for implantation into humans.

If the government were to place RFID technology into passports, does security then matter to the honest citizen? In 2006 the United States began using RFID in passports. The United States Department of State said the chips could only be read from a distance of about 4 inches, but later tests show they can be read from up to 33 feet (Ahson and Mohammand, 2008). Thus, anyone with an appropriate frequency "sniffer" can query a passport tag as an unknowing individual is walking past. This is a privacy concern; all personal information including a digital photo of the holder is stored within the passports RFID tag. This can enable a criminal not only to steal personal information, but use that information with an exchanged digital photo to bypass no fly lists.

While at first the ability to implant RFID tags into individuals seems removed from supply chain application, the two are more closely related than they appear. Human nature recoils to the idea of implantation, but technology that embeds RFID tags into your shirt, identified as yours, based on the credit card used for the purchase, and the location the shirt remains overnight changes a benign supply chain tactic into a much broader tool and a legitimate concern. The RFID industry is aware of this and has proposed numerous solutions.

One proposed solution is the clipped tag. A clipped tag is a specially designed tag that contains a portion made to be torn off by the consumer rendering it inactive. Interestingly, the current clipped tag design may still be read, but the proximity is reduced from feet to inches. This tag is designed so that the clipping of the tag can be verified visually. This step is unlikely to persuade privacy advocates, as the read range of tags are more a function of the reader than the tag itself (Ahson and Mohammand, 2008).

Another solution to counter "sniffing" is tag cryptography. Cryptographic tags are being developed to prevent reading by any reader and instead create tags that are readable only to particular readers. There are many downsides to this method. Everyone knows today's cryptography is tomorrow's data breech. The day new cryptography is released someone is working to break it. For the supply chain these tags cost more, require more power, and limit the economies of scale achieved from standardization. In a closed loop system such as the ExxonMobile SpeedPass, this is not a significant draw back. In fact, "the ExxonMobile SpeedPass uses a cryptographically enabled tag manufactured by Texas Instruments, called the Digital Signature Transponder (DST) (Ahson and Mohammand, 2008)."

RFID Supply Chain Theory

In an ideal implementation, RFID use would begin with the manufacturer placing tags onto products during assembly. The manufacturer would then link this data to cartons or pallets to enable shipment building, package sorting, and advanced shipment notification. As the product moved throughout distribution channels RFID readers would capture product location and timestamps providing visibility into the supply chain. As these goods are received on the docks of the retailer electronic product code information would auto-populate into the retailers inventory system and send a confirmation receipt back to the manufacturer; all without human intervention. Lastly, as detailed below, the retail store would benefit through: inventory management, shelf replenishment, automated re-order, and quicker check-out (UPS, 2005).

Wal-Mart

If a new technology is going to be forced into the supply chain there are few retailers as powerful as Wal-Mart to mandate adoption. RFID technology received this push November 4, 2003. On that day Wal-Mart convened a meeting to inform its top 100 suppliers they would be required to place RFID tags on all pallets and cases Wal-Mart purchased from them by January 2005 (Violino, 2003). Wal-Mart believed even if they collected no new data the efficiency and accuracy improvements in inventory management would be huge in and of themselves (Vijayan and Brewin, 2003). In 2003, Wal-Mart planned to seek tags

costing $0.05, while the Auto-ID Center—a leader in RFID standardization—said tags typically cost ten times that amount and the needed readers sell for $1,000 and up. At $0.50 per tag, implementation was estimated to cost the Wal-Mart trading partners $500 million dollars (Vijayan and Brewin, 2003). Not long after the Wal-Mart mandate other large retailers such as Target, Kroger, Home Depot, and Best Buy announced similar mandates (Shin and Eksioglu, 2014). The mandate provided for advancement of the RFID technology but full implementation of the mandate never materialized.

Fast-forward to 2007: at this time Wal-Mart is scaling back its push into RFID. The main reason? Only 3% of companies that supply Wal-Mart with product are placing RFID tags on their pallets. Secondly, in 2005 Wal-Mart installed RFID in three distribution centers with plans to increase this to 12 distribution centers by the end of 2005. As of 2007 Wal-Mart has only added RFID to two new distribution centers (Weier, 2007). It appears adding RFID technology to the world's most efficient distribution network has not yielded much, if any, return on investment. The only identifiable return on investment has been in reducing out of stocks. By placing RFID readers at the loading dock, again at the entrance from warehouse to sales floor, and finally at the trash compactors, the individual store's computer system can generate lists directing employees on what items, in priority order, need to be restocked (Weier, 2007).

As the years passed, Wal-Mart continued to quietly roll back RFID adoption requirements (Shin and Eksioglu, 2014). While the technology can improve inventory accuracy and supply chain efficiency no certain evidence demonstrates increased profit (Shin and Eksioglu, 2014). As Ms. Walton observed while vacationing in Florida:

> One employee's only job was to restock bottled water that thirsty tourists constantly removed from the shelves. 'All day long, he goes back and forth, he doesn't need a special list generated by computer that says it's time to get more water. You don't need to check out of stock because velocity is so rapid. What would be the point of our tagging that product to ensure it's on the shelf? So we don't. There's no mutual benefit for that product at this time.' (Weier, 2007)

RFID Adoption Rate

Shin and Eksioglu conducted research on companies that had added RFID technology and found the main deterrent to implementation was the large up front expenditure coupled with uncertain return on investment. Their research found RFID enabled companies are able to achieve some efficiency per employee cost savings and a reduced number of product days in inventory, but then fail to demonstrate statistically significant improvements in revenue (Shin and Eksioglu, 2014). It is presumed the increased adoption observed rate in 2005 and 2006 is influenced by Wal-Mart, Target, Best Buy, and other large retailing behemoths influence on the research and implementation mandates of the technology.

TABLE 1
RFID ADOPTION RATE

	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
# of RFID adoptions	1	1	2	5	10	3	0	1	1	0
Cumulative Number	1	2	4	9	19	22	22	23	24	24

(Table from : Shin and Eksioglu, 2014)

Shine and Eksioglu conclude "… as other academic papers argue, RFID technology adoption severely affects inventory management efficiency. However, there is no improvement of RFID technology

adoption in profitability ratios and there is no consistent result of per employee efficiency ratios from the two tests (Shin and Eksioglu, 2014)."

RFID in the Apparel Industry

Finding the Wal-Mart case uninspiring it happens that one of the largest department stores in Europe, Galeria Kaufhof, chose to take its RFID tagging from the container/pallet level to the item level in search of an answer to the question, how does RFID create business value in the retail environment? (Thiesse, Al-kassab, and Fleisch, 2009). Galeria Kaufhof designed this test to include approximately 30,000 individual items that are constantly available and seamlessly tracked throughout the store by 64 RFID readers and 208 antennas. Readers were placed at entries (docks), exits, and checkout counters to allow distinguishing between backroom and sales floor inventory. Additionally, this arrangement allows determination of items that are in stock but not displayed on the shelf triggering automatic replenishment.-

In addition, four RFID enhanced applications were specifically designed for customer service. First, smart shelves were equipped with RFID readers and screens. The screens display data on specific items such as size and color available. Second, a magic mirror allows customers who approach to receive information about materials, care instructions, alternate sizes and colors. Third, smart monitor walls recognize products brought into fitting rooms and a screen in each room displays additional product data and makes recommendations for alternative or complementary products. Fourth, mobile devices can be used by store associates to locate items by signal triangulation either on the sales floor, misplaced on a shelf, or in the backroom. The mobile devices can also be used for rack inventory counts as opposed to manual counting (Thiesse, Al-kassab, and Fleisch, 2009).

At the store level, four additional RFID enhanced reports have been designed. First, trace histories track an item from labeling in the distribution center to the sales floor allowing analysis of process execution and inventory management. Second, smart shelf inventories allow the tracking of inventory changes over time and identification of misplaced merchandise. Third, try-on data provides insight into fitting room utilization as well as complements and substitutes that are tried-on together and either later bought or returned to the shelf. Fourth, merchandise performance allows investigation between items bought directly from the shelf compared to those items that are tried-on before purchase.

Further data analysis from these applications allows extrapolation of how items were chosen, carried about the store, and later returned to shelf, tried-on, or purchased. This data can then be used to optimize floor layout, positioning of fitting rooms, and placement of complementary items. For example, a comparison of the try-on to sales ratio at 3PM with that ratio at 5pm revealed an increase in try-ons of 100% did not correlate to any increased sales during this time. This may be because people are enjoying an outing after work, as opposed to seriously shopping, or perhaps more sales staff is needed to aid with the fitment of tailored items such as suits (Thiesse, Al-kassab, and Fleisch, 2009).

Data gained in this test substantiated read rate accuracy near 100%, and proved RFID as a substitute for existing inventory systems when standardized throughout the supply chain. The test also showed time-savings of 87% when items were read by RFID, at both checking items into inventory and processing customer check-out, compared to bar-codes. RFID tagging also eliminates the mistake of scanning the same bar code two or more times.

Customers were then surveyed about the RFID enhanced experience and results were mostly favorable. Smart shelves received the best ratings with 56% saying they were a great improvement to the shopping experience. On the other hand only 33% found the smart mirrors an improvement, mainly because the information displayed, such as material, was not particularly useful and partly because of the positioning of data on the mirror got in their way.

Interviews with company sales staff were also favorable. The most appreciated feature was RFID inventory counting. Counting inventory has long been a bane to store employees and the store manager who would rather have the employee assisting customers. Second, the search functionality allowed employees to locate misplaced items for customers and correct shelf inventory throughout the day.

Amid the positive effects observed it remains difficult to quantify, in dollar value, the effect of RFID enhancement. Time savings achieved during the receipt and inventory of goods closely relates to labor cost reduction. However, assigning a value to data on shelf replenishment is more difficult to ascertain as seasonal factors, changing fashion, and promotions skew shelf sales. There also exists an intangible aspect to implementation. Does a customer purchase a complimentary belt with her dress because it was recommended by the magic mirror, or would that person have searched for a belt without the prompting? Data cannot know if the person planning to purchase a complimentary belt was unaware the store sold belts. The customer may have intended to purchase said dress and then go next door to purchase a belt, if this were true then the knowledge provided by the magic mirror increased store sales by customer education.

The Next Phase

While RFID in the supply chain has not produced the anticipated results, the ability to triangulate position based on RFID has created several new uses.

Quantas Airlines has created a baggage reconciliation system that utilizes customer purchased permanent RFID tags applied to flier's baggage (Zalud, 2015). This allows the airline to track baggage location in real-time as well as the order in which bags are loaded onto the plane. Then, in the event a passenger fails to board, that one bag can quickly be pulled from the flight preventing costly and annoying delays. Quantas then tied this data into a mobile app so that travelers could be alerted when their bag is unloaded and make a judgment whether to head directly to baggage claim or spend a few more minutes in the airport shops (Zalud, 2015).

Readymix was able to enhance worker and visitor safety in its manufacturing plant by the issuance of more than 150 active RFID tags. Readymix added active RFID to all employee and visitor cards and then equipped all forklifts with RFID readers and two antennas (Zalud, 2015). In a manufacturing setting, forklifts can be extremely dangerous. Unlike most vehicles, a forklift's back wheels are capable of turning up to 90 degrees. Forklift drivers rely on mirrors to be aware of their surroundings, but in a busy manufacturing environment this has led to workers becoming injured while walking in or through the operator's blind spots. By installing RFID proximity technology on each of their 30 forklifts, the forklift can determine if a person has wandered too close to the machine and apply its own brakes. Readymix health and safety manager Yonatan Scherzer says "Readymix is dedicated to the safety and security of all employees, with zero tolerance for human injuries, which is why we turned to RFID (Zalud, 2015)." This application of RFID has not only a dollar savings in workers compensation but a moral obligation to workers health.

Lastly, if there exists a loss of privacy would it be offset by an increase in security? 3:50 AM December 15, 2010 the Las Vegas Bellagio is robbed. A gun man walks up to a craps table pulls a gun and makes off with about $1.5 million in chips (Roberti, 2010). Likely this person had no idea that starting around 2005 Casinos began used RFID gaming chips. Essentially the moment those chips left the building the Casino could inactivate all stolen chips making them worthless and should the thief later try to claim the chips the chips themselves belying his identity.

CONCLUSION

Like many disruptive technologies, the early 2000's claim that RFID was the future of both the supply chain and of retail may have been overstated. Fifteen years later RFID has not brought about the end of the barcode, and it is estimated only 5% of the retail sector has adopted RFID technology (Roberto, 2015).

On the contrary, were the expectations set for RFID reasonable? If a new technology is brought to manufacturer's already operating at six sigma standards or to the world's most effective supply chain, by definition, little value remains to be wrung out of these processes. At this time it appears the real benefit to RFID may not be in hard dollar profit increases, but in improved customer experiences. Customers responded favorably to Galeria Kaufhof's RFID enhanced test store. Consumers are also notoriously

impatient when waiting in lines more than two deep. The bar for RFID checkout is not whether it can increase profit but if the technology can be implemented such that the time savings can zero out against reduced cashier hours with in an acceptable payback period.

RFID tagging also brings new tools to the preservation of human health. Worker safety is a moral responsibility of employers and unless massively cost prohibitive, should be widely encouraged by management and endorsed by the Occupational Safety and Health Administration. All but the most jaded corporate executive would argue the cost of preventing an employee from being injured or killed by a forklift is not offset by the cost of RFID protection systems.

Yes, much like any technology, there are concerns about its use and misuse. Privacy concerns must be addressed and cost must continue to decline. While it appears RFID may not revolutionize the supply chain, it may enhance customer experiences and certainly will lead to a more connected data intensive world.

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