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IoT and RFID in Supply Chain: Benefits, Barriers and Analysis

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ABSTRACT

This dissertation explores and describes the application of Internet of Things in general and RFID in particular in the supply chain management for organizations. The study analyzes the benefits of application of RFID in the supply chain. It also delves into the major bullwhip effect, and how such painful situations can be mitigated by the use of IoT for the companies. The dissertation not only analyzes data from other reports but also explores the findings from some case studies of companies' which implemented the use of RFID in their supply chain. This paper attempts to analyze why IoT has been a trend which is massively beneficial, and at the same time why does its growth not match its potential.

List of abbreviations

RFID – Radio Frequency Identification
SC – Supply Chain
M2M – Machine to machine
IoT – Internet of Things

Glossary

RFID - Radio-frequency identification uses electromagnetic fields to automatically identify and track tags attached to objects.

Supply Chain Management - the management of the flow of goods and services, money and information between businesses and locations, and includes the movement and storage of resources.

Internet of Things - The Internet of things describes the network of physical objects that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the Internet.

Lead time - Lead time is the amount of time that passes from the start of a process until its conclusion.

Introduction

A common problem in the logistics process is uncertainty in forecasting and planning, as each level of the supply chain requires a high amount of inventory to avoid running out. And to avoid such cases, companies often opt to stockpile too much.

Declining customer demand is leading retailers to order below normal in order to reduce inventory. The bullwhip effect can be explained as an event discovered by the supply chain, in which orders sent to manufacturers and suppliers make a bigger change than in sales for the customer. Last line. These unusual orders at the end of the supply chain become more distinct at the top of the supply chain. This change can disrupt the fluidity of the supply chain process, as each link in the supply chain will overestimate or underestimate the demand for the product, leading to excessive volatility. Through the many stages of a supply chain; Key factors such as timing and ordering decisions, demand for supply, lack of communication, and disorganization can all lead to one of the most common issues in supply chain management. This common problem is called the kumquat effect, sometimes also the kumquat effect. An important way to solve this problem is to properly practice supply chain management.

One way to achieve this is to use the Internet of Things (IoT), which primarily uses RFID.

Literature review

RFID is a term that has been around for quite some time. In recent years, academics have become increasingly interested in the analysis of RFID technology investments in various industries. This section is primarily based on three lines of literature: the potential benefits and most common applications of RFID technology, RFID investment in the supply chain with contracts, and two-way supply chain coordination. or three levels, as well as RFID development Multi-agent technology and systems based on manufacturing control for industrial applications and dynamic logistics processes The main causes of inaccurate stocks are transaction and transportation errors, misdirection, delivery delays, and reduction errors, all of which have been discussed as areas in which RFID can improve accuracy. Many articles in the literature have examined the benefits of RFID technology. The advantages in various categories are listed below. Lee and Ozer investigate a single item periodic review inventory system with replenishment policies. They integrate RFID technology with uncertain demand and random distribution of transaction errors, and they investigate the cost of inventory associated with transaction errors. Atali et al. extend the above models by developing two models based on losses such as theft and damage, loss and transaction or scanning errors. They believe that RFID can effectively reduce error rates and improve inventory visibility.

RFID has the potential to replace all digitization activity in the SC. It can be implemented in a "closed loop" environment, where it is used internally by a single company. For example, in an electronic anti-theft system or a user authentication system. It can also be used to improve the efficiency of a SC in a “open loop” environment. This is the case with Wal-Mart, Metro Group, and other early-stage retailers (Boeck & Wamba 2007, pp. 435). RFID technology has opened up new possibilities for a wide range of SC applications, including warehouse operations, material handling, and inventory monitoring (Kim et al. 2008, p. 404).

Additionally, McFarlane and Sheffi (2003, pp.4-5) list some advantages of RFID systems over barcode systems in SC operations, which are described below:

- Speed: Many labels can be read on a computer in parallel at the same time instead of sequentially, one label at a time.
- The content of the various means of transport (such as trailers, boxes, pallets, shopping carts) can be read automatically without opening or sorting.
- Bar codes do not perform well when exposed to the elements, dirty, or damaged in any way that interferes with line-of-sight reading.
- Location - RFID readers can provide approximate location information, especially when the products to be scanned move relative to the reader.

Then he goes on to describe various types of errors that reduce his costs, such as employee theft, fraudulent and administrative transactions, as well as limited inventory, and products sold but not paid for, and obsolete paperwork. Furthermore, RFID has been thought to be a solution for illegal sales and is expected to result in greater material control through greater accuracy of handling and reduced errors (as reported elsewhere). Using RFID, they review a case study in which a strong location and inventory control is featured as well as well as other functions including tracking and inventory management are key to the container's mobility. The paper examines the financial costs associated with RFID technology, and concludes that a significant investment is required, but that the price of the tag can be spread across all participants in the supply chain. Furthermore, they maintain that RFID is an excellent way to keep track of inventory and restocking practices. By building on top of the previous work, they then expand on the RFID further by examining it in a two-level supply chain. When discussing which type of decision-making process manufacturers and retailers can use in conjunction with RFID, the book mainly looks at maximizing their own profits at the expense of others (rather than cooperating). According to Heese, RFID technology is the most useful in supply chains that are decentralized. Unfortunately, it is not possible to eliminate all errors using RFID, but we can detect and manage them quickly. Dutta, Rek, Szmerek, Zhang, Bottani, Wang, Whitaker, and Szmerek were interested in his effort to eliminate errors in his research papers, all of whom wrote about these topics and together make up the large group of noteworthy experts in this area. Every person has something to fear about RFID: Inventory inaccuracy resulting from numerous errors has a wide impact on all facets of business.

Walmart, for example, has become one of the largest and most complex organizations in the world, and this requires all of its suppliers to utilize technology (Lee & Park, 2008). The advantage is being seen by some supply chain members as merely being an expense that must be paid in order to conduct business (Zelbst et al., 2008a). Osyk mentions (2006) has pointed out that several groups within Walmart's supply chain must be using RFID, and others have no choice but to use it. There is the risk that the organization may overlook important information which is readily available in order to help it perform better. An expansion is assumed by Dos Santos and Smith (2008) will need to occur at the operational level before results will be detected at the supply chain level It is recommended by Peng et al. (2008) that a company should evaluate the performance of the performance of an organization based on a variety of operational metrics, such as delivery time, operational expenses, and inventory turnover, with regards to get a more accurate appraisal of the effectiveness of operations (Mabin and Balderstone, 2003).

In terms of SCM, information is the key to better performance (Erickson and Kelly 2007, pp. 36-37). RFID is an emerging technology used in SCM in recent years, particularly in the United States and Europe. It has emerged as a new form of inter-organizational system (I0S) which is used to improve operational efficiency in CS. Because of their ability to be used for real-time identification and long-distance tracking, some believe that RFID systems will fundamentally change the way companies do business (Smith & Konsynski 2003, p. 302).

RFID is revolutionizing the way products and goods are tracked in the SC. It can identify, classify, or categorize and manage the flow of goods and information through a CS (Ngai et al. 2007, p. 63). Karkkainen (2003, pp. 530-531) discusses the potential of using RFID technology to increase the efficiency of CS. The world's largest retailers are increasingly demanding RFID compliance from their suppliers. We are seeing increased interest from companies in this technology (Prater et al. 2005, p. 140).

About RFID and IoT

The story of RFID is somewhat murky. This type of technology was developed during the 1940s, but recently it has been fully discovered to be useful, and subsequently it was implemented by Procter & Gamble and Wal-Mart as one of the first examples of retail and is getting to be included in retail designs. According to the experts, these two corporations' expert assessments, the capabilities of the analytic technology were highly overestimated, which has proven to be the industry wrong. As a McKinsey & Company found in their research, the RFID reader's reliability was much lower than predicted, causing them to demand human intervention when they incurred problems, and thereby increasing the occurrence of mistakes in log-in times (McKinsey Global Institute, 2011). Finally, costs per label did not fell as quickly as they had predicted, and thus many of the companies did not realize the economies of scale they had anticipated. It also has naturally been shown that metals and liquids effectively block radio waves, limiting the ability of RFID to perform more thorough non-invasive tracking of people (Gaukler & Seifert, 2007). Furthermore, new industrial products are more likely to face opposition from the buyers of existing technologies may be adopted by businesses because of their existing organizational arrangements (Bao, 2009). However, in the more recent past, RFID has been deemed to be an alternative to barcodes, which has gained in popularity over the years. nearly half of the participating companies surveyed in the Voluntary Inter-industry Solutions (VISA) have already implemented/tested RFID in their operations, with better inventory accuracy, visibility, and insight the benefits in place.

Over the past decade, the term Internet of Things has gained attention in the business world, primarily due to the growth of the web-based service economy. It flourished by presenting itself as a bridge between the physical world and its representation in information systems.

Technologies such as RFID and sensors provide contextual data to support decision making at the highest level of management. Smart elements enable local decision making and reduce the need for centralized data exchange and processing.

Typically, the logistics operation can be performed by managers who make decisions based on their knowledge of business logistics. In line with this claim, it is clear that the performance of logistics operations can be influenced by the decisions of managers, but this is very rare in practice.

Classifications, Pros and Cons

It has its own limits, of course, and the Internet of Things is a solution to problems with a solution. Internet of Things, often considered the third evolution of the Internet, known as web 3.0. It simply consists of smart devices connected to each other. It comes in various forms.

- Connected objects through chips and smart labels.
- M2M
- Computers, smartphones, and tablets

According to Cisco, 50 to 80 billion connected devices are in circulation around the world in 2020 and generate a large amount of data, all of which can be harnessed to increase process efficiency.

The benefits of using IoT are many, and some of them that can be vividly pointed are as follows: -

- Inventory accuracy
- Diminishing error rate
- Customer relationship management
- Security
- Productivity gains
- Tracking enhancement
- Real time visibility of the overall SC components

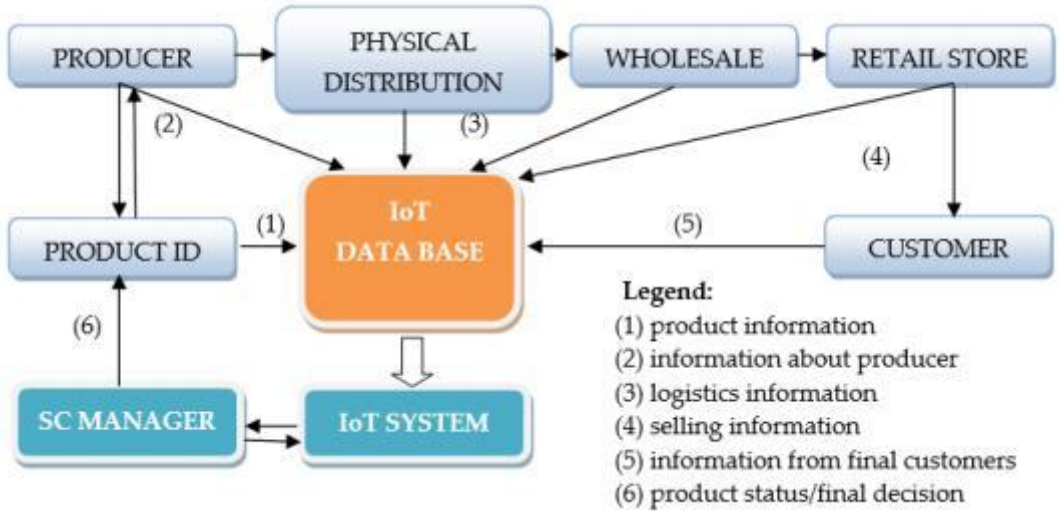
These are not just theoretical. Decathlon, which uses IoT extensively, saw an 11% increase in sales from July 2014 to July 2015 and the company attributed some of that growth to the implementation of RFID. In fact, it has even started the global rollout of an RFID solution to track throughout its supply chain. It currently uses RFID facilities in 1,030 stores and 43 warehouses and has tagged more than 14 Lac products.

There are several drawbacks, which prevent the effective use of IoT in supply chain.

- Data security
- Personal privacy
- Data massiveness
- Environmental issues

IoT's impact in various fields can be measured using some Key Performance Indicators. The main area of application will be warehouse and inventory management, production management and logistics.

IoT Structure and Processes



These chains use similar distribution methods: The distribution of the Internet retail supply is analogous to the distribution of traditional retail. Manufacturers and suppliers are now providing inventory and goods to the Internet retailer on the supply side. Wholesalers can commonly be found working on the distribution end of the supply chain, serving multiple retailers. The majority of Internet retailers and third-party logistics (3PLs) companies generally supply goods that are placed on customer orders, with distribution centers which are utilized to fulfill those orders. Customer service is an important factor in making internet retailers distinct from conventional retailers. In traditional retail, customers' world, physical stores are the most important places to purchase products or obtain services, because they are the primary delivery point.

To prevent products from going out of-of-of-stock, store, distribution centers are provided with store shipments and have those stocked in their locations The products are returned to the store shelves after they have been repackaged from the warehouse. Unlike in Internet retail, the website is where the customers only view product information, [as well as using it as a way of entering and receiving items] the website serves as the front door for the online store. The orders are picked up by the distribution centers and delivered to the address of the customers straight away. For many goods, orders, the traditional retail model is being used, in which the manufacturers, suppliers, or wholesalers ship directly to the retail stores. It isFor similar reasons, Internet retailers commonly make use the product and inventory of their supply chain partners available to customers.

To a customer, a transaction is entered on the website. In the event that the product is available, the DC online retailer might ship it. Customers can order products from an out of the Internet retailer if they do not have them in stock. It is also possible for the retailer to order products from one of their suppliers, or contract manufacturers or use a wholesaler to deliver them to a customer's location. By using a drop shipping process, e-that is essential for retailers on the Internet to offer so many different products and serving their customers' diverse needs. Due to their extensive physical distribution and electronic capabilities, or because of them, multi-channel retailers are more heavily utilizing their store and online network for in their total marketing approach. Customers can browse a website, place an order, and have the product picked up at a local retail location. with cheaper transportation is provided to help expanding the products from the distribution center to the customer. In other words, retailers can ship products that are located near the distribution center and benefit from lower shipping costs and economies of scale (Maltz et al., 2004).

Lean RFID

Businesses know that a lean supply chain is the best way to improve the efficiency of their supply chain. But even lean operations have work to do if they don't use the right tools.
When it comes to cutting edge technology in manufacturing, RFID is pretty straightforward. For small quantities, RFID tags or chips can improve a company's top-down understanding of everything going on in its manufacturing equipment and make lean operations even more efficient.
RFID can improve the basics of running a business by helping it get information much faster than it could using its conventional means. This information may contain items such as:

- Location of raw materials and finished products within an installation, either on the assembly line, or stored on shelves or for recovery.
- The level of inventory available at each of the different facilities.
- The speed at which parts and unfinished products move from one phase to the next and the time it will take for each step of the process.

The "front-line" employees have a great ability to identify and reduce waste in lean manufacturing industries because they are already employed on those frontline jobs. Reliability-related benefits may be included, such as RFID, but incorporating RFID technology will help your employees to become even more dependable. A complex, modernized, and more advanced version of the barcode technology performs numerous daily functions that we're currently engaged in, such as inventory control, but requires additional processing. a tremendous amount of time and effort Nowadays, scanning barcodes one at a time does not serve the purpose as it is possible to read with the reader in bulk, enabling users to distinguish more quickly and easily each of them with each sweep of the beam. Make sure to track of which products arrived at the dock, and how many are being taken on the water. This will also mean you will know immediately if something has been ordered correctly.

Quality control is greatly benefits from the use of radio frequency identification technology. In the same way, it is common practice to replace products that have been damaged during shipment. There are two benefits to this approach: Businesses should expect faster response and action times and lower corrective spending, while customers can anticipate longer and more immediate resolutions. This approach greatly reduces the chances of mistakes with each process being carried out by smaller teams of employees and making each one more efficient.

Employing RFID (radio-frequency identification) badges reduces the operational friction while delivering the data more quickly and reliably. But it is also feasible in retail. It is possible for them to keep up with which products are in the hot spot and where the store locations are left overstocked so as well as determine which products to restock.

This has consequences that go far beyond just counting inventory. Our aim is to provide a holistic audience understanding of the economic behavior and preference profiles with updated location and purchasing data. requirements-based procurement takes over from what was previously available supply-driven Radio-frequency identification helps with inventory management because it has many benefits on both sides of the supply and demand chain.

Case studies

A few case studies from some reputed firms which are known for having successfully implemented IoT were taken, and their findings were used to analyse the kind of situations under which IoT was favourable and what indicators do they provide for the implementation and effectiveness of it.

Volvo

The chain on which the study was done had a Scandinavian supplier, a cross docking warehouse in Gotenberg and the market was in Brazil. There was use of mobile RFID solutions. Over 3000 measurements of various attributes were done, and a unique context of mobility were evaluated. The units which were analysed were:

- Operational Reliability

The errors have been divided into five categories to provide an overview of reliability: - Errors that occurred in the application. End users encountered a software bug that resulted in a blank screen on several occasions, primarily as a result of the same interaction with the app. When end users encountered a blank screen, the app had to be closed and restarted in order to continue reading labels. - Errors by network operators As a result, the data captured from the tag reads was not transferred to the server, and the application no longer functioned

properly. - Errors with mobile devices An RFID reader was disconnected from the rest of the device at some point during setup. The mobile device displayed "No RFID reader connected" twice while the inbound application was running. This has been investigated and determined to be a device-related bug. - Problems with the server For a total of two days, the solution's delivery of mobile messaging services was disrupted. A hardware failure in the provider's infrastructure caused the outage. Some SMS-related services were unavailable during the outage. - RFID tag failure During installation, a pure RFID error occurred because a tag was not readable. Otherwise, the tested labels functioned properly, and weather conditions such as rain, snow, and dirt did not interfere with label reading.

Because only one error was identified and classified as an RFID error, RFID has a high operational reliability of 99.96 percent against 3000 reads. Because the mobile RFID solution is dependent on these various components, it is also necessary to assess their operational reliability. Application errors stand out as a distinct category. This category's operational reliability is 99.26 percent, which is the lowest of the three measurements. However, it could be argued that if this figure is low, the application, as an essential component of the mobile RFID solution, should have high operational reliability. The app must function properly in order to perform the intended task; otherwise, it will interfere with daily work.

- Usability

According to end users, the mobile RFID device was simple and adaptable to their needs. This job involves working in a fairly harsh environment that necessitates the use of durable tools. The mobile device was protected by a plastic cover, which should keep it safe from environments with humidity, dust, and so on. However, the keyboard on a mobile device is small, and it can be difficult to press the correct key at times. Because much of the work is done outside, end users may be required to wear gloves (especially during cold months). As a result, it would be advantageous if the mobile RFID solution had larger keys than conventional mobile devices, especially if the use necessitates frequent user input via the keyboard. The applications were simple for end users to learn and use in their specific environment. Applications designed for this configuration included some user input that end users thought was unnecessary and time-consuming. In this case, end-user scenarios should focus on enabling the "reading of all tags in a sequence without any user intervention." This 'extra input,' however, can be a critical trade-off, as a big win may be to eliminate back-office work or control over other functions and bring them closer to actual RFID operations and back-end integration.

- Productivity

The measured times when using the mobile RFID solution in the on-arrival inspection indicate a level of possible time savings ranging from 10% (A1) to 50% (A2) when compared to current routines. Using the freight app, like using the inbound inspection app, indicates a potential time saver. Time measurements show examples of delays being reduced by more than 30%. (L2). However, it is intriguing and noteworthy that there are instances where the mobile RFID solution contributes to lower productivity. It appears to be associated with situations involving a small number of cases and/or shipments per container, and forced data entry can actually slow operations by more than 10%. (L1). The presented results may indicate the magnitude of the impact on wait time and may be established in relation to other studies. However, the specifics of the case will determine the actual outcome in order to draw conclusions. This was confirmed in workshops with supply chain actors, who also agreed that their own activities would be beneficial. Figure 3 was presented in a previous section, with a summary of RFID savings compared to activity distribution. The mobile RFID-enabled inbound inspection can be interpreted as part of the check-in and receive activities, as well as the load application to be used during the order filling and shipping activities. The arrival and cargo inspection routines differ, particularly in terms of package and shipment quantities. The number of boxes checked in arrival control is significantly higher than in loading operation (due to the relationship between the number of incoming suppliers and the much larger number of outgoing distribution points). This could be one of the reasons why the measured time savings for the loading application are lower than for the arrival inspection application.

Conclusion from Volvo

If properly adapted to the situation and conditions of operability, RFIDs can show operational reliability, not only for the aspect of failure of transmission of data, but for the entire flow of information chain.

There is improvement in lead-time productivity improvements which ranged from 10% to as much as 50%. But under some conditions it also decreased by 10%. This concludes that in general RFID solutions are effective but are subject to the decision of certain use-case scenarios.

Present RFID implementations are associated with high costs, implying fixed infrastructure installing at all sites. However, this is complemented by a mobile RFID solution which can leverage existing infrastructure and utilise the previous infrastructure investments. This facilitates smooth implementations. This is also subject to use case scenarios, but it was estimated in general to have larger than 20% cost savings.

The case study implied suitability for flows of less than 10 readings/minute and not beyond three data inputs. RFIDs can also enable open systems instead of closed loop applications.

Walmart

Strong RFID implementation efforts began in 2003, when Walmart became the first retailer to require its top 100 suppliers to label "pallets and boxes by January 1, 2005, with electronic labels at 10. product codes (EPC)" (Chasse 2007: 2). In early January 2006, the so-called RFID compliance program would target its top 300 vendors. The program failed to gain vendor support, prompting Walmart to impose a service fee, also known as a penalty, of US $ 2 per unlabeled person. pallet in February 2008, which was increased to US $ 3 in 2009. (Feng et al., 2014). Harsh penalties, Walmart's lack of advice and support to its suppliers, and the high costs of implementing this technology, especially when compared to the negligible costs of barcode labels, are prompting suppliers to protest the RFID mandate and, ultimately, Walmart's failure to implement it (Trebilcock, 2010).

The company's top management believed that inaccurate stock numbers were causing a lack of sales and customer satisfaction. They believed that improved supply chain visibility and more accurate ordering decisions enabled by RFID would solve these problems.

RFID scanners had been installed at Walmart. The early years were not without difficulty, and there were setbacks. However, according to a study conducted by the University of Arkansas RFID Research Centre on Walmart's use of RFID, stores that incorporated RFID reduced out-of-stocks at the store level by 16 percent compared to non-RFID locations.

Findings

As compared to barcode readers, RFIDs provide real time data and improve visibility. This resulted in a decrease in the inefficiency of inventory inaccuracies and improved the inventory management. It also positively impacted the responsiveness through the real time inventory information.

Decrease in labour costs was also observed as there is a decline in the inventory counting and product scanning error rates.

The primary reasons cited by the company for not implementing the RFIDs were ‘no customer demand’ and ‘lack of ROI’.

Retailers did not resort to adoption of RFID owing to the high cost associated with implementing the technology. There was also a perception that the technology was immature.

Walmart also offered a grocery pick up system where customers could purchase goods online and then retrieve them from the store when they are ready. RFID powered this process and helped it by avoiding it from becoming costly and inefficient.

A lot of big data is generated which improves the potential of the top management to improve the efficiency of the supply chain. It was estimated that Walmart was collecting roughly 2.5 petabytes of data every hour from customers’ transactions in 2012.

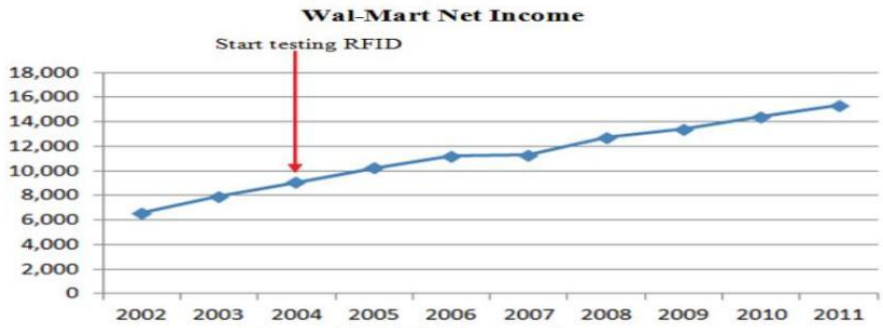


Figure 16: Wal-Mart net income
(Wal-Mart 2002 until 2011 annual reports)

Tesco

Robots - In 2015, Tesco began a five-store pilot test for six-foot-tall robots known as RFspot Pro. RFID-tagged merchandise is read by robots roaming the aisles of stores and warehouses. According to SC Digest, the RFSpot pro robot, which has three sets of wheels, can move at one meter per second and read RFID tags from a distance of up to nine meters. To collect item location data, the robot roams the store floor as well as the back room. Sellers used portable devices or reading portals before technology. Tesco employees could spend up to 7 hours performing this task, whereas the robot can take stock inventory in just an hour, which is a fraction of the time required by employees. Tesco can save money on labor because, while robots rarely require an operator, the amount of human interaction required is limited. Aside from reading labels and assisting in the location of products, the technology will enable managers to identify lost items, replenishment and

restocking requirements, and data on top performing products in terms of sales (Swedberg, 2015).

Tesco announced a collaboration with IBM in 2014 to integrate the IBM Shopping Advisor augmented reality mobile application into its stores. Tesco employees are required to photograph the aisles of the store, including the quantity and location of the products, using a smartphone or tablet. The IBM software "then connects to Tesco's product database to analyze and identify the images." It compares the current screen to the planned layout and immediately overlays data that reveals insufficient quantities, missing products, or misplaced items" (IBM, 2014). Because the app measures planned positions and the planned quantity of product that the customer is confronted with, it enables employees to identify the type of non-compliance with the planned arrangement, which can range from missing product, missing liners, to additional linings and missing products.

Inform App - Tesco has decided to create its first "buddy" app, Inform, aimed at store managers in the United Kingdom. The mobile app is now available in stores. Its key features include the ability to "download, log in, and track stock levels and availability in real time" by scanning barcodes or side shelf labels. The app then provides real-time product data, which, like Walmart's My Productivity software, speeds up replenishment and reduces stockouts. It also allows store employees to assist customers in aisles instead of working in the back office manually checking specific items. Tesco's Bring Your Own Device (BYOD) strategy includes the Inform app, which allows employees to use their own iOS, Android, or Windows Phone smartphones to run the app. When new technologies are implemented in the store environment, they are said to increase adoption levels because they bridge the gap between business use and customer use.

Findings

There was reduction in out-of-stock levels by 95% and shortened the average time it takes for staff to check the products by 7%.

With packaging innovation Tesco's suppliers can increase consistency and lower rejection rates and Tesco can reduce in-store waste and on shelf availability of fresh products.

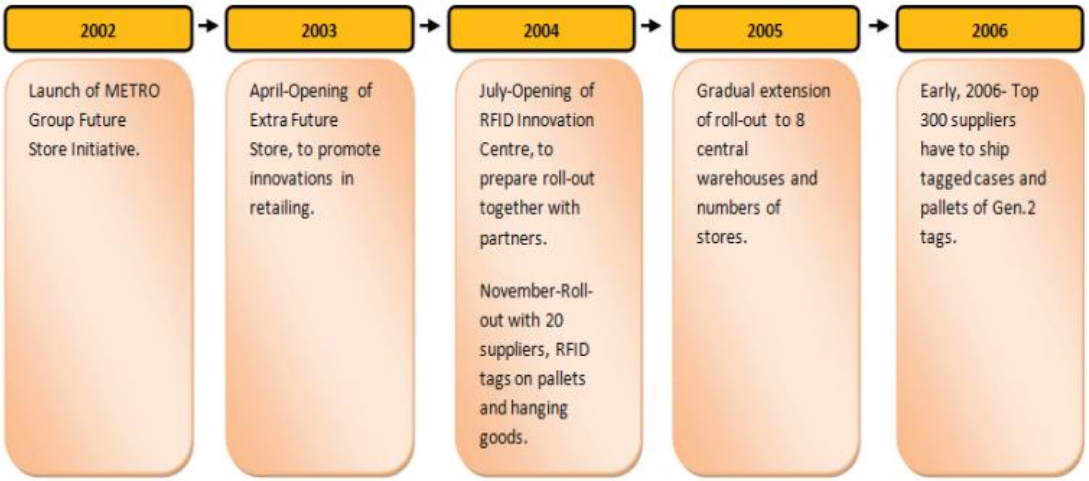
Technology	TESCO	Impact and Results for Tesco	Walmart	Impact and Results for Walmart
RFID	Yes	◘	Yes	◘
Drone	No	---	Yes	○
Blockchain	No	---	Yes	◘
Real-Time Big Data Café	No	---	Yes	●
Mobile Applications	Yes	◘	Yes	●
Augmented Reality	Yes	◘	No	---
It's Fresh & Buy One Keep One Packaging	Yes	◘	No	---

● - Very High Impact; ◘ - High Impact; ◘ - Minor Impact; ○ - No Impact

Metro Group

There were several reasons for Metro Group implementing RFID.

- Higher visibility, accuracy, productivity, and efficiency for supply chain operations
- Optimise inventory, minimize stock losses etc.
- Reduce out of stock with the aim of achieving top line and bottom-line gains, but also improve customer service levels.



Metro Group started item level field trials. RFID gates equipped with motions sensors capable of activating readers are also used. EPC compliant RFID tags are used to ensure no need for physical checking and providing real time information.

RFID was used in several other departments also like – order picking, warehouse management, department stores, stores of the future and also at home.

Findings

Metro claims significant achievements in the Future Store Initiative due to the implementation of RFID and other technologies after a year of pilot testing different technologies. Thanks to RFID, Metro claims that process efficiency increased from 12% to 17%, theft and loss decreased from 11% to 18%, and commodity availability increased from 9% to 14%. During this pilot phase, however, the metro points admit to some issues. RFID readers on shelves have "blind spots" where they cannot reliably record products and struggle to detect liquid and metallic products. Metro also reports that the cost of beacons, readers, engineering, and cabling for a full SC-wide REID implementation is prohibitively expensive, even for Metro-sized retailers (Metro Group 2011).

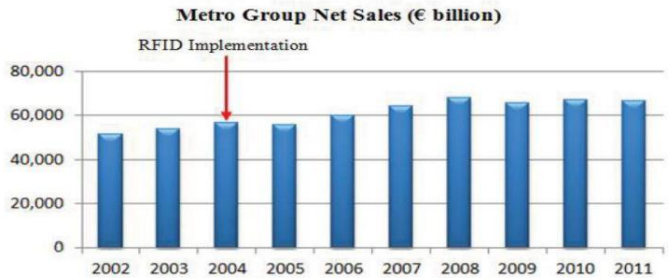


Figure 13: Metro Group net sales
(Metro Group annual reports, 2002 to 2011)

There were fewer item misplacement and shelving errors. There was a 11% to 18% reduction loss or theft of items. There was also a 10%-20% reduction in out-of-stock situations. This positively influenced sales of merchandise in the Metro Group, and it experienced 10%-15% growth in sales. The pallet processing became 16 seconds faster per pallet. There were 2.84 Euros savings for each dispatch.

Some other companies

Metro implements the RFID system in actual shelves that store goods to be delivered or sold, which is a very effective measure not seen in Wal-Mart stores, giving Metro a competitive advantage. The shelves are referred to as smart shelves because they include an RFID reader that automatically tracks the products that are placed on them.

Decathlon discovered that using RFID allows for more precise inventory adjustments to meet customer needs (Decathlon, n.d.).

Furthermore, Decathlon emphasizes the following benefits: faster checkout in stores equipped with RFID readers, lower prices due to lower costs (storage, transport, fewer thefts), better after-sales service (product exchange possible payment ticket), security (less theft means lower prices for products).

Almost all products sold in Decathlon stores are now RFID-enabled, including clothing, shoes, and non-metallic accessories. According to Patrice Rubout, project manager, no less than 85 percent of products have been factory labeled since 2014, and the percentage will be 100 percent in 2017. Furthermore, flight crews can use "inventory snowshoes," which allow for an accurate and complete inventory, recording all relevant information (model, size, color, stock). Inventory can now be completed five times faster than previously.

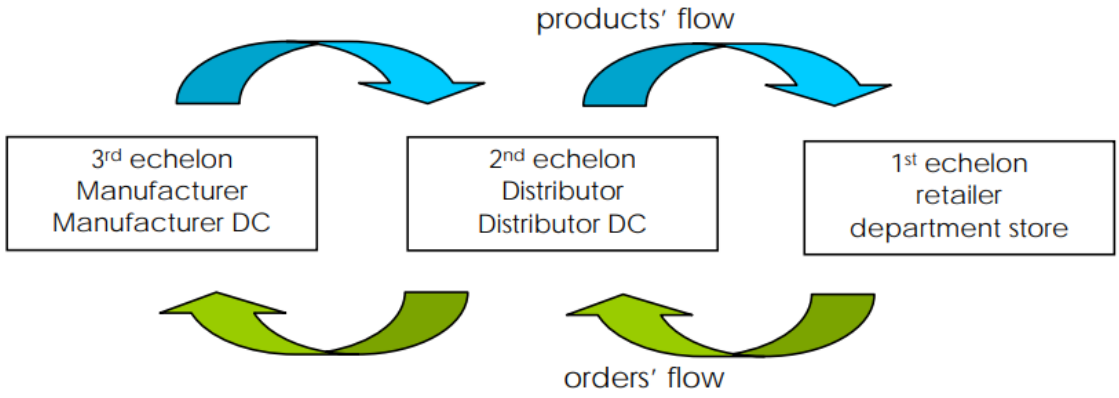
Swedberg (2013) reports that American Apparel completed a continuous installation of an RFD system in all of its stores in 2012, consisting of fixed readers in the warehouse as well as at the entrance to the md storefront at the point of sale. Employees also use portable readers to track items on the shelves on a regular basis. This system ensures a thorough reading, and by dividing the magazine into zones, the software can determine which zone the label is in. If a customer misplaces an item of clothing while trying it on, staff members quickly locate it and return it to its proper location. Stockouts are also reported by the software because a specific label is no longer read in the store area. At the start of implementation in 2011, Stacey of Technology, a company that had implemented the technology in more than 50 stores, claimed that the system improved inventory accuracy by up to 99.8 percent while also reducing employee theft. In 2011, internal contraction had decreased on average).

In 2009, the RFID Research Center at the University of Arkansas included two Bloomingdale's stores in a study. According to the research, inventory accuracy has improved and cycle count time has been reduced by 96 percent. The board took two years to make a decision, but in 2011, it began rolling out nationwide RFID with a focus on large-sized core additions so that the company could ensure all of them. On the sales platform, suitable designs and sizes are available for purchase. Recent pilot projects have demonstrated RFID's ability to significantly improve sales, gross profit margins, and discount rates by better leveraging real-time invoicing and corrective action (Business Wire, 2014).

RFID technology, according to Ngai et al. (2012), can help improve the operational visibility, efficiency, and effectiveness of the garment manufacturing process. Companies that require greater visibility into the production flow can better understand what is happening in the production flow and improve employee coordination in the factory. The study revealed operational improvements that aided in the reduction of operating costs and the improvement of profitability. Increased visibility of the production line, reduced machine downtime, less downtime for culverts, lower defect rate, less late delivery, and less overtime were among the improvements. Furthermore, this implementation revealed previously hidden issues, such as poor departmental coordination, and provided more accurate data for performance review and payroll. According to the Motorola white paper (2010), item-level RFID can also benefit manufacturing by improving decision-making, reducing workloads, making better decisions, and increasing efficiency. which saves money and gives you a competitive advantage particularly for SMEs (Ceptureanu 2015; Motorola, 2010). Better forecasting / raw material management, improved shipment verification, optimized finances, increased automation via WIP / Kitting, reduced counterfeiting for better brand protection and product authentication, and a reduction in hidden shortages are among the more detailed benefits.

RFID is also said to provide flexibility for product recalls. RFID and EPC-enabled products can identify each product sold in a store and aid in the recall process.

Bullwhip effect



Primary cause

Forward purchasing practices of seasonal items by wholesalers and intermediary retailers amplify the seasonality observed by manufacturers. As a general practice in the dry food industry, wholesale buyers often induce increased seasonality for manufacturers by purchasing excessively large quantities of product during the peak season of demand for that product in order to " obtain reduced unit prices.

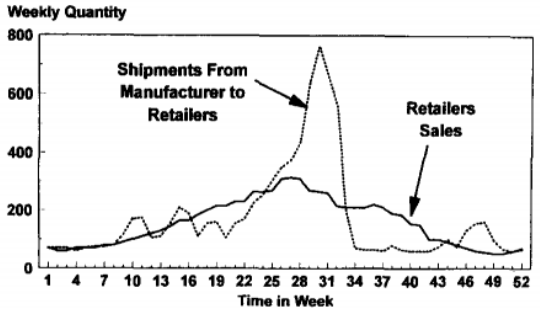


Fig. 2. Bullwhip effect in chicken noodle soup sales (from Lee et al., 1995).

Lot of orders by the participants. In some cases, it is associated with orders from the MRP system at the end of the month. Demand can be relatively continuous from consumers, but due to ordering costs or periodic ordering system runs, it is batch processed early in the supply chain. This grouping of orders induces a variation in demand in the supply chain that is not present at lower levels.

		Bullwhip effect	
		Manufacturer's DC	Distributor's DC
Pallet level tagging	BE Decentralized information LB	35.84	3.62
	BE Centralized information LB	17.51	3.62
	% BE variation	30.10	-
	Economical impact [€/year]	172 738.43	-
Case level tagging	Decentralized information	49.78	5.03
	Centralized information	15.21	4.51
	% BE variation	44.73	5.31
	Economical impact [€/year]	256 686.05	25 387.51

Probable solution

A wide variety of corrective actions are recommended, most of which involve the installation of information systems such as point of sale databases, EDI systems, etc.

The bullwhip effect has been observed and various causes have been attributed to it in various academic disciplines. The first academic description of the whip phenomenon is generally attributed to Forrester (1961). Forrester states that it is empirically common that variation in manufacturer perceived demand far exceeds variation in consumer demand, and that seasonality is more important for manufacturers than for retailers. In addition, he notes that the effect is amplified at every step of the supply chain. He argues that the main cause is the difficulties in the feedback loop between companies and that these systems are too complex to be improved by managerial intuition alone. His remedy is to understand the system as a whole and model that system with specific simulation models of "system dynamics" so that managers can determine the appropriate action.

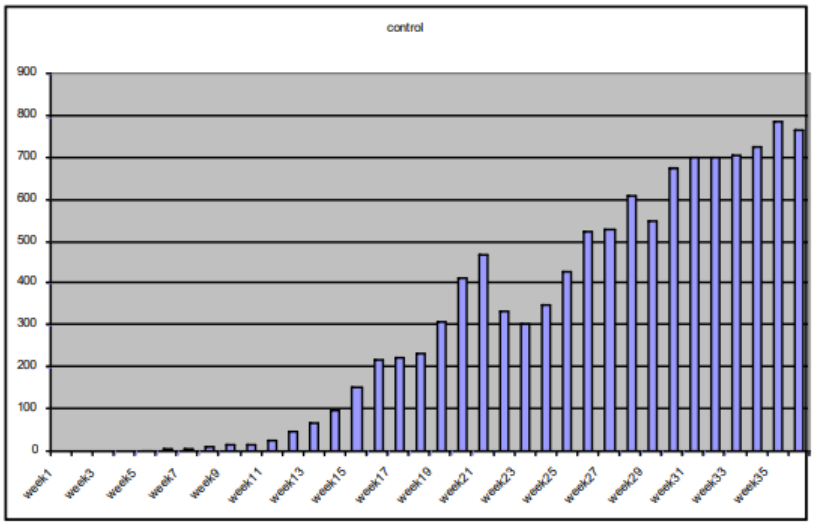
Role of RFID in bullwhip effect

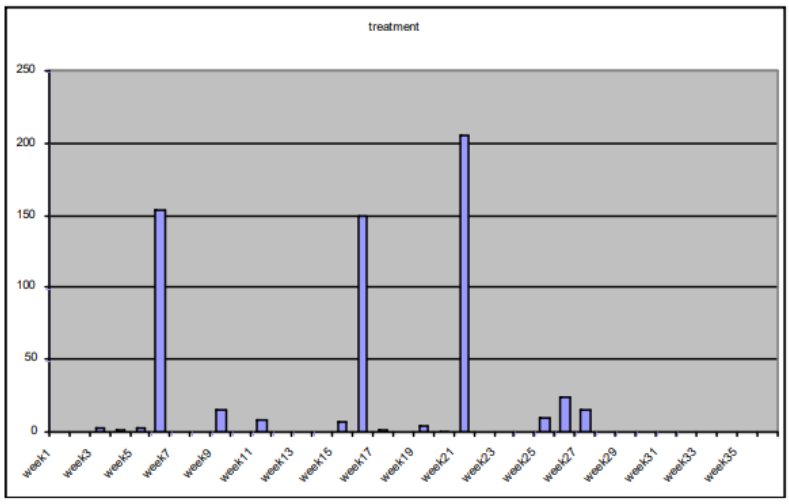
RFID technology is critical in the exchange of processes throughout the supply chain. This is due to the fact that RFID can provide visibility throughout the supply chain. Businesses can reduce risk and be more profitable than ever before with this real-time, RFID-enabled data. The main advantage of RFID technology is the real-time information exchange between organizations up and down the supply chain. According to Véronneau and Roy (2009), one of the primary benefits of RFID is increased visibility in the supply chain. RFID can also be used to counteract the bullwhip effect, which is caused by a lack of visibility and the exchange of information in real time. On the one hand, this is a benefit because the best decisions can be made using the most up-to-date information. On the other hand, the volume of data at the time posed storage issues. However, data storage is becoming increasingly large. Another significant advantage is that RFID lowers business costs. Because labor, transportation, and installation costs for moving inventory are reduced, operations become more productive. Another advantage they mention is the use of RFID for inventory management.

Finally, they conclude that RFID can mitigate the bullwhip effect because it supports the need for timely information: "RFID technologies offer the possibility of reducing the uncertainty that leads to the bullwhip effect through more'real-time information"' (Jones & Chung, 2008,

p. 125). Following their research, Vance et al. (2010) concluded that "RFID technology has significant potential to increase supply chain agility and mitigate the tyranny effect through additional and enhanced information that RFID only provides" (p. 33). In addition to the visibility issue, Véronneau and Roy (2009) claim that RFID reduces the direct work of routine tasks such as inventory control. RFID improves accuracy in addition to this. RFID technology has many advantages over barcodes, according to Fescioglu-Unver, Choi, Sheen, and Kumara (2014), as cited in Pasqualeto, Costa, and Da Silva.

RFID tags, for example, have a longer lifespan and can be reused. RFID tags are also more durable, even in harsh environments, and can store more data. The most significant advantage over barcodes is that they can be scanned without line of sight and can scan multiple labels at the same time.





Ref: [1](Testing the potential of RFID, Anthony Vance, et. Al, 2009)

The above before-after graph shows the surplus inventory levels of the warehouse which was observed during different months. The previous chart shows that there was higher level of surplus goods in the warehouse which translates to higher inventory storage cost. However, after the implementation of RFID in the warehouse, there is a visibly significant drop in the surplus amounts, thus reducing the cost of the inventory storage.

[1]https://bit.ly/3exi6a4 Anthony Vance, et. Al, 2009

Department wise analysis of RFID impact

Warehouse management

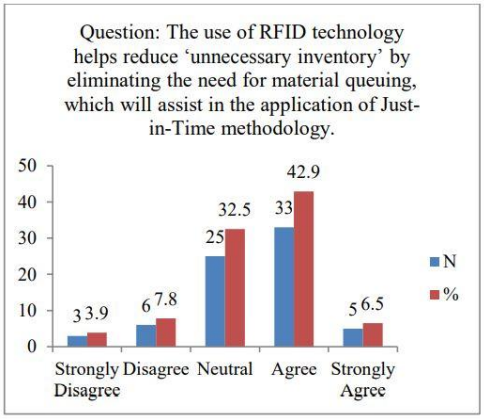
The Key Performance Indicators to measure the performance level improvements achieved with the inclusion of the RFID systems in the warehouse and inventory management system is as follows:

- Costs
- Inventory levels
- Delivery time
- Goods returns
- Stock out conditions
- Service level
- Resource optimization

There are several items and products in IoT which help in improving the KPIs. Some are as follows:

- Smart racks
- Smart glasses
- Monitoring cameras
- Smart forklifts
- Smart warehouse management system

On seeing this, a person might want to explore the processes which are adopted by them to improve the functioning. They enable route optimization, and also eliminate the in-process collisions which might cause derailment in an otherwise smoothly running operation. They provide with a fast, cost-efficient, and flexible operation method.



The level of handling of items that are normally difficult to reach has been improved and improved. These items are also referred to as dark assets, that is, items that are hard to spot on the shelves or shelves. There is also the added benefit of real-time visibility into inventory levels. This helps prevent out-of-stock situations that are costly for the organization. In deficiency situations, for example, when an item has been lost, due to its better visibility, there is a much faster and more agile response possible. It also enables the monitoring of the workspace, which can also meet the security needs and avoid such problems as stock reduction. Storage units such as pallets can be recognized and located, allowing better traceability. They also enable simultaneous, multitasking detection and analysis of threats for a variety of purposes.

Departments	Observations
Labour costs	• Warehouse labour reduction of 14 percent (Burnell, 2005) • Elimination of 2-yard administration positions (RFID Journal, 2002) • Customs processing labour cost for containers reduced by 25 percent (O'Connor, 2007f) • Reduced labour by up to 60 hours to count inventory (O'Connor, 2008c)

Inventory control	• Retail store stock-outs reduced by 11 percent; 21 percent; 25 percent; 26 percent; or 50 percent (Burnell, 2005; Hardgrave et al., 2008b; O'Connor, 2007b; O'Connor, 2007c; Webster and Wal-Mart's, 2008) Warehouse inventory count accuracy increases from 96 percent to 99 percent (RFID Journal, 2002a) • Retail store reduction in understated perpetual inventory of 13 percent (Hardgrave et al., 2008a) • Reduction in phantom inventory of 50 percent (Chain Store Age, 2007a) Time reduction of 80 percent to count inventory (Roberti, 2007) • Inventory count accuracy of 98.4 percent; or 99.6 percent (Collins, 2006a; O'Connor, 2007b) • Retail store customer service level improved from an average of 85 percent to 99 percent (Gaudin, 2008) • Retail store inventory accuracy of. 99 percent (O'Connor, 2008c)
Inventory cost	• Lost goods reduction of 18 percent (Burnell, 2005) • Shrinkage reduced by 15 percent (Wilding and Delgado, 2004b) • Reduced perishable product loss by 10 percent (Swedberg, 2007f) • Safety stock reduction of 30 percent (Wessel, 2008a) • Warehouse inventory reduced by 50 percent; or 17 percent (O'Connor, 2008b; Roberti, 2008)
Throughput	• Reusable container lead time reduced 15 percent (Tierney, 2004) • Daily yard throughput increased 38 percent during peak season (Blanchard, 2004) • Production lead time reduced 27 percent (O'Connor, 2006c) • Production capacity increased 6.5 percent, (Collins, 2004b) • Supply chain inbound and outbound through-put time reduced by 50 percent (Deffree, 2005) • Number of goods processed at warehouse doubled and sometimes tripled (O'Connor, 2007g g) • Accuracy of pallets shipped to customers increased from 92 percent to 97 percent (Chow et al., 2006) • Container locating reduced from 4 to 12 hours to immediately (Schor, 2006)
Throughput	• Product locating accuracy of 99.9 percent (Swedberg, 2007b)
Decision quality	• Reduction in manual inventory orders of 10 percent or 42 percent (Sullivan, 2005b; O'Connor, 2007a) • Reusable container cycle time reduced from 47 days 40 days – enables postponement (RFID Journal, 2002b)

Data Table Source: www.emeraldinsight.com/0144-3577.htm

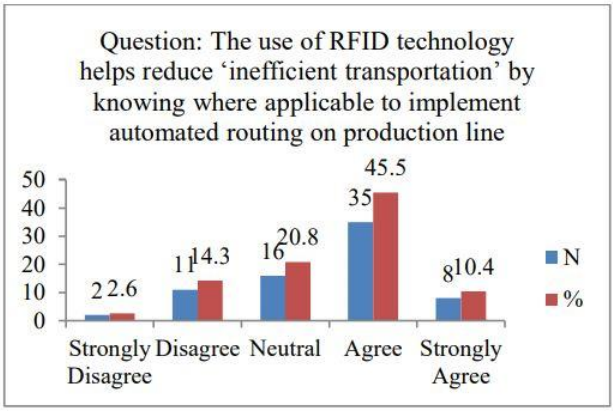
Operations

The Key Performance Indicators to measure the performance level improvements achieved with the inclusion of the RFID systems in the operations department is as follows:

- Route optimization
- Quality
- Operating costs
- Delivery time

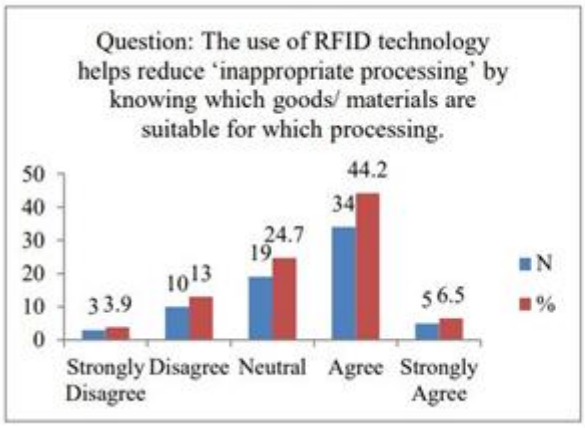
There are several items and products in IoT which help in improving the KPIs. Some are as follows:

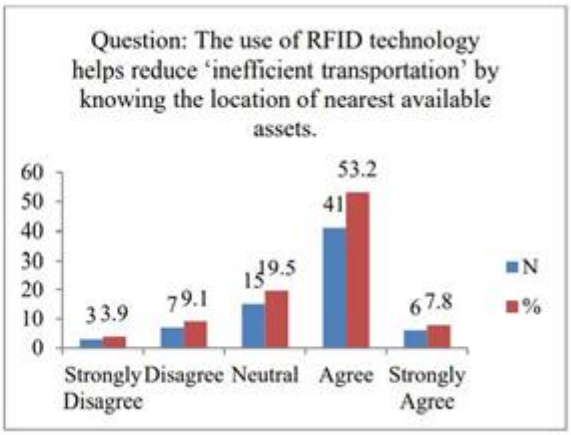
- GPRS sensors
- RFID sensors
- Routers
- GPS satellites

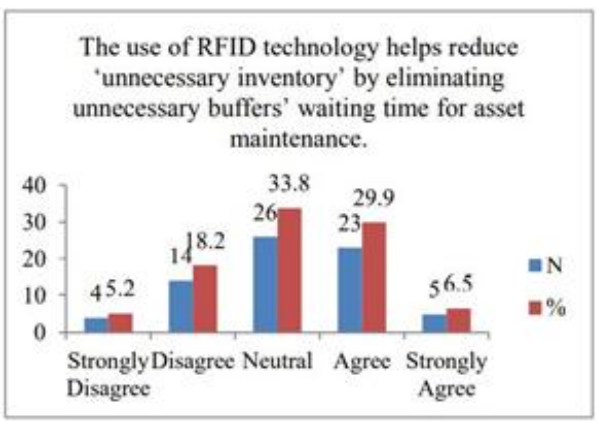


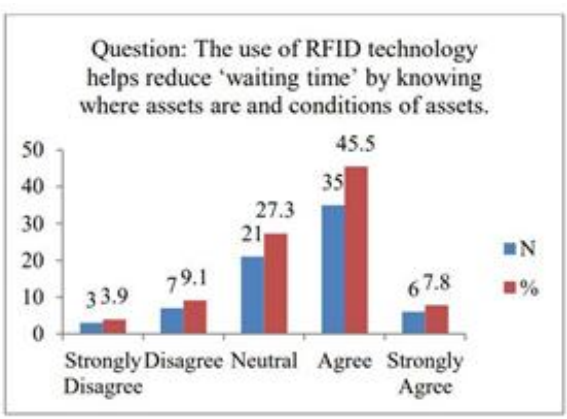
There is continuous visibility of products throughout the supply chain. Real-time shipment tracking is available to us with features such as condition monitoring (temperature, humidity, and vibration, etc.). This helps to protect and preserve the quality of the product. It also improves the activity of bottlenecks and external traffic, transport mobility, road safety and drivers. Energy efficiency can be maximized, and routing strategies are optimized. Service delivery is also improved.

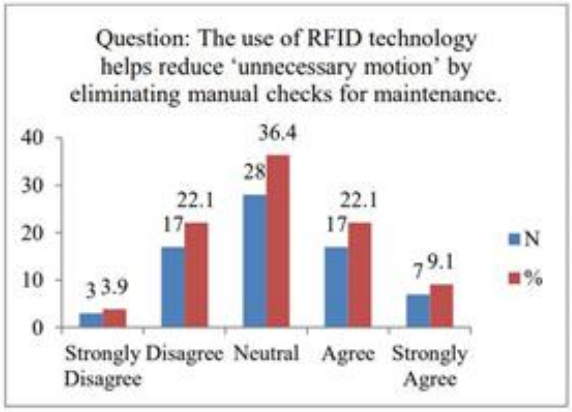
Maintenance management is comprised of two major functions: maintenance and asset management (Adgar, Addison & Yau, 2007). Asset maintenance management is another area where RFID technology can be used. Poorly managed equipment maintenance can result in lost production time, missed deliveries, and increased machine and worker downtime. Because it allows operators to identify tools, machines, and spare ce or

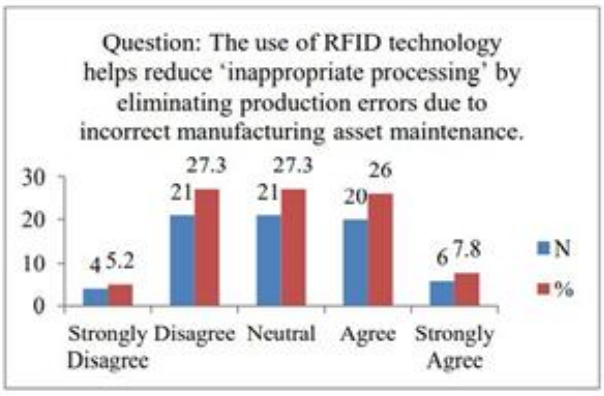




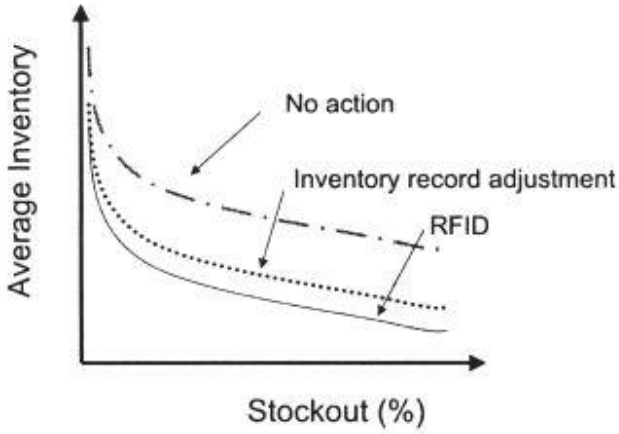








The goal of asset tracking is to ensure that products arrive at the correct location, at the appropriate time, and under the appropriate conditions. For asset tracking, two main technologies are used: barcodes and RFID. Businesses that use RFID as an asset tracking tool benefit from increased visibility, accuracy, faster tracking, and efficiency. It is also critical to understand the significance of asset maintenance. RFID technology has the potential to significantly improve mobile asset management in a variety of ways. According to research, nearly 87 percent of respondents consider asset maintenance to be extremely or very important to their organization's success Jusko (2007).



RFID technology can be used to reduce manufacturing waste through manufacturing control, asset tracking, and asset maintenance. For example, among the six items tested under the category of maintenance and monitoring of manufacturing assets, RFID technology implementation has the potential to reduce waste by (a) knowing the location of the closest available assets and (b) knowing the location of the assets and their condition Furthermore, RFID technology can be applied to manufacturing control to (a) enable automated just-in-time strategies, (b) implement automated routing on the production line where applicable, (c) know which products / materials are appropriate for which processing, and (d) eliminate the need for material glue, which will aid in the application of the just-in-time methodology. As a result, the relationship between lean manufacturing waste reduction and the use of RFID technologies in manufacturing control is more significant than the relationship between manufacturing asset monitoring and maintenance.

Departments	Observations
Efficiency	• Retail shelf inventory replenishment three times faster (Sullivan, 2005b) • Warehouse handling time reduced by 50 percent (Deffree, 2005) Time for double transaction at yard (drop-off and pick-up) reduced by 66 percent (Blanchard, 2004) • Yard gate efficiency improved 75 percent (O'Connor, 2007e) • Yard gate personnel productivity improved 50 percent (Blanchard, 2004)

Shipping efficiency	• Time to process an order for shipment reduced from 45 minutes to six minutes; or reduced to 20 seconds compared with 80 seconds to 20 minutes for a bar code system; or reduced by 80 percent (Shister, 2005; O'Connor, 2007d; Katz, 2006; Bacheldor, 2006) Pallet build speed reduced from 90 to 11 seconds (Shister, 2005) Average time to load a truck reduced from 50 to 20 minutes; truck loading 40 percent faster than handheld barcode system (Swedberg, 2007d; RFID Journal, 2003) • Read time for reusable assets (dolly and 25 trays) reduced by 83 percent (Wilding and Delgado, 2004b) • Time to check quantity and mix of goods at distribution center reduced 68 percent (Wessel, 2008a)
Receiving efficiency	• Pallet breakdown decreased from 17.75 minutes to 2.7 minutes at retail store (O'Connor, 2006b) • Arrival inspection time reduced 10 percent to 50 percent (Holmqvist and Stefansson, 2006) • Check in and truck unload time reduced 15 to 20 minutes (Burnell, 2005) Order verification time reduced from 20. seconds to five seconds (Katz, 2006) • Productivity increase for goods receipt of 57 percent (Bacheldor, 2006) Time needed to compare deliveries with orders reduced 80 percent (Wessel, 2007) • Time to process a delivered pallet at DC reduced from 5.36 to 2.65 minutes a 51 percent reduction (O'Connor, 2006b) • Time to check quantity and mix of goods at grocery store reduced 80 percent (Wessel, 2008a) • Time required to receive apparel at a distribution center reduced by 70 percent (Wessel, 2008b)
Utilization	• Reusable container loss reduced from 4 percent to 2 percent (Wilding and Delgado, 2004a) • Reusable container purchasing cost reduced by 4 million pounds per year (Wilding and Delgado, 2004a)
Responsiveness	• Rush order processing time reduced from six hours to three and sometimes two hours (O'Connor, 2007g) • Supply chain response time reduced from seven to five days (Swedberg, 2007e)
Effective sales	• Sales increase of 12 percent in retail apparel store–only denim apparel items tagged (Wilding and Delgado, 2004b) • Sales increase of 15 percent in retail apparel store–individual garments tagged (O'Connor, 2008c) • Unit sales increases of 14 percent; 14.1 percent; and 41.1 percent (O'Connor, 2006a; Chain Store Age, 2007b; Hudson, 2007) • Sales dollar increases of 14 percent; 18.7 percent; and 30

	percent (Hudson, 2007; Chain Store Age, 2007b; Swedberg, 2007c)
Effective retail promotion	• Promotion product availability of 92 percent by day three of the promotion launch (Collins, 2006b) • Sales increase for stores that moved the display to the location before the promotion began: 48 percent; 61 percent; or 140 percent (Roberti, 2005; Roberti, 2006; Chain Store Age, 2007a)
Invoice reconciliation	• Discrepancies reduced from 80 percent to 0 percent (Collins, 2005) Container shipment records accuracy increase from 70 percent to 100 percent (O'Connor, 2007f)

Data Table Source: www.emeraldinsight.com/0144-3577.htm

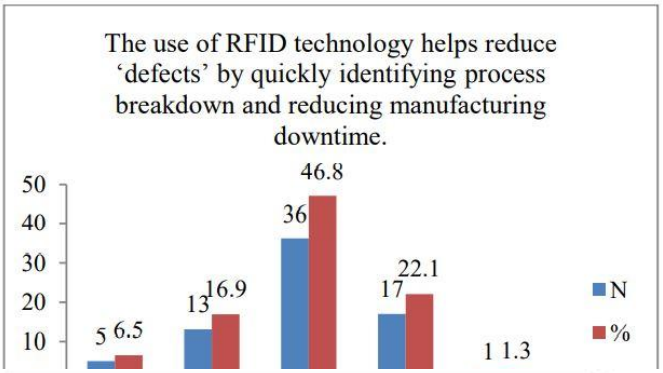
Manufacturing

Key performance indicators to measure the impact of RFID in manufacturing are as follows:

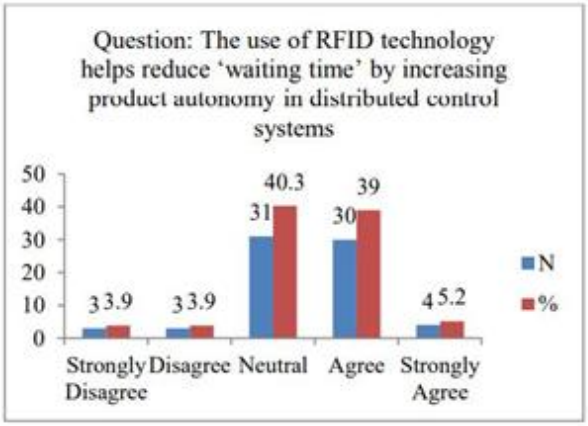
- Cost
- Lead time
- Quality
- Productivity
- Service level

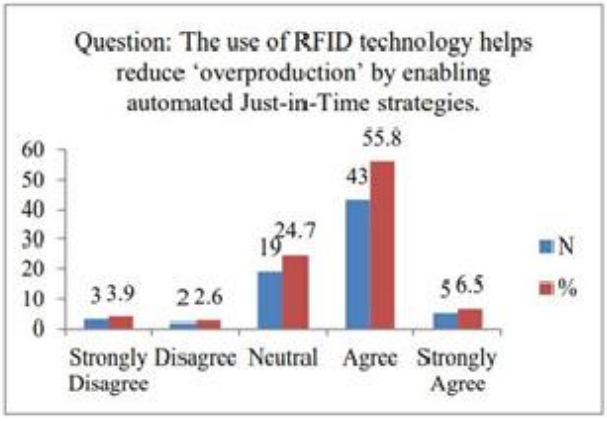
There are several items and products in IoT which help in improving the KPIs. Some are as follows:

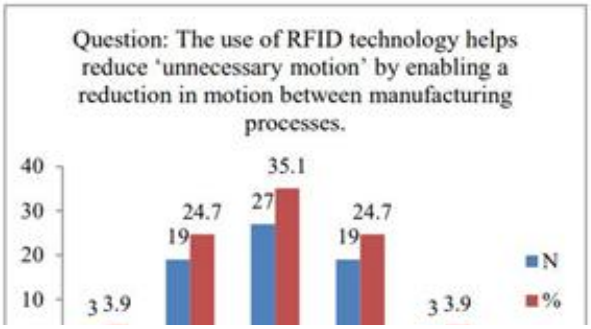
- Embedded machine sensors
- Machine analytics

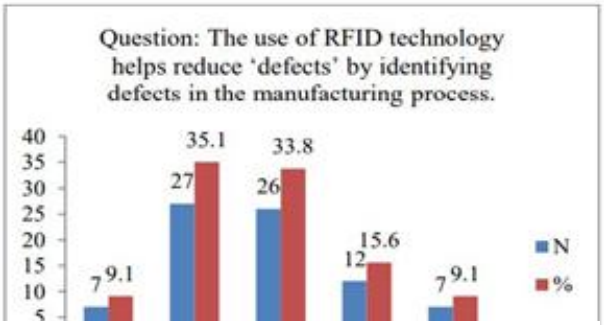


The Internet of Things can help with real-time health monitoring, which is useful in detecting asset degradation, which is one of the main causes of business disruption. It also allows remote maintenance. Other than that, there is a huge benefit to the predictive maintenance services it provides. Detecting physical stress levels, preventing build-up and failure, improving measurement of performance, setup time and overall productivity can be tracked, and necessary actions can be taken as needed. There is also an improvement in machine-to-machine and machine-to-person interactions.









	Issues	Waste percentage	Waste zone type	% of RFID impact in waste reduction	Total waste reduction via RFID
Manufacturing problems	Technical production problems	7%	Design	20%	1%
	Political production problems	3%	Design	0%	0%
	Intra-organizational supply chain problems	5%	Information flow and Brink	80%	4%
Supply problems	Forecasting problems	36%	Information flow and Brink	50%	18%
	Financial problems	25%	Brink	0%	0%
	Main supplier production problems	15%	Information flow and Physical flow	60%	9%
	Tier2,3 supplier production problems	9%	Information flow and Physical flow	60%	5%

Example of RFID application in manufacturing industry

A microcomputer assembly company used RFID technology for inventory control and product traceability; the main benefits obtained by this company were a reduction in component replacement costs and a reduction in delivery times. General Motors (GM) has attached RFID tags directly to cylinder heads and engine blocks to track every manufacturing process that passes through the engine block or cylinder head, allowing any manufacturing errors to be identified immediately. Kabel Premium Pulp & Paper has incorporated an RFID-based identification solution into its manufacturing process, allowing Kabel factory employees to continuously monitor and track the production step being processed for a given batch of paper. RFID is being used in clean rooms by some semiconductor manufacturing companies to gain control, improve operator quality and efficiency, and increase equipment utilization. RFID technology has enabled manufacturing plants to run smoothly while increasing output and lowering costs.

Departments	Observations
Labour cost	• Production employees reduced from 20 to 12 with no change in production volume (O'Connor, 2008a) • Production labour cost reduced 17 percent (Violono, 2005)
Waste	• Packaging errors eliminated (Bacheldor, 2007)
	• Production cycle time reduced from 88 to 46 minutes (Collins, 2004b) Parts replenishment process redesign freed up 50 percent more floor space to the manufacturing

Process redesign	line which along with efficiency improvements from RFID to boost production from 175,000 units annually to 275,000 (57 percent capacity increase) without expanding the facility and with a reduced workforce (O'Connor, 2007e) • Military supply chain average delivery time reduced from 28 to 16 days, supply backlog reduced from 92,000 shipments to 11,000, inventory Table V. reduced from US$127 million to $70 (Collins, 2006c)
Resource usage	• Yard parking spaces required reduced up to 40-60 at any given time (Blanchard, 2004) • Reduced required tractors from 120 to 67 in one year (RFID Journal, 2002b)
Production control	• Production planning accuracy improved 29% (O'Connor, 2006c)

Data Table Source: www.emeraldinsight.com/0144-3577.htm

Study of RFID implementation in Renault

We believe that the use of RFID technology in the manufacturing sector will increase manufacturing efficiency, which will lead to improved organizational and supply chain performance. The ability of an organization to produce goods and services at relatively low total costs to immediate customers, based on the organization's capabilities to eliminate waste and make full use of resources, is referred to as efficiency. The concept of organizational efficiency can be extrapolated to the supply chain level, as supply chain partners engage in integrated and coordinated activities to increase capacity to eliminate waste and fully utilize resources. resources in business processes as processes extend along the supply chain Reduced costs and, ultimately, prices for end customers in the supply chain can provide a competitive advantage. As a result, we contend that manufacturing companies, as well as their supply chain partners, are turning to technologies such as RFID to improve efficiency-related capabilities. As a result, efficiency is achieved through activities centered on the timely production of goods or services at a lower cost.

Outcomes of Effectiveness: While both efficiency and effectiveness are important, Hunt and Duhan (2002) see the pursuit of effectiveness as an effort to provide more value to the customer. Access to necessary resources is a concern for efficient supply chains. Organizations should prioritize activities that promote efficiency. Supply chains that seek capabilities, results, and benefits are defined by efficiency. Efficiency is achieved through activities that are likely to improve performance. Simply put, efficiency is defined as an organization's ability to meet the needs of its customers.

According to the study's findings, manufacturers who use RFID technology can expect improvements in both manufacturing efficiency and manufacturing efficiency. Improving efficiency directly leads to improved organizational performance. However, increasing efficiency has no direct impact on the organization's performance. The supply chain's performance has an indirect impact. According to the findings of this study, investing in a specific infrastructure, such as RFID, leads to greater efficiency in terms of customer satisfaction. Manufacturing executives are constantly researching strategies, programs, and practices that improve organizational performance. JIT and TQM have been used successfully to improve performance through market orientation programs. Because these programs have been adopted by the majority of manufacturing organizations, they no longer provide competitive advantages. Programs that maintain performance levels but do not lead to performance improvements should be supported. Manufacturing firms have also implemented supply chain management strategies to improve end-customer satisfaction in their supply chains. Manufacturing executives have begun to use RFID technology to improve JIT and TQM capabilities throughout the supply chain. RFID technology holds great promise for improving organizational and supply chain performance. Managers can expect improved process efficiency and effectiveness, as well as the ability to scale up the business, when they plan to adopt or expand the use of RFID technology. Throughout the supply chain, efficiency and effectiveness are maximized.

Data discrepancy with RFID and IoT

Companies have been able to automate their inventory management processes and use inventory management software since the early 1980s, thanks to the availability of cheaper and faster IT. Automated replenishment systems track the amount of product in stock, frequently using POS data, and place replenishment orders based on control policies defined by the underlying software. Depending on the inventory environment, the software system frequently records and controls inventory keeping units at the individual item, case, or pallet level. In any case, inventory ledger and actual stock inventory are the same metrics, which is a critical assumption made by these inventory management systems.

If the information provided to an automatic replenishment system is incorrect, and the control mechanisms do not take the inventory discrepancy into account, the system does not place the order when it should, or it has more inventory than necessary. This results in either lost sales and revenue or a high inventory level and unnecessary operating costs. Rinehart (1960) examines a case study of a federal government procurement facility and discusses how the inventory gap affects supply chain performance. He reports that approximately 2,000 SKUs had accumulated discrepancies among the 6,000 SKUs chosen at random. Iglehart and Morey (1972) report a discrepancy in inventory from a 1965 survey at the Naval Supply Depot in Newport, Rhode Island. A sample of 714 SKUs from the 20,000 SKUs carried in the warehouse reveals that 25% of the SKUs had accumulating discrepancies. Cumulative errors accounted for approximately 4% of monthly billing. According to more recent research (Raman, DeHouraious, and Ton, 2001), of the 370,000 SKUs surveyed in retail clothing stores, more than 65 percent of inventory records did not match physical inventory at the store level. Keep track of the SKU.

When these case studies are compared, two important observations emerge. For starters, retail environments (which have higher inventory turnover and more customer contact) accumulate significantly more spreads than fulfillment centers (which have lower inventory turns and less contact with customers). customers). Second, recent advances in information technology have clearly not solved or eliminated the problem of inventory discrepancies. With real-time tracking technology, the manager should have complete visibility into inventory movement within the company at all times. Consider RFID technology. The movement of labels on cartons or products can be tracked by installing readers in strategic locations. Labeling can be done on an individual item, a box, or a pallet. RFID, in theory, enables you to track and trace both in-stock and in-process items, resulting in complete inventory visibility and accurate reporting of inventory discrepancies. Naturally, we believe that any new technology will improve over time. This section focuses on the importance of visibility in inventory management within a business. It is important to note that in the following, we use the terms "item" or "product" to refer to a unit of inventory. This terminology does not imply that RFID applications at the box or pallet level are excluded. The term "item" is a simple nomenclature used in inventory control literature to refer to the inventory unit. A unit of inventory (an "item") could be a shirt, shirt boxes, or a pallet of shirt boxes, for example.

There is a strong parallel between previous efforts to study the value of emerging information technologies and current RFID efforts. Many studies on the value of electronic data interchange were conducted in the early 1990s (EDI). When EDI was introduced as a means of connecting business partners with accurate and timely information, expectations and hopes were high. Surprisingly, the findings on values were mixed. Some were positive, but the majority were negative. FDI did not result in significant cost savings or other benefits for the majority of firms. There was a large body of literature on empirical studies of EDI values, and we won't be able to cover it all here. Finally, studies that found positive returns revealed that businesses needed to rethink their business processes in order for new information systems like EDI to benefit business partners. Others have discovered that supplier partners must learn to use new technology so that positive results are only seen in long-term studies. Observations from the EDI literature support our findings. The ability to obtain more information more quickly and accurately does not generate business value on its own. It should be used with caution. The majority of the EDI literature has been empirical studies on the impact of EDI, whereas our interest is in how analytical models can be developed to use the information. Of course, we must keep in mind that RFID allows for a much broader range of data accessibility than EDI.

Another issue that exists is stock depletion. Transaction errors are easier to deal with than shrinks caused by theft, deterioration, or damage. Although transaction errors can occur regardless of inventory availability (for example, an incorrect scan of another product), the reduction is proportional to inventory availability. Through a simulation study, Kang and Gershwin (2005) investigate errors caused solely by reduction and their impact on inventory management. They show how the cut increases lost sales and has an indirect cost of lost customers (due to unexpected out of stock) in addition to the direct cost of lost stock.

Barriers inadopting RFID

A number of challenges are currently impeding the spread of RFID in the Indian industry as an SCM solution and a method to reduce product shrinkage. Cost, a lack of knowledge, and the immaturity of RFID technology have been identified as barriers to adoption. The price RFID is currently too expensive for retailers to implement, according to this study. Despite significant advancements in RFID technology over the last decade, the cost of various RFID components remains a significant barrier to widespread adoption. The retailer, RFID vendors, and associations all agreed that the most significant barrier to integrating RFID into a retail environment was cost. Furthermore, RFID has been ruled out as a possible SCM solution in the majority of cases based solely on this factor. RFID readers and tags have proven to be an

expensive component of an RFID implementation. RFID tags in a supply chain solution, on the other hand, must be replenished on a regular basis. RFID readers, on the other hand, have an initial cost but require little maintenance in most cases. A large-scale operation, such as integrating RFID into a retail supply chain, necessitates a large number of RFID tags as well as the cooperation of all value chain participants. As a result, labels are the more expensive of the two. The cost of an RFID tag is proportional to the law of economies of scale. Economies of scale refer to the reduction in unit cost as production scales up. In other words, economies of scale are realized when RFID tags can be produced on a larger scale at a lower entry cost. Because of the lower costs of these materials, the latest silicon technology and other RFID advancements will have an impact on production volumes. RFID adoption will increase as the price of RFID tags falls and becomes more affordable. Potential customers must also alter their approach to evaluating the RFID business case in their organization.

Traditional models concentrate on the cost-benefit analysis of barcodes and RFID, which has a limited scope due to the high probability of convergence. A middleware application will almost certainly be required to integrate an RFID solution for a retail supply chain. Middleware has also been shown to be a costly component of an RFID system. A middleware application will almost certainly be required to integrate an RFID solution for a retail supply chain. Middleware has also been shown to be a costly component of an RFID system. Many vendors provided hardware solutions and relied on a third party to integrate middleware and communication between RFID tags and warehouse management systems. As a result, it has been confirmed that the overhead costs associated with RFID implementation are an impediment to its adoption in Indian supply chain management. which improves general technological knowledge in Indian industry Inadequate Knowledge Another impediment is a fundamental lack of understanding of approaches to integrating technology into existing IT infrastructure. While RFID implementations share some characteristics, they are unique to each business based on their size, industry, and relationships with other businesses. A manufacturing company (supplier), for example, that will place RFID tags on its products will have different implementation requirements than the retail company that will receive the labelled products. Initially, consumer goods manufacturers will be more concerned with how to effectively modify their warehouses and production lines, as well as how to label products and/or pallets with RFID tags, while retail companies will be in the dark. Initially, the processing of data received from labeled products was of greater concern.

Manufacturing companies must choose the best approach to meet their needs. These organizations will remain resilient and fail to overcome the barriers to implementing RFID technology in their businesses unless they have a clear understanding of the various approaches to RFID compliance. Another popular concept is "thinking," which represents a lack of knowledge of RFID technology in India as well as potential customers' skepticism about their RFID vision. The overall perception of RFID Gen -2 among the retailers polled was found to be low. Loss prevention personnel have a good understanding but fail to recognize RFID's true potential as a retail SCM solution and an effective loss prevention mechanism. Because of this lack of awareness, information sources are forced to seek solutions from retailers. RFID research participants are a non-profit organization founded solely to raise RFID awareness through communication and the formation of a knowledge base. The RFID consultant made an interesting point when he stated that RFID "brings different knowledge into the same room."

This implies that integrating RFID throughout the supply chain may necessitate more than just RFID retailers and suppliers. Other stakeholders, such as standards organizations, government agencies, product manufacturers, logistics companies, wireless providers, and other innovative technology providers, must communicate. Forming a corporation is one way to accomplish this. Technological immaturity RFID, like barcodes, needs to be developed further in India in order to become a well-established and widely accepted technology. Furthermore, Indian retailers have some very good systems that have matured over time, and it will be difficult to see how RFID can improve these systems. The supplier is referring to the old barcode systems in this case. Retailers have spent a lot of money to get their products from distribution centers to their stores, and they are doing well right now. Furthermore, the number of RFID device vendors is limited. RFID may become a reality in this context, but it is still considered primitive in the Indian context. When users' perceptions of the technology are taken into account, the barriers to entry become even higher.

ROI Overview

Return on investment analyses are used to determine whether an investment pays off over time. Analytical models, simulations, case studies, and experiments have frequently been used to investigate them. As previously stated, RFID technologies can provide several benefits in supply chains, including lowering costs such as labor costs and inventory costs, automating processes or improving efficiency, and creating value such as increasing revenue or customer satisfaction. However, the cost of RFID remains higher than that of current identification technologies, so businesses must decide whether to invest in RFID technologies. As a result, ROI analyses can help support decisions about the feasibility of RFID implementations. There is still a scarcity of literature on this subject. According to Goel, in order to understand the ROI of implementing RFID, an organization must first analyze the RFID business case. He also concludes that they must first understand RFID technology, then the potential applications of RFID in their environment, and finally decide how to invest. ROI analyses compare the costs and benefits of RFID deployments. A positive return on investment is determined by the cost of the technology, the price of tags, readers, and middleware, the cost of implementation, the cost of maintenance services, and so on. The degree of RFID tagging is a significant cost factor. Box / pallet level labeling is less expensive than item level labeling, so it can provide more benefits. According to Gaukler and Seifert, there is no positive return on investment from item-level labeling for manufacturers, but there is a positive return on investment for 24 retailers. The cost of the labels is also lower in a closed cycle because they can be used multiple times, whereas in an open cycle they are only used once.

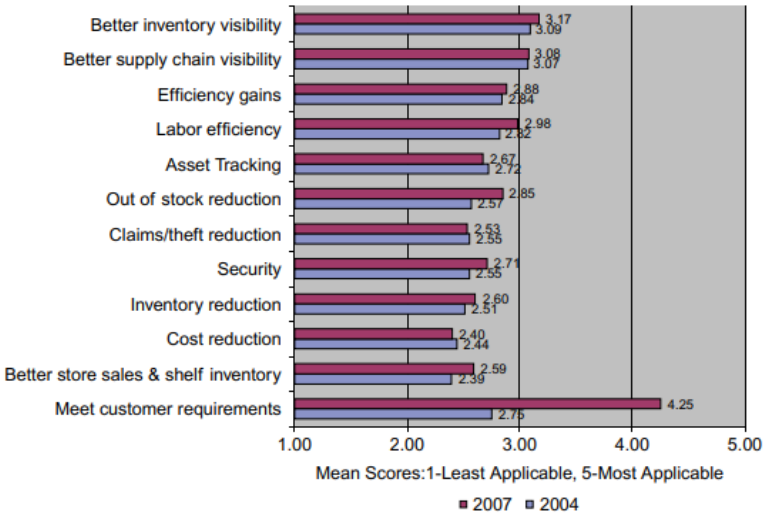
Closed-loop RFID implementations in manufacturing and asset management have yielded positive returns on investment in recent years. A positive return on investment is also dependent on the advantages that RFID can offer. Traditional ROI analyses concentrate on direct benefits, whereas more recent RFID analyses concentrate on indirect benefits as well. RFID technologies provide direct benefits such as increased sales and/or decreased lost product, which can be observed and quantified. Indirect benefits consider non-financial benefits such as increased customer satisfaction and shorter customer response times, among other things. These enhancements cannot be quantified through direct economic calculation, but they can increase direct benefits in the future. According to Angeles, selecting the right technology is critical for a positive return on investment. He writes that when selecting RFID technology, three factors should be considered: the needs of the business, the needs of its partners, and the needs of industry. Another critical factor is the use of RFID technologies throughout entire supply chains. When all players in a chain share the cost of RFID, it makes implementation easier for everyone. Gaukler et al. show in a recent paper that splitting the cost of RFID between a manufacturer and a retailer can maximize total supply chain profit. In 2005, for example, Wal-Mart requested that its top 100 suppliers use RFID at the pallet and case level. Wal-Mart split the cost of RFID implementation with its suppliers. ROI analyses are limited in scope. IBM and Accenture have collaborated to create a return-on-investment calculator.

This calculator is concerned with a supply chain that includes a manufacturer, distributor, retailer, and so on. The main topics of interest to us are the level of labeling (article, box, and pallet), the reduction in labor costs, the reduction of stock levels, and more detailed information on the company's processes. Companies can make use of this calculator by modifying the nature and number of variables. IBM Business Consulting Services conducted a "EPC Forum Survey" with over 60 corporate Auto-ID Center sponsors and non-sponsors. The goal of this study is to provide an early indication of company orientations and priorities (Gramling et al.). The primary sponsors of this work are Procter & Gamble, Wal-Mart, Target, and Johnson & Johnson. Finance, supply chain, marketing, and technology are among the roles represented by participants. Furthermore, the firms are from Europe, South America, and the United States. The majority of those taking part are manufacturers. According to the findings of this survey, the majority of end users anticipate favorable ROI results from case and pallet implementation. They also state that more than 70% of retailers intend to implement fully automatic identification by the end of 2004, while approximately 50% of manufacturers intend to launch by the end of 2004.

Conclusion

RFID, as a new technology, has the potential to solve a wide range of supply chain management issues. However, its high cost limits its widespread application, and supply chains lack a model to use when deciding whether or not to implement RFID technology. This document considers a two-tiered offer with a supplier and a retailer that suffers from misplaced inventory and lead time, and it is assumed that market demand forecast error varies with lead time reduction. The delivery. Given that RFID technology can eliminate wasted inventory and shorten supply chain lead times, we present a service level perspective and use a news provider model to investigate the level of service difference and gains from centralized / decentralized supply chains. In both centralized and decentralized supply chains, the level of service increases not only as the number of lost products decreases, but also as delivery times decrease. Second, our study is unique in that we validate the use of RFID technology, which affects the level of service in the supply chain. We discovered that, in the centralized supply chain, RFID adoption improves the level of service based on the cost of the RFID tag, but improves the level of service regardless of cost in the decentralized case. Third, the label cost thresholds are the same in both the centralized and decentralized cases, but with different service levels. Furthermore, we show that the linear transfer payment coefficient strategy can coordinate the decentralized supply chain with the adoption of RFID technology, as supply chain and retailer profits increase but retailer and supplier profits decline.

Review from CEOs, Directors, on why they installed RFID



This survey looked into the potential advantages of RFID technologies in supply chains. We prioritize cost reduction and value creation, especially when it comes to inventory inaccuracies and love at first sight. Following that, we examined analytical models, simulations, case studies, and experiments designed to assess the impact of RFID technologies on supply chain management. Finally, a return on investment analysis was presented. According to the results of this survey, RFID technologies can provide several benefits in supply chain management by improving the traceability and visibility of products and processes along the supply

chain. Increasing process efficiency and speed, improving information accuracy, and reducing inventory waste are just a few of the advantages. Pioneering companies such as Wal-Mart, Metro, Mark and Spencer, Tesco, Gillette, and Procter & Gamble have made significant implementations. However, RFID applications are still limited because the costs of RFID are frequently much higher than the costs of current identification technologies. RFID technologies have proven to be appealing in a variety of contexts and for a wide range of businesses, but most prefer to begin with pilot projects and ROI analyses to assess costs and benefits. According to this review, the majority of the analysis and simulation models available in the literature are limited to a product, a retailer, a manufacturer, and so on.

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References

Alexandra Ioana Florea, Andrei, R., & Zamfir, A. (2016). *Economic Computation and Economic Cybernetics Studies and Research.* Issue 4.

Ali, O. M. (2012). *Improved supply chain performance through RFID technology: comparative case analysis of Metro Group and Wal-Mart.* University of Wollongong Thesis Collection.

Attaran, M. (2004). *RFID: an enabler of supply chain operations.*

Barbara A. Osyk, B. V. (n.d.). *RFID adoption and implementation in warehousing.*

Barjis, J. (2010). *Organizational and business impacts of RFID.*

Bottani, E. (2007). *Reengineering, Simulation and Data Analysis of an RFID system.*

Chen, J. C. (2013). *Warehouse management with lean and RFID application: a case study.*

Chuang, M.-L., & Shaw, W. H. (2008). *An empirical study of enterprise resource management systems implementation.*

Colby Ronald Chiles, M. T. (2005). *An Analysis of Current Supply Chain Best Practices in Retail Industry Case Studies.* Engineering Systems Division in Partial Fulfillment of Degree.

Eleonora BOTTANI, A. R. (n.d.). *THE IMPACT OF RFID AND EPC NETWORK ON BULLWHIP EFFECT IN THE ITALIAN FMCG SUPPLY CHAIN.*

Heller, F. K. (2017). *Technological Innovation Applied to Walmart and Tesco's Supply Chain.* Lisbon: School of Business and Economics, Management from the NOVA.

Holmqvist, M., & Stefansson, G. (2006). *Mobile RFID : Case from Volvo.* 39th Hawaii International Conference on System Sciences.

Huber, N. (2007). *Barriers to RFID Adoption in the Supply Chain.*

In Lee, K. L. (2015). *The Internet of Things: Applications, investments, and challenges for enterprises.* Clayton, MO, USA: Business Horizons.

John K. Visich, S. L. (2009). *Empirical evidence of RFID impacts on supply chain performance.* IJOPM.

Jung, H. (n.d.). *Trends in Supply Chain Design and Management.*

Kach, A. (2011). *Use of Rfid Technology to Overcome Inefficiencies in the supply chain: an analysis of renault's operations in Iran.* International Journal of Management.

Karakostas, B. (n.d.). *Towards Autonomous IoT Logistics Objects.* VLTN, Belgium.

Lee, H., & Ozer, O. (2007). *Unlocking the Value of RFID.*

Lochan, N. (n.d.). *The potential impact of RFID Technology on the Bullwhip effect within the automotive industry.*

Mehrjerdi, Y. Z. (n.d.). *Coupling RFID with supply chain to enhance productivity.* Yazd: DIE, Yazd University.

Metters, R. (1996). *Quantifying the bullwhip effect in supply chain.*

Monika Mital, P. C. (2017). *Adoption of Internet of Things in India: A test of competing models.*

Noha Mostafa, W. H. (2019). *Impacts of Internet of Things of Supply Chains: A Framework for Warehousing.* MDPI.

Osyk, B. V. (2006). *An empirical study of RFID implementation in the warehousing industry.*

Pamela J. Zelbst, K. W. (2010). *Impact of RFID technology utilization on operational performance.*

Pedro Ferreira, R. M. (n.d.). *IoT-aware business processes for logistics : limitations of current approaches.* Faculty of Science, University of Lisboa.

Richards, G. (2011). *A complete guide to improving efficiency and minimizing costs in the modern warehouse.*

Sarac, A. (2009). *A literature review onthe impact of RFID technologies on supply chain management.*

Senthamiz Selvi Arumugam, V. U. (n.d.). *IOT Enabeld Smart Logistics Using Smart Contracts.*

SHIRUR, S., & TORGAL, S. (2014). *RFID TECHNIQUE: BARRIERS TO OVERCOME IN THE INDIAN SUPPLY CHAIN MANAGEMENT.*

Tope Omitola, G. W. (2018). *Towards Mapping the Security Challenges of the Internet of Things Supply Chain.* Southampton: Procedia Computer Science.

Tu, M. (n.d.). *An exploratory study of Internet of Things adoption..* International Journal of Logistics Management.

Wei Xu, Z. L. (2013). *The Impact of RFID Investment on Complex Product in.*

Zelbst, P. J., & Green, K. W. (2011). *Impact of RFID on manufacturing effectiveness and efficiency.*

Zhang, L.-H., Fan, T.-J., Chiang, W.-C., & Tao, F. (2014). *Misplaced Inventory and Lead-Time in the supply chain: analysis of decision making on RFID investment with service level.*