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RFID technology and its impact on the supply chain

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Abstract

As a supply chain major, I am constantly learning about what makes an organization leaner and how to provide better customer service. I have also learned that technology is constantly evolving and businesses are taking advantage of these opportunities more than ever. Technology is providing companies with ways to become faster and more efficient in all areas of the supply chain, from the original equipment manufacturer down to the end consumer. The purpose of this research paper is to explore one technology that has made a great impact on the supply chain and is increasingly becoming more popular. RFID Technology is a smarter way to track shipments, time deliveries, and keep inventories; this in turn makes processes faster, more efficient, and with less error. It goes beyond other systems because it encompasses more information than prior technologies.

My research will explore; the methodology for obtaining information, a literature review on RFID technology and the supply chain, definitions of supply chain management and radio frequency technology plus their history, components of RFID, industries that currently use the technology, the integration into the supply chain, the implementation process, the difference between RFID and the barcode, the benefits and challenges, and concluding remarks. RFID Technology and the supply chain were chosen because together they are making a large impact on one another. It is important to explore what is happening in business today in order to complete a better understanding. In part of doing this senior thesis, my goal is to further my knowledge as well as, help others to understand the importance what is currently taking place. This impact is something that is often overlooked or unknown, but is a large part of what is happening in many companies today. The methodology behind this paper provides the foundation for the topics and end conclusions.

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RFID Technology and its Impact on the Supply Chain

By

Trina A. Nash

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Table of Contents

Introduction

As a supply chain major, I am constantly learning about what makes an organization leaner and how to provide better customer service. I have also learned that technology is constantly evolving and businesses are taking advantage of these opportunities more than ever. Technology is providing companies with ways to become faster and more efficient in all areas of the supply chain, from the original equipment manufacturer down to the end consumer. The purpose of this research paper is to explore one technology that has made a great impact on the supply chain and is increasingly becoming more popular. RFID Technology is a smarter way to track shipments, time deliveries, and keep inventories; this in turn makes processes faster, more efficient, and with less error. It goes beyond other systems because it encompasses more information than prior technologies.

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in many companies today. The methodology behind this paper provides the foundation

for the topics and end conclusions.

Methodology

       The research for this paper was conducted through related case studies, articles, and books. RFID technology is a new technology, making all of the research within in the last six years from publication. Case studies are based on secondary data sources and articles were obtained through the library databases from the Eastern Michigan University Halle Library to provide for a paper with research that is accurate. The books that have been used in this thesis are <u>RFID Technology and Applications</u>, <u>RFID Technology and Impacts of Supply Chain Management Systems</u>, and <u>Principles of Supply Chain Management: a Balanced Approach</u>. All of the research that is used provides enough information to do a thorough senior thesis with added commentary from my prior knowledge for completion. Headings and subheadings were chosen by matter of importance pertaining to this particular study. Now that the methodology has been discussed, the following literature review will provide an insight to what the thesis will explore.

Literature Review

"RFID is a valuable technology for tracking inventory in the supply chain. It can synchronize information and physical flow of goods across the supply chain from manufacturers to retail outlets and to the consumers at the right place at the right time. Likewise, RFID can track returned goods through the supply chain and prevent counterfeit. It also helps to reduce out-of-stock items. There is no doubt that RFID is invaluable for improving inventory management and supply chain efficiency" (Wisner, Tan and Leong).[1]

"Radio Frequency Identification (RFID) promises to transform supply chain management by providing detailed information on the flow of products throughout the value chain" (Whitaker, Mithas and Krishnan).[2]

"Tags can be used at all stages in the supply chain – on containers, on pallets, on boxes, in packaging, in individual products" (Rundh).[3]

"RFID possesses multiple advantages such as high storage capacity, remote reading, repeated reading and writing, better data security, and the ability to read numerous tags simultaneously. All industries have to pay attention to this new technology, especially the logistics and retail industries" (Lin).[4]

"The current challenges facing RFID adoption include: management commitment, dual systems, cost challenges, legal and patent challenges, operational automation, selection of hardware and software and technology support for adoption" (Ngai and

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[1] 2009, Principles of Supply Chain Management
[2] 2007, "A field study of RFID deployment & return expectations"
[3] 2008, RFID: "Invaluable technology or new blockage in marketing process?"
[4] 2009, "An integrated framework for development of RFID technology in logistics and supply chain management"

Gunasekaran).[5]

"China completed a three-year, $6 billion project to implement RFID- chipped national ID cards- the largest RFID project to date" (Weier).[6]

"For years, companies linked to the global supply chain have summoned executives to the boardroom to discuss the cost of implementing RFID. But in light of recent food poisoning outbreaks of E.coli and salmonella, analysts say, government mandates are likely to switch the topic of conversation to the cost of no implementing RFID" (Track, Trace, Taste: RFID gains momentum during food recall time span).[7]

The literature review touches on a few key areas that will be reviewed and analyzed throughout the length of this thesis. The thesis will start out by explaining what supply chain management is and its history. The definition will provide the basis of what both topics are and the history will give a better understanding as to where both topics came from.

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[5] 2009, "RFID adoption: issues and challenges"
[6] 2009, "Slow and steady progress"
[7] 2009, "Track, Trace, Taste: RFID gains momentum during food recall time span"

Supply Chain Management Definition and History

The origins of Supply Chain Management date back to the 1950's and 1960's when U.S. manufacturers were employing mass production techniques to reduce costs and improve productivity. During this time-period, there was little focus on creating supplier partnerships, improving process design and flexibility, and/or improving product quality. Development of new products was slow because manufacturers relied on in-house resources, technologies, and capacities. Sharing of technology and expertise was non-existent in creating strategic relationships and there were large investments made in work in process inventory to keep machinery running and maintain balanced material flows (Wisner, Tan and Leong). [8]

In the 1960's and 1970's, material requirements planning systems and manufacturing resource planning systems were developed. The importance of effective materials management was realized and the amount of impact that high levels of inventories had on manufacturing and storage costs. Computer capabilities became more sophisticated resulting in an increase of inventory tracking software, which made it possible to reduce inventory costs. This also created an improvement with internal communication with need for purchased parts and supplies emphasized (Wisner, Tan and Leong). [9]

In the 1980's, SCM became increasingly popular as global competition increased, which created a demand for lower-cost, higher quality, and higher levels of customer service. Manufacturers utilized Just-in-time (JIT) inventory and total quality management (TQM) strategies to improve quality, efficiency, and delivery times.

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[8] 2009, Principles of Supply Chain Management
[9] 2009, Principles of Supply Chain Management

Business process reengineering (BPR) was emphasized and is known now as the radical rethinking and redesigning of business processes to reduce waste and increase performance. In the 1990's managers, consultants, and academics started to see that there was a difference between SCM and logistics; third party service providers (3PL) became more popular, along with the global supply chain. Today we are connecting SCM with e-commerce systems to become more efficient in dealing with suppliers, manufacturers, wholesalers, distributors, retailers, and end customers to provide better service to everyone involved (Wisner, Tan and Leong).[10]

The origins of Supply Chain Management are important because the concept is a big part of business today and will be an even bigger part of business tomorrow. Companies are still trying to learn and explore ways to create or improve their supply chains. I decided to go into SCM, because it is a field that encompasses many elements of many companies, which supplies me with the foundation to do more with my career. With the evolution of globalization, it has become a career field that has become more in demand and will only get more attention in the years to come. The four main elements than make up SCM are purchasing, operations, distribution, and integration (Wisner, Tan and Leong).[11] As the above historical information showed, supply chain management is not a brand new concept, but it has become more frequently recognized. This is due to the push towards a global economy (trade relations and dependency) and sustainability (efficient operations and waste reduction). There are many definitions of SCM, but they all incorporate the same ideas, below are a few (Wisner, Tan and Leong)[12]:

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[10] 2009, Principles of Supply Chain Management
[11] 2009, Principles of Supply Chain Management
[12] 2009, Principles of Supply Chain Management

"The design and management of seamless, value-added processes across organizational boundaries to meet the real needs of the end customer."

- The Institute for Supply Management

"The planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers.

-The Council of Supply Chain Management Professionals

"Managing supply and demand, sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, and delivery to the customer."
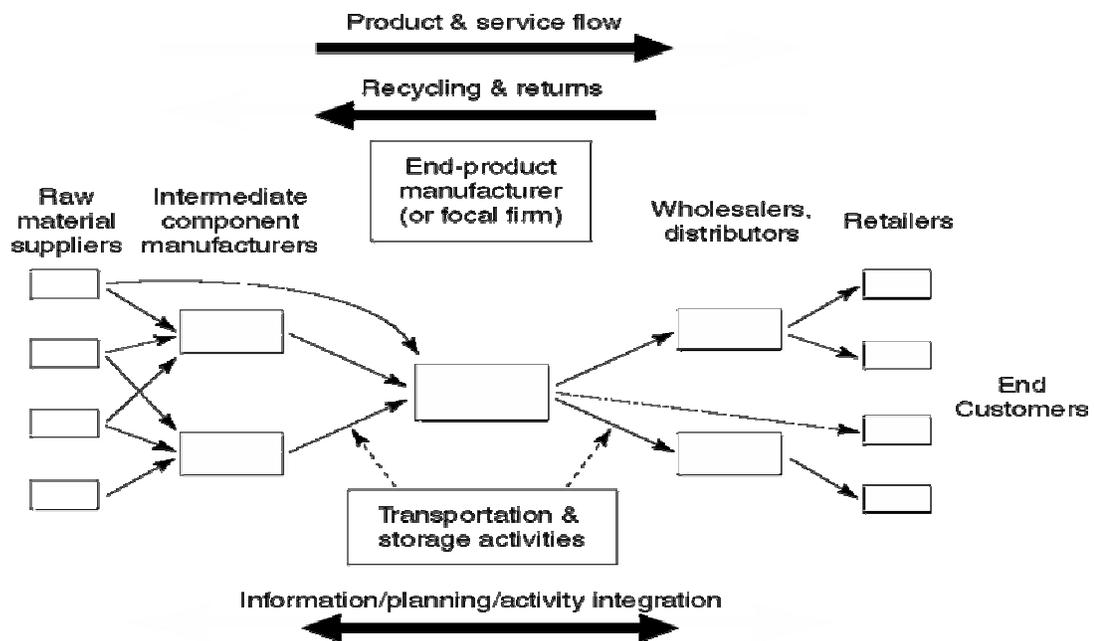
-The Supply-Chain Council

Figure 1- Example of a common supply chain from Principles of Supply Chain Management: A Balanced Approach (Wisner, Tan and Leong).[13]

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[13] 2009, Principles of Supply Chain Management

No matter the length of the definition or the differences in terminology, my studies have taught me that supply chain management is cutting costs, maintaining efficiency and quality, and providing value-added services from the original equipment manufacturer all the way down to the end consumer. SCM focuses on the customer and making sure that they are fully satisfied with any products or services provided, while building a trusting relationship that can be beneficial for both partners now and in the future. A large part of this today is technology; this is something making a large impact on the supply chain, which is why it is important to discuss its role as supply chain enabler.

Supply Chain Enabler

In order for companies to become successful in the supply chain, they must fully integrate all departments and partners, rather than certain areas. If full integration does not take place, the company will not see full results and will most likely fail due to inadequacies. Full integration is much easier today then it was twenty years ago and this is because of technology. Technology is an "enabler" for supply chain management systems and better efficiency, because of the automation that it creates. Although technology can solve a problem and identify a need, it should not take over the supply chain completely. A large part of supply chain management is customer service, which is not something technology can provide alone. The systems can provide increased accuracy, better inventory tracking, and a reduction of costs, which are all characteristics that partners and customers enjoy, but speaking with them is a good way to maintain the relationship so they keep coming back. Many consumers are already in fear that technology will take over and yes it enables to do a lot more with a lot less, but companies need to remember communication is the key to all relationships. Technology has enabled use to create better systems for our supply chain and below are a few that have become quite popular in SCM and relate well to RFID.

Current Systems in Use

Since technology has become such a big enabler in terms of making the supply chain efficient, it only seems sufficient to look at other technology systems that are currently in use throughout the supply chain. Today, many larger and medium sized companies will design their own in house software, while other smaller companies will buy it off the shelf. These systems use electronic data interchange (EDI), which is the simple exchange computer to computer of business documents. There are a few systems that have been stressed in my studies and remain relevant to the paper.

The first system is enterprise resource planning, commonly referred to as ERP. Many companies in many industries are using this system because it provides them with a lot of benefits in one system. ERP is a packaged system that is bought off the shelf or is customized to the company's preference. "It allows a company to automate and integrate the majority of its business processes, share common data and practices throughout the system, and produce and access information in a real-time environment" (Wisner, Tan and Leong).[14] It relates to RFID, because companies can use with the hardware to communicate inventory levels and information.

The second system is customer relationship management (CRM) and it focuses on managing the firm's customer base. This helps companies to keep customers satisfied and continue to buy products/services from them. Companies are able to see which customers buy what and keep track of there customers preferences through a database. Along with CRM, is supplier relationship management (SRM). SRM is the "systematic management of supplier relationships to optimize the value delivered through the

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[14] 2009, Principles of Supply Chain Management

relationship over a life cycle", as defined by Accenture in the <u>Principles of Supply Chain Management</u> (Wisner, Tan and Leong).[15] CRM and SRM are both incorporated into the ERP system to fully integrate the supply chain operations by using the internet in most cases.

A third system is Collaborative Planning, Forecasting, and Replenishment (CPFR), which is focused on product forecasting and demand. The system "combines the intelligence of multiple trading partners in the planning and fulfillment of customer demand" (Wisner, Tan and Leong).[16] All of these systems are important to the supply chain today and provide for efficiency internally and externally. Although these systems can be expensive to implement, just as with RFID, it is well worth the cost savings achieved in a matter of years or less in many cases. Now that these systems have been touched on, it will easy to relate them to the next section; RFID definition and history.

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[15] 2009, <u>Principles of Supply Chain Management</u>
[16] 2009, <u>Principles of Supply Chain Management</u>

Radio Frequency Identification (RFID) Definition and History

Radio frequency identification (RFID) is a technology that enables large amounts of information to be stored on chips (tags/transponders) that can be read at a distance by readers, without requiring line of sight scanning (Wisner, Tan and Leong).[17] RFID is a smarter barcode that will one day replace the barcode that we are familiar with today (or so it is thought). RFID is an innovative technology that will make the supply chain faster and efficient with less human error. The technology is affecting the supply chain in many different industries from retail to pharmaceuticals to government defense and security to agriculture. The technology has had a slower growth than predicted, but the value added benefits are beginning to defeat the challenges. Below is a diagram of a typical RFID system; the tag is placed on an item such as, the pallet (hold many boxes), a box (holds many items), or a single item. After the tag is placed on an item, the reader then transponds the information to the RFID software that then processes the information into the communication network or database used by the supply chain partners.
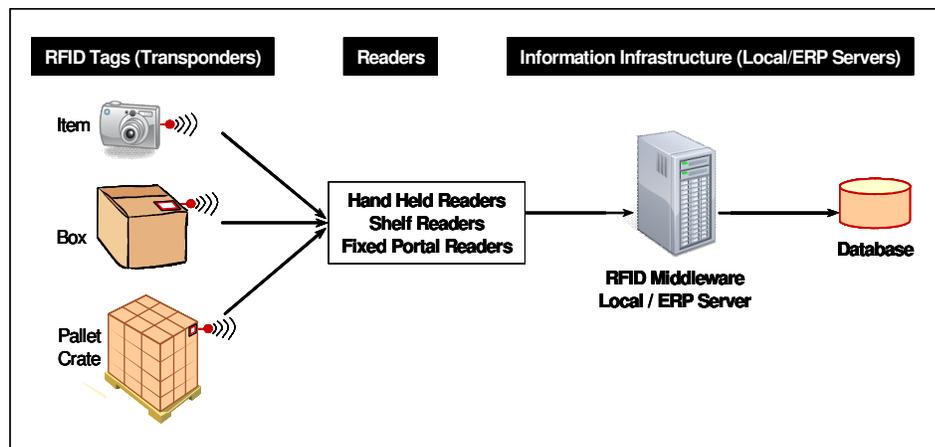

Figure 2- Example of an RFID system from the Principles of Supply Chain Management: A Balanced Approach (Wisner, Tan and Leong).[18]

The first RFID applications can be traced back to World War II when it was used

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[17] 2009, Principles of Supply Chain Management
[18] 2009, Principles of Supply Chain Management

in conjunction with radar technology for Identification Friend or Foe (IFF) systems where the tag and reader were designed to detect whether an airplane was ours or that of an enemy. After this came, Electronic Article Surveillance (EAS) in the 1970's which was mainly used in retail sales to detect theft. This was done through short-term range communication technology to set off an alarm if an unscanned item was detected past the exit door (Miles, Sarma and Williams).[19] In the 1980's RFID applications were introduced for animal tracking, industrial use, and payment on toll roads (Rochel).[20] Currently RFID technology is being used in many ways including; inventory tracking, animal tracking, passport recognition, country/state ID cards, food tracking, etc. The technology is helping companies to reduce waste, theft, inventory costs, and providing a more accurate inventory count. The possibilities are endless with RFID technology, but overcoming the challenges is a stepping stone for many companies and industries. In order to fully understand what RFID technology is, next the thesis will explore the standards, components, and frequencies that make up the technology.

Standards, Components, and Frequencies of RFID Technology

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[19] 2008, <u>RFID Technology and Applications</u>
[20] 2008, <u>RFID Technology and Impacts on Supply Chain Management Systems</u>

In order to understand RFID technology completely, it is necessary to understand the current standards in use, the components that make up the technology, and the frequencies that make it possible for transmission throughout the process from the tag to the reader and so forth. The first part of this section will be the review of the two standards that are in current use.

Standards

There are two types of major RFID standards that are used in the world today; the EPC standard and the 18000 standard. EPCGlobal, a subsidiary of GSI that created the UPC barcode, which has been used for decades, manages the electronic product code (EPC). The 18000 standard is a standard managed by the International Organization for Standardization, commonly known as ISO (Wisner, Tan and Leong).[21]

EPCGlobal is an organization that is funded by large companies with the interest in developing an international RFID standard to better supply chain operations. The electronic product code is used to identify an item in the supply chain and hold the data that identifies the producer, the object class, and the serial number of the item (Rochel).[22] EPCglobal classifies the EPC tags into five class types; zero, one, two, three, and four. Class zero is a read only passive tag that can only hold up to sixty-four bits. Class one is a write once, read many passive tag that requires at least ninety-six bits. Class two is a read and write passive tag that also requires at least ninety-six bits. Class three is a read and write battery powered semi active tag that enhances the range of the signal to pick up at a further distance. Class four is a read and write transmitter that has an active tag. The

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[21] 2009, Principles of Supply Chain Management
[22] 2008, RFID Technology and Impacts on Supply Chain Management Systems

EPC standard is the standard that is commonly adopted, especially in the commercial sector. The U.S. Department of Defense (for general applications) and Wal-Mart both use the EPC standard, although the U.S. DOD uses the ISO 18000 as well (Wisner, Tan and Leong).[23]

The International Organization for Standardization is an organization that is comprised of representatives from many countries setting international standards. Although the ISO has developed many standards for RFID use, the ISO 18000 standard is supply chain specific (Rochel).[24] The ISO 18000 standard determines the parameters for air interfaces (18000-1) and six frequency specific air interfaces (18000-2 to 18000-4 & 18000-6, 18000-7). From previous knowledge developed in the class international business law, ISO develops its parameters for these situations through agreement between the countries involved. They come to a consensus of what is appropriate and what is not; although these are not laws, they are guidelines that countries like the U.S., abide by when using ISO standards. The U.S. Department of Defense uses the ISO 18000 for air interface communication between the RFID readers and the tags. ISO 18000-2 is for a frequency band with a frequency less than 135 kilohertz or low frequency. ISO 18000-3 is for a frequency band of 13.56 megahertz or high frequency. ISO 18000-4 is for a frequency band of 2.45 gigahertz or microwave frequency. ISO 18000-6 A/B is for frequency bands between 860 and 960 megahertz or ultra high frequency. ISO 18000-7 is for a frequency band of 433 megahertz or ultra high frequency. The frequency bands

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[23] 2009, Principles of Supply Chain Management
[24] 2008, RFID Technology and Impacts on Supply Chain Management Systems

ultimately match to corresponding RFID systems (Rochel).[25] RFID components and

frequencies are the next topics that are essential towards a better understanding of the

standards.

Components

　　An RFID system consists of four parts; the tag (transponder), reader, RFID

software, and communication network. The tag consists of a computer chip and an

antenna for wireless communication with the handheld or fixed-position RFID readers

that transmit inventory information to the enterprise information system. The RFID

software manages the collection, synchronization, and communication of the data with

warehouse management, enterprise resource planning systems, and supply chain planning

systems, and stores the information in a database (Wisner, Tan and Leong).[26]

Tags (Transponders)

　　There are three different types of tags (transponders); passive, active, and two-

way (semi-passive). Passive tags are read only, smaller, least expensive, provide shorter

range, better durability, and do not have a battery. Active tags are read/write, contain

more memory, provide longer range, most expensive, bulkier, contain limited life, and do

have a battery. Two-way (semi-passive) tags are able to communicate in and out, without

reference to an antenna (Rundh).[27] Tags can be used either one time or several times. In

terms of a tag that is used once, would be when a consumer purchases a single item then

throws out with the packaging at their disposal. In terms of a tag that is used several

times, this could be on a truck window to clear them for entry into a plant or on a

reusable pallet, which holds multiple products when shipped.

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[25] 2008, <u>RFID Technology and Impacts on Supply Chain Management Systems</u>
[26] 2009, <u>Principles of Supply Chain Management</u>
[27] 2008, RFID: "Invaluable technology or new blockage in marketing process?"

Since passive tags do not have their own power source, they use the power that is transmitted by the reader through an electromagnetic field. Active tags use their own power source, which enables them to be used as a microprocessor but also for transmission of the data. This makes for a longer reading range than a passive or two-way tag. Two-way tags do not have their own power source, but hold a power source for the microprocessor and the data transmission is powered by the reader (Rochel).[28]

Readers

There are two main types of readers; hand-held and fixed readers. Hand-held readers are able to read or write data nearly everywhere and are mobile. Fixed readers are installed at the main gates for identification of people, goods, or vehicles. A third reader that is mentioned in Principles of Supply Chain Management is a shelf reader, which could also be viewed as a fixed reader that is positioned on a shelf to transmit inventory information (Wisner, Tan and Leong).[29]

RFID Software

RFID software can be different depending on the company or industry, but there are four main layers that make up the software. The first layer consists of the management of the devices. These devices depending on the manufacturer/standards will have different configuration parameters and control actions that must be executed for optimal operations. The second layer is used for data acquisition from the RFID reader; this is the area where several factors conspire to make the technology unique and different from other sources of data. The factors can include false negative reads, filtering based on subparts of the EPC, and duplicate suppression. The third layer has to

[28] 2008, RFID Technology and Impacts on Supply Chain Management Systems
[29] 2009, Principles of Supply Chain Management

do with actions that have to do with the data itself. Data has a half-life, which means that the value of data diminishes quickly in time, making it necessary for workflows to be performed in real time. The fourth and highest layer of the software is interfacing. This is the layer where information systems enable companies to interface with each other and share data about goods tagged with EPC tags (Whitaker, Mithas and Krishnan).[30] Although the RFID technology possesses its own software, it is necessary for companies to employ a communication network to interact with one another.

Communication Network

A communication network is necessary in order for companies to interact with each other. This can help to resolve issues with security and authentication can be addressed through predetermination between known trading partners. It can also help further develop the relationship between the trading partners enabling more trust and reliability. "EPCglobal and Auto-ID Center developed the object name service (ONS) in 2005 which provides a mapping from the EPC to the original supplier, enabling a direct connection when necessary" (Whitaker, Mithas and Krishnan).[31] The ONS service only covers the minimal needs that are part of a larger process.

The four components of RFID discussed were the tag (transponder/chip), reader, RFID software, and communication network. Together these four components make up the technology that makes it possible for better inventory tracking, efficiency, and cost reductions. The last aspect of the technology is the frequencies that are used to transmit the signals from the tag to the reader, which will complete provide a complete understanding of the standards and components.

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[30] 2007, "A field study of RFID deployment & return expectations"
[31] 2007, "A field study of RFID deployment & return expectations"

Frequencies

There are four frequencies that tags use to transmit data to the reader; this includes low frequency (LF), high frequency (HF), ultra-high frequency (UHF), and microwave. Low frequency is when there is less than 134 kilohertz, high frequency is at the higher than 135 kilohertz to the lower end of megahertz, ultra high frequency is the higher end of megahertz and microwave is above one gigahertz. Low frequencies are used for short reading distances, such as at an entrance that is fixed. High, ultra high, and microwaves are for longer reading distances with high frequency at the lower distance of the spectrum and microwaves at higher part of the spectrum (Lin).[32]

There are three types of coupling methods to give an idea of reading ranges. A close coupling system can read less than a centimeter away. A remote coupling system can read at more than a centimeter, but less than a meter. The long-range system can read more than a meter away (Rochel).[33] Clearly, it is more beneficial in most cases to have a higher frequency reader to read a tag along with the use a long-range system, but it is also more expensive for companies to employ. In cases, such as an entrance gate it is not valuable to employ a long-range system because a short-range system can do the same thing for a lower cost. Now that all the basics of supply chain management and RFID technology have been reviewed, the implementation process can be discussed.

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[32] 2009, "An integrated framework for development of RFID technology in logistics and supply chain management"
[33] 2008, RFID Technology and Impacts on Supply Chain Management Systems

Supply Chain Integration

Supply chain management has one distinct goal; to create value for the services and products that are provided to the end-consumer and in return, companies will benefit from the supply chain network. In order for this to happen, companies must integrate activities internally and then with their trading partners. This is ultimately known as supply chain integration, but what does that mean? Supply chain integration is the sharing of information and coordinating resources to collaboratively manage a process (Wisner, Tan and Leong).[34] All of this can be achieved through the use of RFID technology in the supply chain network.

There is a common trend when integrating the supply chain for many companies and provides a good model for better understanding of what the adoption of RFID technology can do for the supply chain network. First, the firm must identify their critical trading partners, which are commonly known as the first tier suppliers. By starting out with just the critical partners, companies can concentrate time and resources on managing key process links, enabling them to perform well. Second, review and establish supply chain strategies which should be done on an annual basis to ensure that the company is satisfied with its strategies internally. Third, the company should align their supply chain strategies with key process objectives. Companies should identify the important processes and establish process objectives to assure the resources and efforts are effective. Fourth, after the processes are determined and aligned, companies should develop internal performance measure to evaluate the key processes. This can be done by determining procedures and measures that will remain in place. These will provide

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[34] 2009, Principles of Supply Chain Management

the guidelines for collecting and reporting the performance data for the key processes. Fifth, after the performance data is collected the company must then assess and improve internal integration of key supply chain processes. This requires process coordination and collaboration between the functional areas both internally and externally. The company should work within all the functions internally and determine what needs to be adjusted (Wisner, Tan and Leong).[35]

After a company can perform internally, they are ready to expand and integrate with external partners. Sixth, the company should work with its supply partners to develop external supply chain performance measure for the processes they all value as key. These are criterions that are created by collaborating between the partners and determining what are good measures of their performance. After the performance measures are in place, partners will need to collect data and analyze what may need adjustment. Seventh, assess and improve external process integration and supply chain performance. If trading partners are down on performance measures, it is a good indicator to whether they are the right fit or whether the measures need to be adjusted. This is something that gives the company good insight on what is working in the performance measures and what is not. If the other partners are keeping up to par with the measures, maybe one partner needs to be let go, due to poor performance or inadequacies in the relationship. After the key processes and key supply partners are doing well in the collaborative relationship, companies can look to expand their integration into second and third tier suppliers. It can take some time before companies integrate this far because it means expanding there information sharing to their suppliers'

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[35] 2009, Principles of Supply Chain Management

supplier. Integration is a great thing, but companies need to be fully satisfied internally and with their key partners before integrating further (Wisner, Tan and Leong).[36]

RFID technology can create supply chain integration because of the amount of collaboration and trust it requires. The technology is an information sharing system that allows partners to exchange information about demand forecasting and inventory, from the raw materials to the finished goods. If a company is already integrated with their suppliers, it could work either in favor or opposition for adoption of RFID. One thing that is working in favor for adoption is that the company has already built up the foundational trust that is needed to work together and share valuable information. They know how each of their partners does business and how they meet their performance measures. On the other hand, it may be harder to get your already integrated supply partners to change their systems and invest in the technology. When supply partners get comfortable with the way things are done and do not believe there is a need for change, it can be quite difficult to tell them otherwise. Companies should take caution when proposing to their partners a new system, be ready with a plan. If a company is not already integrated with its suppliers, then it is going to be nearly impossible to get them to take on a technology. For the majority of companies there will be an integrated supply network already in place because RFID requires a great deal of collaboration. The implementation process will provide more detail on how a company should adopt radio frequency identification technology into their supply network, which is quite similar to the way supply partners integrate any process.

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[36] 2009, Principles of Supply Chain Management

Steps in the Implementation Process

Based on the authors of the SCM Review article, "The 7 Success Factors of RFID", the seven steps to implementation are as follows: (Forrest and Fish)[37]

The first step of the implementation process is for a company to "develop a clear strategy with top managements support" (Forrest and Fish).[38] A good way to develop a clear strategy is by making a SWOT analysis of what RFID technology could do for their supply chain. A SWOT analysis is a way for businesses to analyze their current strengths, weaknesses, opportunities, and threats. The clear strategy, whether it is the SWOT analysis or another route, needs to be done with the support of top management. This can be very difficult because senior management is used to doing things a certain way and implementing a new technology especially at RFID's cost can be a risk they are not willing to take. Since the advance of technology has only taken place within the last decade this makes senior management adamant, because it is a new way of changing operations. Once top management gives their support for implementation, then investment can take place, which is huge.

The second step of the process that a company will most likely do is a "small project with the RFID technology" (Forrest and Fish).[39] This will be a test for the company to see if it is worth the substantial investment or if they should look to other options. Since the cost is quite hefty for implementing throughout the supply chain, the company may test it with one of their first tier suppliers; these are the suppliers that they do business with directly. This would require some research to determine which of the first tier suppliers they would like to start with, but it is important that the supplier be

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[37] 2006, "The 7 success factors of RFID"
[38] 2006, "The 7 success factors of RFID"
[39] 2006, "The 7 success factors of RFID"

shown what is in it for them as well. One way to start is to show that particular supplier

what the strategy is that was developed earlier, what it entails, and how it can benefit

them. Suppliers are more attentive and responsive to risky investments when they see

what could happen for them as well. After the small project is decided upon, the

company and supplier should work together to determine whether the benefits outweigh

the risks thus deciding if further implementation is the way to go. If this project proves to

be worth following then the company will choose to further the implementation of the

RFID throughout their supply chain.

The third step is to "implement gradually", meaning to expand to other first tier

suppliers (Forrest and Fish).[40] Now that there is some data from the small project, it will

be easier to get more of the first tier suppliers on board with the adoption. After this, the

company can look to include second and third tier suppliers, which are the suppliers of

their suppliers that they are indirectly connected with. The article from which the steps

were derived states it simply, "start small, dream big" (Forrest and Fish).[41] As more

suppliers come on board, it will help to speed up the implementation process of the RFID

technology throughout the entire supply chain (this sounds easier then it actually is!).

The fourth step in the process would be "to continually improve the procedures"

(Forrest and Fish).[42] Continuous improvement is a big part of the supply chain in today's

business practices and is commonly known as, the Toyota lean production system or six-

sigma management. It comes from the Kaizen philosophy, which was termed in the

1930's by Masaaki Imai and focuses on continually improving processes and

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[40] 2006, "The 7 success factors of RFID"
[41] 2006, "The 7 success factors of RFID"
[42] 2006, "The 7 success factors of RFID"

management (Wisner, Tan and Leong).[43] The philosophy teaches management that there is always room for improvement in some way, there is always room to grow and improve the practices.

The fifth step is to "negotiate and build trust among supply chain partners" (Forrest and Fish)[44], which goes along with step three of gradually expanding RFID throughout the supply chain. Negotiating a deal with your selected suppliers on what items will be launched with RFID is the first step in the process. For example, do they start out with just putting the technology on a pallet or on each individual item? The tags themselves are costly at about ten cents apiece (which is down from two dollars in 1999) (Wisner, Tan and Leong)[45], so it would not be reasonable to place them on a ninety-nine cents item compared to a hundred dollar item. Identifying who will pay what costs, how the process will take place, and other terms will be a big part of the negotiation. This will help to determine what partners the company should invite to participate in the implementation and what partners are not ready for the change.

The sixth step is for the collaborative partners to develop a "cross- functional team" (Forrest and Fish)[46]. A cross-functional team is when there are employees working together from both sides to plan and implement the technology processes. Working out the kinks of each side is a key part to getting the technology ready for deployment and a cross-functional team will help to bring in both perspectives. This makes the process faster and efficient, making the strategic move of more value for each player. The technology cannot be forced upon the suppliers because it will cause issues that will more

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[43] 2009, Principles of Supply Chain Management
[44] 2006, "The 7 success factors of RFID"
[45] 2009, Principles of Supply Chain Management
[46] 2006, "The 7 success factors of RFID"

than likely lead to failure; this happened to Wal-Mart when they first implemented. This is based on my own prior knowledge, but when Wal-Mart first implemented the technology into their systems they mandated that all their suppliers do so as well. Unfortunately, this backfired on Wal-Mart because many suppliers felt bullied and told Wal-Mart they would not or could not. Wal-Mart has since only mandated their top suppliers that have agreed to collaborate with them on the technology. Once a company starts getting the technology rolling with their collaborative partners they can further the processes down the supply chain.

The last step to implementation is "expanding the technology throughout the entire supply chain", (Forrest and Fish)[47] which has yet to happen completely. The amount of risks that come along with implementation has made many companies very hesitant towards the newer technology, but if done in the correct manner, the value-add can be astonishing. Companies that have already implemented a large part of their supply chain have seen spectacular results, but this is certainly no easy task. Reducing the supply chain base can help to get more suppliers on board, but the implementation itself requires a lot of investment of both time and money. Next, the thesis will discuss more about RFID and the industries that are currently adopting the technology.

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[47] 2006, "The 7 success factors of RFID"

Current Industry Use

"RFID was expected to change retailing forever. That didn't happen. Then it was expected to make the pharmaceutical market safe from counterfeit drugs. That didn't happen either. Still, the tracking technology has grown into a $5 billion a year industry, and shows up in lots of places..." (Weier).[48] The preceding quote was taken from an article called, "Slow and Steady Progress" that was written in November 2009 and it just goes to show that there is a good size market for the technology. Many industries are currently using radio frequency identification technology in order to create better efficiency in their practices. These industries include; retail, manufacturing, pharmaceuticals/hospitals, government, airlines, banks, restaurant/food, and transportation/logistics. Although, there are many scenarios in the following industries where RFID is effective in the supply chain, only a few are given.

Retailers can use the technology to track the inventory from the time it is ordered from the supplier to the point of sale at the register. Wal-Mart has been a big part in pushing this technology on their suppliers, to create a better supply chain with more visibility from the manufacturer to the store. Retail is the original industry the many companies thought RFID would take off in, but it has had a slower growth than it was once believed. In 2008, there were a total of 468 million RFID tags consumed in the retail industry and although this is not were many thought it would be, it is still too early to give up on the technology and its impact on the retail supply chain (Weier).[49] Apart

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[48] 2009, "Slow and steady progress"
[49] 2009, "Slow and steady progress"

from retailers, now manufacturers are also recognizing the extent of what this technology can do for their supply chain.

Manufacturers can place a tag on their products that stores additional information about the product in order to track the item. For example, a part to a car can have a tag placed in it, which will store the information of the manufacturer. If a failure takes place with that part, the technology can aide in finding owners that have similar vehicles with the same part that was made in the same batch. The manufacturer can make a recall before it becomes a larger issue, which in turn can save a company both time and money because they were able to track the problem and fix it.

Pharmaceuticals are also learning the importance of RFID, because it can track a bottle of drugs produced especially, higher dollar or higher controlled drugs which to reduce the chances of theft. This can really have an impact by lessening the chance of these particular drugs ending up on in the wrong hands to be sold and/or abused. Along with the pharmaceutical industry, hospitals are also using the technology to keep track of the drug inventories and other supplies to reduce waste and theft. Technologies are becoming to the point that advanced hospitals will only release a certain amount of items for regular care, but there is also a device in store for emergency circumstances.

Government agencies are currently using the technology for identification purposes, security, and defense to become provide a safer environment in such situations. "In 2008, passports and secure documents accounted for sixty-five million tags sold and military accounted for fifty-five million tags consumed" (Weier).[50] The government has realized that this technology can aide them greatly especially in security and defense

[50] 2009, "Slow and steady progress"

sectors. The United States, India, China, and the United Kingdom are adding RFID tags

to their citizens passports. "China recently completed a three-year project, which

included a six billion dollar investment to update national ID cards (largest project to

date)" (Weier).[51] Defense agencies can use the RFID to trace their military supplier's

activities and verify that the products are made correctly. High security areas can also

install the security at entrances to verify an approved person or vehicle.

The airline industry is using RFID technology to track their customer's checked

luggage. If a bag is lost or stolen, it easier for an airline to locate the baggage with this

technology in place; it is easier to re-route luggage if the flight is changed due to the

airline or customer. One disadvantage, working against them is that prices are already

high to check in baggage and some airlines may have to boost prices higher in order to

implement and maintain the technology. One advantage is the fact that it will provide

better customer service because counter agents will be able to tell the customer if

something went wrong and track the location/time that the luggage will be available if it

does become lost (Lin).[52]

Banks can use RFID in many ways in the present and future. The tags can be

placed in monetary documents such as, cash or bonds in order to secure that it is real.

This is a scenario where the return on investment would be quick, because there would be

less counterfeit money circulated. Agencies would be able to focus on important issues,

rather than tracking down counterfeiters and wasting resources to do so. Realistically this

would result in less inflation because people would not be able to use fake money to pay

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[51] 2009, "Slow and steady progress"
[52] 2009, "An integrated framework for development of RFID technology in logistics and supply chain management"

for items (whether they made it or not) and keep it cycling through the economy. The Federal Reserve only makes a certain amount in the year and destroys a certain amount, tracking this could result in the weeding out of bad money in our system.

The food industry is using RFID to track mainly meat, poultry, and produce to ensure the safety of the item, beginning to end. This can be very useful in the case that a produce contains something such as, E.Coli and if this is caught in an early stage it could prevent further contamination. "Companies like IBM, which has partnered with Nortura BA, Norway's largest meat processing company to test a tracking system for two years, are quietly developing technologies to keep consumers informed about the origin, quality, and safety level of food products" (Track, Trace, Taste: RFID gains momentum during food recall time span).[53] The technologies that they are developing incorporate using RFID and this is an industry that can greatly benefit from implementing this into their supply chain. Restaurants can also use the technology to track deliveries making it possible for them to happen overnight as opposed to during work hours.

Logistics and transportation is a large part of **_any_** supply chain in the world today; it is one of the key components. It provides the movement of goods throughout the entire network, including the deliveries and returns. If RFID tags are implemented within truck windows then they can be scanned at weigh stations, which then can be sent to a network to provide tracking information. For example, this can help companies' better plan deliveries and plan when they need schedule the required help. Transportation is affected in many other ways, not just in the supply chain; some toll roads can collect fees without

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[53] 2009, "Track, Trace, Taste: RFID gains momentum during food recall time span"

employees present with the aide of RFID, which in turn; can reduce the cost to the state, make the pass through faster, and prevent less error. This is one area that would affect many other industries, especially if it were implemented by most or all transport companies. The industries that are most recognized in receiving large benefits from the implementation of RFID have been reviewed. Next, the difference between RFID technology and the barcode will be explored, for illustration purposes.

<u>Difference between RFID and the Barcode</u>

The question that many companies are pondering is this; what makes RFID technology different from its predecessor the barcode? Both technologies are equipped to automatically identify for data capture, which means they can both store information about the particular item moving along the supply chain. This is Automatic Identification (Auto-ID) meaning that information about the good is captured automatically by the reading devices, which are connected to information systems (Rochel).[54] This data can be collected from within the supply chain activities and by the supply chain participants.

The barcode has been used for decades, because it is inexpensive and can provide many benefits for supply chain operations. The barcode provides a symbolic representation of bits of information that are printed and placed on the product to be read by a machine or scanner. Barcodes are either one or two-dimensional; one-dimensional hold serial numbers that are linked to an entry in the database and two-dimensional can store more information. The barcode has its limitations just like many other identification systems. First, it is that it is dependent on the employee being in sight of the product because the scanner is manually operated thus providing more room for error. Second, if something gets on the label the scanning process will fail. Third, more than one barcode cannot be scanned at once. Fourth, is that once the barcode is printed the information can not be changed because it is not electronic. Fifth and most important is the lack of supply chain visibility, because the Universal Product Code can only represent a class of products as opposed to a single unique item (Rochel).[55]

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[54] 2008, <u>RFID Technology and Impacts on Supply Chain Management Systems</u>
[55] 2008, <u>RFID Technology and Impacts on Supply Chain Management Systems</u>

RFID technology enables information to be transmitted electronically through electromagnetic waves, which means there are a lot of benefits over the barcode that use the UPC. First, items can be identified without personnel being in sight since the reading ranges are farther. This also depends on the components used in each scenario, which were discussed earlier, but the main point is the possibilities are present. Second, the reader can read multiple tags at the same time and the data can be updated to the network more quickly. Third, each item can be uniquely identified through the use of EPC (electronic product code), instead of just identifying the product class. Fourth, is that there is more supply chain visibility because each item can be identified, information can be adjusted, and everything is automated (Rochel).[56] When things are fully automated, there is no room for human error because the information is transmitted through computers, which saves each participant in that supply chain resources that can be used in other ways to add value. RFID is clearly a technology that can better the supply chain, which leads to the next topic, benefits.

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[56] 2008, RFID Technology and Impacts on Supply Chain Management Systems

<u>Benefits</u>

Personally speaking, there has been many times that a person has told me, "how are you going to grow as an individual if you never take the risk of trying something new" or "if what your doing is not working then change it." These words can definitely speak some truth when looking at the amount of failing companies in the current economy that did too little too late. Now is the time for companies to change, now more than ever. What can they do? How can they change? There is only one answer to these questions; try something new.

Radio frequency identification can create substantial benefits for a company and their supply chain. RFID can provide inventory tracking and management, supply chain automation, supply chain partnership and communication, better information visibility, higher quality service and an overall reduction in costs.

First, RFID can provide inventory tracking and management from the beginning to the end. For example, it is possible for farmers to track a live cow to when it is in the packaged in the store. "RFID tags are capable of logging the temperature and sensing the pressure, which in turn accelerates the track-in-trace system from poultry to drugs" (Track, Trace, Taste: RFID gains momentum during food recall time span).[57] Now think about this; if farmers were to implement this technology, then it would be possible for a consumer to let a grocery store know if something in the meat made them sick. That grocery store could then let the particular supplier know, which could then be traced to the farmer. The farmer could then determine if there was something wrong with that

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[57] 2009, "Track, Trace, Taste: RFID gains momentum during food recall time span"

particular cow or if it was more than just one making the meat bad. They could then fix

the problem and prevent in the future by changing the variable that was causing the cow

to carry something, which is making the end consumer ill.

Second, RFID technology creates supply chain automation because with the

system in place everything is completed electronically. The technology automates the

supply chain by synchronizing information and physical flow of goods across the supply

chain. It also can track returned goods through the supply chain and prevent

counterfeiting while reducing out-of-stock items. The technology can help in four

specific areas of the supply chain including materials management, manufacturing,

distribution, and retail. In the area of materials management, a fixed reader can be

positioned at the entrance and the RFID reader can read the items being delivered. It

provides the handling, routing, and storage information of incoming goods and the

inventory status is then updated automatically. Manufacturing can benefit, because a tag

can be placed on the item to store customer specifications, which is especially valuable

for customized orders. The distribution center can benefit in a couple ways; fixed readers

can confirm that the truck picking up or dropping off goods is the correct vehicle; the

loaded vehicle can store the information when it is leaving keeping track of its movement

in real time, and information can be automatically updated. Retail stores can benefit the

most out of the four functional areas because the system automatically updates the

inventory status. This process keeps track of the inventory from the shelf to the point of

sale and even when the item is returned. If RFID were fully implemented, to every item

in a store, it would be possible to skip checkout and walk out the door where the fixed

reader placed within the door would scan the items. The items would then be charged to

an established credit card or account with that particular store (Wisner, Tan and Leong).[58] This is something that has not been fully implemented, but the fact that it is possible in the years to come is amazing.

Third, the technology can provide improved supply chain partnership and communication. As stated earlier, supply chain integration requires a collaborative effort by the companies involved. Integration can simply not take place without partnership, which requires trust and communication. The improved communication is possible because partners are willing to share information, which provides them with knowledge about inventory and demand. Teams work together to continually improve their processes, which is a key foundation in supply chain management.

Fourth, radio frequency identification can enhance supply chain visibility because of the synchronization of information sharing. If supply chain visibility is improved, the partners are more willing to share other information that is more beneficial, both internally and externally. Resources are saved because information flows through only one portal within the supply network (Wisner, Tan and Leong).[59]

Fifth, the supply chain integration with RFID can result in higher quality service and a reduction in overall costs due to automation. A professor once told me this, "it is not the computer that makes the errors, but the operator." These words have stuck with ever since, especially learning about the supply chain. As things become more automated, there will be less room for human error, which results in higher quality service because customers will not get the wrong information about inventory. This will

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[58] 2009, Principles of Supply Chain Management
[59] 2009, Principles of Supply Chain Management

also be less costly to the company because they are not covering the imperfections that may result. Labor costs will also be reduced because it will not be necessary to have employees to input inventory data and so forth. Although, the cost to implementation is high, the cost savings are also substantial if done correctly. There are many benefits that will result from RFID adoption, but there are also many challenges and issues that need to be overcome.

Challenges

RFID technology has many benefits for supply chain management; there are also many challenges that are causing hesitation for companies considering its adoption. In the economy of today, many companies are looking for ways to improve their supply chain operations in order to cut costs and create better efficiency, but many are not willing to risk the investment in the chances that implementation does not occur properly. This hesitation is with good reasoning, but it does not mean that the benefits are not worth it. The challenges that companies face in adoption of RFID includes; a lack of management and supply chain partner commitment, cost, legal and patent problems, operational automation, selection of hardware and software, and technology support for adoption. Along with the challenges for adoption, there are other issues that are present in RFID technology.

The biggest challenge towards adoption is gaining the commitment from top commitment and supply chain partners, because without them the project is sure to fail. As discussed earlier in the implementation process, without the support of top management the resources for investment simply would not be possible, but some companies are faced with the cost of **not** implementing the technology into their supply chain. The most important figure for top management is the return on investment; therefore, the team who is proposing such a project should definitely do their research on what others in the industry are doing (Ngai and Gunasekaran).[60] Gaining the commitment from both top management and supply partners is the number one challenge for companies today, along with the cost.

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[60] 2009, "RFID adoption: issues and challenges"

The cost of implementing RFID into the supply chain is quite high, which is causing a big roadblock for the technology's adoption. The investment requires new hardware, application software, middleware, tags, and the cost of integrating RIFD-based system with the legacy system of the company. The implementation also results in large fees from consultants and employee training because, it is critical that employees how everything works. Companies can create a cost-benefit analysis in determining whether the adoption is fit for their company (Ngai and Gunasekaran).[61] Companies should be aware that even if the cost is high to implement; the cost to maintain is not, because the system is automatic, companies will not need as large of a labor force to keep the systems going.

The legal and patent challenges are something that can be overcome more easily than the commitment and cost challenges. Companies should consider having a legally binding agreement before the adoption of RFID, therefore if it is smoother throughout the adoption. Companies need to collaborate about every detail and concern they have with each vendor, coming up with agreements that work for everyone is crucial (Ngai and Gunasekaran).[62] Companies can not force their vendors to participate in the adoption because the vendors will end up resenting them in the end which will eventually break down the relationship. Patents are also a concern because small vendors cannot afford to pay high royalty fees that their large partner corporations can (Ngai and Gunasekaran).[63] Since the supply chain encompasses many partners in many sizes, it should be made so that RFID is more applicable to be more widely adopted.

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[61] 2009, "RFID adoption: issues and challenges"
[62] 2009, "RFID adoption: issues and challenges"
[63] 2009, "RFID adoption: issues and challenges"

Another challenge that companies are facing is operational automation, meaning that companies should review their needs and figure out which processes can benefit from automation through the use of RFID. When evaluating business operations, companies can study their processes and determine the volume of information sharing that is flowing throughout their supply chain, in order to aide the decision for adoption (Ngai and Gunasekaran).[64] Many companies are facing the fear that this will only be a phase to the next technology and it may be true, but then again look at the barcode's success.

The selection of hardware and software is a big challenge in adoption of RFID because there are many different tag types, standards, and systems to choose from when implementing the technology into a company's operations, as well as their partners. Performance is another factor for companies to consider, since there has been an issue with the tags due to factors such as weather, reliability, etc. Companies would like the hardware to integrate with the software system tightly, so that the software system can correct any unreliable data that is captured through RFID (Ngai and Gunasekaran).[65] Some companies are considering or are using RFID coupled with the barcode for back up in case one fails, but this could become quite costly. If companies implement, they need to work with the supply chain partners and collaborate on what software/hardware would be best for them too.

Technology support is a big part in deciding whether to adopt RFID and all the new software it brings along with it. Companies realize this is a new process and they

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[64] 2009, "RFID adoption: issues and challenges"
[65] 2009, "RFID adoption: issues and challenges"

need to have the training to understand how the RFID systems work, especially in case something goes wrong with the system. Training of staff is important, because even though the solutions come from foreign markets, we need to learn how to provide the technical support. Training can be rather difficult because, knowledge is limited since the technology and its software is new (Ngai and Gunasekaran).[66]

Companies are not only facing these challenges for adoption, but there are also other issues with the RFID technology. The environment, security and privacy, data management, tag failure rate, quality assurance, and expertise for deployment are becoming larger issues than once thought. The environment is an issue for RFID transmission because data is transmitted electronically and when water or liquids become a part of the equation then this can cause reading issues for the tags and transmission completion. The liquid/water can come from the label adhesives that can cause the tag to fail or the liquids can be absorbed by radio waves to limit or create failure completely of the tags. In addition, other systems send off frequencies or pick them up, which can cause an interruption in the transmission process. Aside from the environment, consumers are worried about an invasion of privacy and/or security issues. Consumers are concerned the technology threatens their privacy and need to be aware if the technology is in use. This issue could be overcome, with the proper training and education. Data management is an issue because RFID focuses on individual products, which results in a lot of inflowing data. This means companies would need to establish the architecture to filter and translate the data into relevant information. Tag failure rate is an issue because they vary in performance, even when they are produced in the same

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[66] 2009, "RFID adoption: issues and challenges"

batch. It is estimated that tag failure rate can be as high as ten percent, which makes it

hard for a company to sustain live operations. The software system would have to

accommodate for the tag failure rate because it is not completely reliable. The problem is

that even with the amount of tags in circulation, it is still not enough to conclude where

the issues lie. Quality assurance for the readability is also an issue because of the failure

rate, but some companies are placing mandates on the production to ensure tag

effectiveness. RFID expertise is an issue and deployment cannot take place when there

are not enough professionals to provide the knowledge and skills in order to succeed

(Ngai and Gunasekaran).[67]

   As it appears, there are a lot of challenges and issues companies face in the

deployment and adoption of RFID technology, but there are also many benefits.

Companies should consider that there are always problems when entering a new market

and nothing will be gained, if nothing is ever tried.

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[67] 2009, "RFID adoption: issues and challenges"

Conclusion

RFID technology and the impact on the supply chain can be substantial, from the integration and implementation to the benefits and challenges it faces today. There is no doubt that companies can grow with the use of the technology and its contribution to the next era in inventory management. The challenges and issues can be overcome, if more development is completed within the technology. One thing is certain after completing the research, technology is here to stay and the effect it had on the supply chain will contribute to our future economy. Globalization is taking place and this only speeds the process up, therefore companies should be equipped and aware for the new era of change. There is no doubt, that some companies will realize this too late, but there will be some that also embrace the change and grow beyond where they could have ever imagined. Now is the time to change and really understand what supply chain management is, along with its impact. My work is successful if the thesis has provided a better understanding between RFID and the supply chain, or at least sparked further interest in the topic. Just remember this, the era is here and is only going expand in the coming years!

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