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Chapter

RFID Applications in Retail

Narges Kasiri

Abstract

Radio Frequency Identification (RFID) technology is one of the latest product tracking technologies being utilized by retailers. Operations management improvements were among the first recognized applications of this technology earlier in the century. RFID applications in managing retail operations, such as inventory management and control, lead to significant benefits. However, RFID applications are not limited to operations management and go beyond the operations side to offer improvements in other areas in retail such as marketing and managing customers' shopping experiences. In this research, we review the applications of RFID technology in retail since its introduction and how those applications have evolved over the last two decades to help retailers provide omnichannel services to their customers in the current market. We will demonstrate what strategic and tactical factors have helped retailers implement this technology and what factors have slowed down the process of adoption. We will also report on the latest status of the utilization of RFID in the retail sector.

Keywords: RFID, RFID applications, RFID in retail, Retail sector, RFID in retail operations

1. Introduction

Retail stores manage millions of items on a day to day basis to deliver to their customers. Point of Sales (POS) systems with barcodes were among the first technologies used to track products across the supply chain and in stores. Barcodes, as an identification technology, are not utilized at item-level but usually represent a group of products. Retailers need to scan products at pallet level at the point of receiving shipments, in inventories entrance and exit places, and at the POS to keep track of what is coming into and leaving stores [1]. With barcode systems, inventory inaccuracy is created because stores barcode scanning are not always performed at the right time and the right location. This inventory inaccuracy leads to a significant loss at retailers. Retailers needed to explore new ways of tracking their items to lower the inventory inaccuracy and prevent consequent losses. Radio Frequency Identification (RFID) technology appears to be the new technology solution that could improve the inventory record accuracy of stores for various items.

RFID technology applications have been recognized in many areas such as healthcare, finance, manufacturing, and retail. The share of the RFID market in retail is projected to be the largest of all sectors with about 34% by 2026, followed by transportation sector (25%), financial and security services (22%), and other industries such as healthcare and manufacturing at smaller portions [2]. RFID tags can store more information about each item at real time and can have individualized identification for items versus barcodes with a small data storage capacity that can only identify a group of items. RFID readers do not need to be on the line of sight to

read RFID tags information which means items can be scanned more frequently and faster at any movement. These capabilities allow little mistakes in tracking records and largely eliminates inventory inaccuracy.

RFID technology's benefits to retailers were identified early at the beginning of the 21st century. However, RFID's applications in retail stores on a large scale took a while to be implemented. This paper reviews utilizing RFID, as an ideal solution to retail operations, since earlier this century and will cover a twenty-year horizon (2001–2020) divided into three equally long periods of 2001–2007, 2008–2014, and 2015–2020.

2. Early introduction and utilization of RFID (2001–2007)

In studies done earlier in this century, RFID was recognized as the next major identification technology to replace barcode systems in the retail industry [3–7]. Barcode systems have been used to track customer purchases, to manage inventory records, and to offer promotion and advertising in retail since 1970 [8]. Barcode tags, however, need to be on the line of readers to be read, a requirement that makes physical inventory counting a labor-intensive task and prevents stores from updating their inventory records frequently and on time. Therefore, with barcode systems, inventory inaccuracy is significant [9]. Inventory inaccuracy refers to the difference between inventory on record and the actual number of items on hand in stores. Inventory inaccuracy is caused by many factors such as transaction errors in the POS system, or shrinkage caused by possible employee/customer theft. Inventory inaccuracy means that stores may not be able to place inventory orders on time, resulting in out-of- stock conditions and consequently losing sales and hurting customer shopping experience. RFID technology, on the other hand, enhances product visibility in store operations and across the supply chain through the ease of reading RFID tag information and updating inventory records on a real-time basis.

Studies have investigated RFID benefits in different areas of retail operations, such as supply chain management, and show how inventory inaccuracy and consequently out-of-stock conditions are improved with the implementation of RFID across the supply chain [10–12]. Enhanced information visibility, provided by RFID in the supply chain, decreases uncertainties and lowers high inventory costs associated with the uncertainties [13, 14].

Many pilot studies during this period investigated and explored the applications of this technology at the pallet level, case level, and item levels in stores [1, 6, 12, 15, 16]. Bottani and Rizzi [1] conducted a case study in 2005 to analyze pallet and case-level implementation of RFID and enhanced visibility generated at the receiving gates and entrance doors from backstore to sales floors. They demonstrated that safety stock and inventory holdings can be significantly reduced and RFID benefits are broad, ranging from labor efficiencies to inventory management improvements. Cost–benefit analyses in this period showed that pallet-level implementations of RFID were more cost effective than case-level implementations.

Metro Group in Germany conducted some case studies in their stores to show item-level RFID applications can improve customers' shopping experiences as well. They introduced some tools provided by RFID technology such as automatic checkout, smart carts that help customers navigate stores and find their items easier and faster, and smart dressing rooms that help customers find their desired apparel items more conveniently [6, 16]. They demonstrated that utilizing these tools significantly enhances customers' shopping experience.

Walmart retail stores in the US were the first retailers that decided to mandate the implementation of RFID at pallet and case level across some of their supply

chain in 2005. Walmart also did a pilot study with 24 stores over a period of around 6 months to measure how RFID can improve inventory management. They demonstrated out-of-stock conditions were significantly reduced with the implementation of RFID technology [12].

In Asia, two Singaporean fashion retailers piloted item-level RFID on their apparel stores and reported significant reduction in stocking time from hours to minutes that consequently increased the frequency of counting items with handheld readers and improved inventory accuracy [17].

3. Delays and reflection time on implementing RFID solutions (2008-2014)

Financial crises and the great recession that started in 2008 did not work to the advantage of retailers that were planning to implement RFID applications in their stores. During financial crises, businesses tend to adopt strategies that could help them sustain and survive by spending low and investing less. RFID technology implementation plans were mostly postponed or slowed down during the financial crises. However, this period was the best time to develop some foundations with respect to policies, regulations, and standardization of the technology.

Privacy issues raised by consumer protection agencies and standardization issues across different platforms put forward by case studies and pilot projects led to the development of some regulations and privacy policies by governments, institutions, and businesses. European Commission (EC) took an active role by funding many initiatives across Europe [18]. Initiatives such as Coordinating European efforts for promoting the European RFID value chain (CE RFID) [19] and Building Radio frequency Identification solutions for the Global Environment (BRIDGE) [20], conducted from 2006 to 2009, highlighted that wide implementation of RFID technology needs some regulations, standardizations, and privacy policies in place. For example, the BRIDGE project, coordinated by GS1, helped the industry to develop standardizations such as establishing a common format for the data stored on RFID tags, or the availability of possible frequency bands.

RFID tags can store identifiable consumers' private data, which need to be protected. Therefore, EU members signed an agreement on the Privacy Impact Assessment framework in order to protect consumer privacy [21–23]. This agreement established some rules to be followed in the design of smart chips such as RFID tags to protect the privacy of consumers' data. Consumers should be informed if RFID tags are utilized in stores. In addition, tags must be deactivated at the point of sales at no cost [24]. This framework was later expanded to cover some rules for smart meters as well. In the United States, lawsuits against RFID application patents as well as privacy issues in 2011–2013 were setbacks for large-scale implementations of the technology. The National Institute of Standards and Technology (NIST) in the US has helped to establish some guidelines to help retailers; however, most of the development of policies and standardizations have been initiated by corporations in the US.

In addition to developing policies and standardizations, businesses had more chances to identify and learn broader applications of RFID technology in retail. The focus of most of earlier pilot studies was how this new tracking technology helps manage inventories better in order to avoid out-of-stock conditions. However, the applications of the technology go beyond only inventory management and tracking items throughout the supply chain. As shown in the balanced scorecard developed in [25], RFID benefits extend to marketing and merchandising operations in retail as well (**Figure 1**).

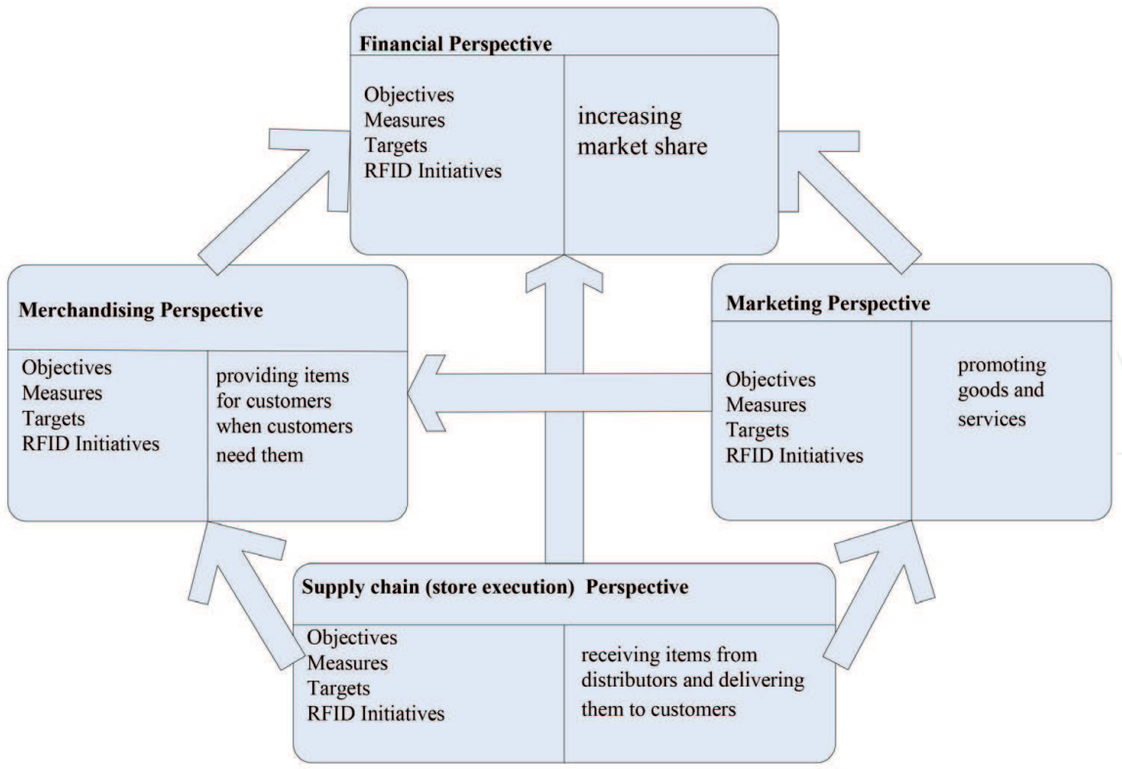


Figure 1.
Balanced scorecard for RFID applications in retail.

In marketing, stores can monitor the behavior of consumers better when customers use tools such as smart carts or smart dressing rooms provided by RFID. Retailers can learn about consumers' preferences and reflect that in the promotion and advertising offered to customers in real time while they shop. The available tools such as smart dressing rooms and smart carts also enhance customer shopping experience. Use of these tools enables customers to find their desired items more conveniently and faster, which eventually leads to higher customer satisfaction and increase in sales.

In merchandising, enhanced visibility on consumer behavior in stores provided by RFID can help retailers identify better assortments of products. In addition, an enhanced visibility means better shelf-replenishment; that is stores can reduce the shelf space since enhanced visibility on shelves allows retailers to replenish them as soon as they become emptied. Less shelf space leads to holding less number of items on shelves at any given time and consequently less inventory and capital held in stores, which allows retailers to invest in carrying more variety for products in stores.

There were also more studies during this period conducting cost–benefit analysis of the implementation of the technology. The fixed cost of implementation includes middleware, fixed antennas, sensors, and readers and the variable cost includes the cost of tags per item. The cost of tags can be added to the cost of each product but then the big question is who has to pay for that cost. Should the cost be transferred to consumers or should that be shared between retailers and manufacturers? The tag cost as the variable cost of utilizing the technology is huge and cost–benefit analysis studies have shown it to be a major barrier to the implementation of the technology during this period. Kasiri and Sharda [26] showed that the cost of tags in item-level implementation of RFID, as the variable cost, is cumbersome. Moreover, the cost can exceed the benefits in some cases depending

on the extent to which stores implement RFID applications. The cost barrier was expected to weigh less as the cost of tags became lower over time.

4. Large-scale implementation of RFID (2015-2020)

Surveys of businesses show the implementation of RFID has picked up in this period. A survey of 60 retail executives throughout the United States and Europe showed about 73% of retailers had plans to implement RFID in 2016 [27]. Another survey in 2018 [28], however, showed that 92% of retailers in North America plan on implementing RFID, which is about a 20% increase from the 2016 results.

The cost of implementation has been decreasing over time, as expected, and at the same time retailers have learned how to partially implement the technology. Retailers realized that they do not need to fully implement the technology. In some cases, only tags and hand-held readers are used to add visibility of items in stores without many of the infrastructures such as antennas. Cloud services, on the other hand, have allowed retailers to eliminate some of the middleware cost as well. The leading European fashion stores C & A is one of many retailers that explored lower cost implementations with partial utilization of the technology [29].

RFID platforms can generate big data that are the records of tracking items throughout the supply chain and stores in real time. Businesses need big data and business analytics capabilities to fully utilize technologies [30]. The results of the analysis of such data can help retailers improve their processes such as shelf-replenishment process as well as variety and assortment planning that have been used in the same format for many years. A new timely replenishment process can result in better management of physical space, layouts, and lowering holding costs in stores. Furthermore, a better variety and assortment planning means fulfilling customers' expectations and eliminating unpopular items that releases some capital and allow investment opportunities in other areas in retail.

Competing technologies to RFID have been developed and utilized over time as well. For example, Quick Response (QR) codes give retailers better ability to manage items compared to barcodes, Near-Field Communication (NFC) technology has some capabilities compared to UHF RFID, and most recently Amazon's cameras increase product visibilities in stores for fast checkouts. In addition, retailers have different priorities in investing in new technologies and there is competition for dollars invested in various technologies by retailers. For instance, a retail chain can focus on improving inventory operations, but another retailer may be focused on improving marketing operations and customer shopping experience in stores by developing new apps that can assist customers make decisions during their shopping time in stores. In a different example, Gucci as an Italian luxury brand name does not suffer from inventory inaccuracy issues but their priority is customer shopping experience and they have utilized RFID tags to protect customers against counterfeiting across the supply chain until products reach their customers [31].

Omnichannel retail has been widely available during this period of time. Retailers' customers can shop at any time, in any place, and via any shopping channel. Omnichannel retailing needs accurate inventories and enhanced product visibility more than any other time. Item-level RFID can, therefore, accommodate the needs of omnichannel retail more than other technologies available [32]. In addition, blockchain as the latest technology in retail can provide automatic exchange of product data carried by RFID tags between different partners across the supply chain. The blockchain in retail solutions are currently being studied in a consortium of large retailers such as Nike, Macy's, and Dillard's in an RFID lab at Auburn University [33].



Figure 2.
3-S model for RFID retail adoption.

The 3-S model (substitution, scale, and structure) introduced in [34] discussed and projected different phases of the adoption of RFID earlier when this technology was introduced. Later the 3-S model was adapted by [35] to describe the current stage of retailers' implementation of RFID applications in retail (**Figure 2**). The substitution and scale stages are covering mostly what has been achieved during the three periods discussed in this paper. In the substitution phase, the RFID technology was utilized to replace the applications of barcode systems in tracking products. In the scale phase, the RFID applications are enabling retailers to manage their operations with more accuracy, efficiencies, and at a higher speed and scale. The structure phase, that is re-engineering processes and completely overhauling retail operations, is still underway. The RFID technology will enable retailers to accomplish things they could not imagine before and allows retailers to tap into completely new domains and applications.

5. Conclusion

Retailers have different needs based on the way they operate in stores. Some retailers must manage large inventories in stores. An enhanced visibility on their products help them improve inventory accuracies and avoid out-of-stock and increase their efficiencies. On the other hand, some retailers have small backstore inventories and every item they receive is put directly on their shelves and available to their customers. Inventory management is not their priority, but they need to focus more on customer shopping experience. Therefore, the enhanced visibility of items in stores is expected to promote retailers' marketing operations. Depending on the way retailers operate and what their priorities are, retailers have to plan on implementing appropriate applications of RFID technology.

As discussed in this paper, RFID has been utilized broadly with various applications. As a revolutionary technology, RFID's implementation can go beyond improving the current processes in retail operations. The current processes can innovatively change to debut completely new applications that are only possible with the enhanced visibility of items in real time. The ensuing big data that is derived from the visibility provided by RFID tags can be analyzed, leading to innovations in retail operations.

Implementing item-level RFID needs to be part of omnichannel strategy in the retail sector. With the wide-spread usage of online retail services such as Amazon, the competition in retail is tougher than ever before. In omnichannel services, retailers need to grant their customers easy access via different channels and make their products available in a variety of delivery services. The accessibility and fast delivery will not be possible with the level of visibility provided by barcode systems. Utilization of technology in retail is evolving quickly and RFID technology is the one that can definitely help retailers win in this overhaul.

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