APPLICATIONS OF RADIO FREQUENCY IDENTIFICATION (RFID) IN SUPPLY CHAINS: BENEFITS AND CHALLENGES

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Abstract: Information technology has permeated supply chain at every point and fundamentally changed how businesses manage their supply chains. Among others, radio frequency identification (RFID) has recently received substantial attention due to its potential to enhance supply chain visibility and enable a paradigm shift from inventory to information and from cost to value. Since information technology such as RFID is readily available in the hardware and software markets, firms cannot expect it to produce sustainable competitive advantage on its own. In this paper, we identify various areas of supply chains, including demand management and supplier relationships, manufacturing flow management, order fulfillment and warehouse management, customer service, product development and recall, where deployment of RFID technologies can be beneficial. While RFID holds tremendous potential for improving supply chains, successful RFID implementations are not without challenges. Thus, we also discuss barriers that firm must overcome to capture the full potential of RFID.

Keywords: Radio frequency identification (RFID), supply chain management, supply chain processes, enterprise information systems, technology implementation and benefits.

INTRODUCTION

Supply chain management (SCM), an integrated approach to the planning and control of materials, services, and information flows from suppliers through factories to the end-customer, represents one of the most significant paradigm shifts of modern business management by recognizing that individual businesses no longer compete as solely autonomous entities, but rather as supply chains (Chen and Paulraj, 2004). With the growing importance of supply chain management, communication and information technologies (IT) have assumed an increasingly pivotal strategic role. More than ever before, IT is permeating the supply chain at every point, transforming the way exchange-related activities are performed.

Communication and information technologies (IT) provide firms with a great potential for significant savings in costs by coordinating the various stages of supply chains. Recent research has found $488 billion in untapped annual operating margin available to U.S. manufacturers through supply chain best practices and Internet-enabled technologies. By becoming more demand driven, companies can capitalize on a huge opportunity to grow revenue and profit margins (Friscia, 2005). Among other technologies, radio frequency identification (RFID) has recently received substantial attention.

Radio frequency identification (RFID), a wireless tracking technology, allows a reader to activate a transponder on a radio frequency tag attached to, or embedded in, an item, permitting the reader to remotely read and/or write data to the RFID tag. As such, RFID can be applied to a variety of tasks, structures, work systems and contexts along the supply chains to help firms improve their efficiency and gain a competitive advantage. According to the resource-based view (RBV), however, competitive advantage is largely derived from idiosyncratic resources or capabilities that are not readily replicable by other firms (Barney, 1991). The major effects from the implementation of RFID are automational effects...
on operational processes followed by informational effects on managerial processes (Visich et al., 2009). Since information technology such as RFID is readily available in the hardware and software markets, firms should understand that it is a new tool to increase timeliness and accuracy of information, and not assume that RFID implementations will automatically give them a competitive advantage (Soon and Gutiérrez, 2011; Visich et al., 2009; Powell and Dent-Micalef, 1997).

Therefore, the competitive advantage comes from the effective use of the automated information delivered by RFID systems in a larger enterprise system. Further supporting this perspective is a recent paper showing that RFID utilization directly impacts supply chain productivity and indirectly impacts financial performance through supply chain productivity. However, no connection was found between RFID utilization and financial performance (Green, et al., 2009).

With its origin in RBV, the “strategic necessity” perspective proposes that information technology provides value to the firm by (1) increasing coordination efficiency, (2) leveraging relational intangible resources, and ultimately (3) producing sustainable competitive advantage (Ngai et al., 2011; Clemens and Row, 1991; Kettinger et al., 1994). Thus, this perspective appears to provide a relevant theoretical framework for understanding conditions under which RFID can foster competitive advantage as not all echelons of the supply chain are able to benefit from RFID (Bottani and Rizzi, 2007). Grounded on this strategic necessity perspective, in this paper, we set forth to explore how and when RFID fit into the current thinking of supply chain management and potentially enhance a company’s competitive position in the market.

The rest of the paper is organized as follows. In section 2, we offer the background and the current state of RFID. Section 3 presents how RFID can benefit various stages of supply chains. Despite the fact that many companies have reaped the expected benefits of RFID, RFID implementation is not without challenges. The potential issues and challenges associated with the implementation are identified in section 4. Finally, conclusions are drawn in section 5.

RADIO FREQUENCY IDENTIFICATION (RFID)

Considered a significant improvement over the conventional barcode, radio frequency identification (RFID) is an automated tracking or data-collection technology that enables equipment to read tags at a distance, without contact or direct line of sight. The RFID is also deemed more reliable because the barcode can be stripped away if the paper product labels are ripped or damaged (Angeles, 2005). This does not mean that RFID designs are flawless. RFID tags must be resilient, robust and have a fault tolerance and recovery feature (Zuo, 2011). In addition, an RFID tag can carry substantially more information than a barcode and the information on the tag can be changed as inventory changes status.

Background on RFID

RFID technology is not brand new. It has been around for decades—the British used it to identify aircraft as friend or foe during World War II. RFID has emerged as an automatic data collection and information storage technology (Hammad, 2009). It is used to identify missing pets, monitor vehicle traffic, track livestock to help prevent disease outbreaks, track life cycles of products, manage inventory shelf life and follow pharmaceuticals to fight counterfeit drugs. Injected under human skin, RFID can store an individual’s medical history or control access to secure areas. Recent research has shown that the three areas emerge as the major trends in RFID include supply chain management (SCM), health industry, and privacy issues (Chao, et al., 2007). Therefore, more research into RFID’s is much needed.

Public and industry interest in RFID technology took a substantial leap forward in 2003 when Wal-Mart mandated its largest 100 suppliers to begin using RFID tags on shipped items at the pallet level by 2005 (Bansal, 2003). Other firms, including the U.S. Department of Defense (DoD) and Target, soon followed Wal-Mart’s lead in requiring suppliers to implement RFID. Dow Corning has an internal group that explores new alternatives in automatic identification, and Avery Dennison, a world leader in labels and ID tags, has a whole division dedicated to RFID technology (Sullivan, 2008). Following the same path as many prior technologies, with its costs
declining, the size of hardware decreasing and its technological capabilities increasing, all at a rapid rate, RFID is forecasted to replace the ubiquitous barcode technology for item identification over the next decade (Curran and Norrby, 2011, Wyld and Jones, 2007).

An RFID system, in its basic form, includes readers and tags. As small as a grain of rice or as large as a brick, an RFID tag, or transponder, consists of a microchip attached to an antenna and embedded in a product or put on as a label. The tags are commonly applied in a “slap and ship” manner to the case, pallet, or in rarer cases, the individual products. When the tag comes in close proximity to a reader, the data are captured and redirected to a computer, which is often connected to a network (Srivastava, 2004). More advanced tags can also have information written onto them. A distinctive capability of the reader is that all the data transfer can occur without a direct line of sight to the tag, and an entire pallet or container can be read and/or written by simply passing by the RFID reader.

The Technical Aspect of RFID
The standard data format for RFID tags is a 32, 64, or 96 bit Electronic Product Code (EPC). The EPC data may include details of cost, date of production, date of shipping, expiration data, etc. It is similar to a Vehicle Identification Number (VIN) on automobiles (Taghaboni-Dutta and Velthouse, 2006). This enables the RFID tag to uniquely distinguish each item throughout the entire supply chain and provide real-time location and individual product data.

There are three different kinds of RFID tags available: active, passive, and semi-passive. Active tags typically have internal read and write capability, their own batteries, and can transmit their signals over longer distances (Curtin et al., 2007). They are typically used in situations in which the reader cannot be located close to the tag, as in electronic toll collection. Passive tags have no power source or transmitter; they draw power from the readers and then transmit the information stored on their chips to the reader. Lighter, smaller, and cheaper, they can last for a long time and usually operate in close reading range. Semi-passive tags have batteries but do not initiate communication with reader as active tags do; the batteries can be used to activate sensors to monitor a product’s environmental conditions (Higgins and Cairney 2006).

The reader is a device used to communicate with the RFID tags. It is equipped with one or more antennas that emit radio waves, similar to those of an AM/FM radio, and receive radio waves from the RFID tags. RFID systems work at a number of different frequencies including 125 KHz (low), 13.56 MHz (high), 860-930 MHz (ultra high), and 2.45 GHz and 5.8 GHz (microwave). In a passive RFID system, the reader sends out a signal on a designated frequency, querying if any tags are present in its read field, and if a chip is present, the tag takes the radio energy sent out by the reader to power-it-up and respond (Wyld, 2006). Current reader can read at a rate of 1,000 tags per second. Thus, a truck could simply drive by an RFID reader and all the tagged items inside the truck can be read at the same time).

HOW CAN RFID BENEFIT THE SUPPLY CHAINS PROCESSES?
RFID systems hold the potential for both providing significant “freedoms” that will liberate considerable human labor from certain workflows and facilitating the possibility of making information visible to all participants throughout the value chain (Lee, 2012, Angeles, 2005). This section will identify areas where RFID can be incorporated into various stages of the supply chain management process and provide examples where implementation is beneficial. Some of these real-world examples are based on authors’ experience or study with Avery Dennison, Cap Gemini Ernst & Young, and Sherwin-Williams companies, while others are grounded on extant literature. A summary of different areas where RFID can be beneficial is listed in Table 1.

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Demand Management and Supplier Relationships

It is generally agreed that much of the supply-chain inefficiency seen today is due to supply and/or demand uncertainties that are the result not of customer or producer attributes but rather the lack of information sharing among supply chain constituents (Thonemann, 2002). With the implementation of an RFID system into the supply chain network, coupled with a willingness to share information across the network, these inefficiencies can be reduced or even eliminated. If a store is getting low on a particular SKU, the system would recognize that because it sets thresholds based on replenishment speed and automatically generates orders based on information tied to forecast systems (Spekman and Sweeney, 2006).

Wal-Mart is a prime example of where sharing information between supplier and retailer can be beneficial to both parties. Wal-Mart has been sending data of tagged pallets, cases and promotional displays from its RFID-enabled stores back to each of its 600 suppliers within 30 minutes of a tag being read. This data has enabled such suppliers as Campbell Soup Co., Kimberly Clark, and Procter & Gamble (P &G) to measure the execution of promotions and boost sales (Tajima, 2012, Roberti, 2007). Suppliers are now enabled by the retailer to track whether promotional shippers have been placed onto the sales floor or if sales are exceeding expectations. This creates a great opportunity for suppliers to act according to real-time demand data and respond effectively and efficiently while increasing sales for the supplier and retailer.

RFID’s are showing good results with the fresh products supply chain. The Spanish company ECOMOVISTAND has developed an innovative and ecological packaging and transport unit, called MT, for the grocery supply chain, which can be used in the entire product flow cycle. MT’s are an intelligent product platform using embedded, active RFID tags. Data flows are integrated into an information system that the MT serves; (1) as packaging at the producer, (2) as transport unit, (3) as storage at warehouses, and (4) as display stand at the supermarket, all in the same mechanical system, being thus a Returnable Packaging and Transport Unit. MTs can cover the entire supply chain and provide value-added services to the customers (Martinez-Sala, et al., 2009).

Manufacturing Flow Management

RFID has many value-added applications to the manufacturing flow process. In the manufacturing of big ticket items, such as automobiles, the tags can be attached at the beginning of the assembly process to track the item from raw components to a finished good. By taking advantage of data capacity stored in an RFID tag, critical manufacturing information on a product can be locally stored with the product. RFID technology provides a means for a product to rapidly retrieve its needed information as it advances through shop floors (Qiu, 2007). Each finished good containing a tag would have the ability to accurately identify the origination of each component along with where and when all components were added. This is especially valuable in the event of defective parts or processes that could result in costly reworks and recalls. With the RFID system, the manufacturer would be able to identify only those products created with the defective process or containing defective parts, thereby reducing the amount of rework and recall needed.

The Ford Michigan Truck Plant (MTP) in Wayne, Michigan has begun to implement RFID into its 80 years old manufacturing process. Ford utilizes a just-in-time (JIT) manufacturing process, receiving quantities from suppliers, as needed, and supplying them to the manufacturing line just in time. To aid in its JIT manufacturing, Ford has added RFID locators to its manufacturing warehouses. Pallet load parts are pulled to the workstations by operators pushing call buttons that operate on Ford’s SMART system, which communicates with the WhereNet active RFID real-time locating system infrastructure throughout the building (Kempfer, 2006). This process has allowed Ford to increase efficiency by decreasing time spent to locate palletized items, reducing the chance of lost pallets, which could result in costly down time on manufacturing line. Ford also uses RFID in locating its finished products. Each finished good containing a tag would have the ability to accurately identify the origination of each component along with where and when all components were added (Lee, 2012). At the end of Ford’s assembly process, an RFID tag is hung on the rearview mirror of each vehicle to help Ford locate the vehicle in the plant’s parking lot and alert authorities if its movement is unauthorized (Srivastava, 2004).
RFID can also be used in the collection of raw materials. Three pilot tests, using iRFID (Intelligent RFID), have been conducted by oil refineries to manage the level of oil in the tanks, monitor the vibration level of cooling fans, and to facilitate in the mixing process of different crude oil levels during the formation of gasoline. All three pilots were slated to run for three months and then expanded to include additional RFID-based sensors, as well as tighter integration with the refineries’ distributed control systems (Bachelor, 2007a).

Another study simulated the impact of the RFID on the inventory replenishment of a thin film transistor liquid crystal display (TFT-LCD) supply chain in Taiwan. The result of the experiment shows that the RFID-enabled pull-based supply chain can be effectively achieved with a 6.19% decrease in the total inventory cost, and a 7.60% increase in the inventory turnover rate (Wang, et al., 2008).

Dow Corning uses RFID to track data in steel drums including material numbers, batch number, quantity and other significant information. They also have imbedded flow path logic that issues alerts when chemicals go into the wrong area. This helps eliminate cross contamination and potentially hazardous mistakes (Sullivan, 2008).

RFID systems also allow for the creation of real-time Bill of Materials (BOM), which helps to ensure that all necessary components are available at just the right time. This ensures that there are no interruptions in the manufacturing process or storing of unnecessary materials, reducing holding costs associated with inventory. In addition to creating up to the minute BOMs, RFID has the ability to provide precise cost of Work-in-Process (WIP) to accurately reflect inventory values, to monitor temperatures of sensitive products to reduce spoilage, and to identify idle areas throughout the flow to improve efficiency.

Order Fulfillment and Warehouse Management

Numerous opportunities exist to improve the logistics of order fulfillment by incorporating the RFID system. Substantial productivity improvement is possible because the probability of lost goods would be greatly diminished, merchandise-picking accuracy would improve, and storage space would be used more effectively (Spekman and Sweeney, 2006).

Thalia, Germany’s leading book retailer, has incorporated RFID into its order fulfillmeat process to eliminate lost shipping containers. Its RFID system tracks full containers leaving the warehouse and the empty containers being returned to the warehouse. When a pallet is loaded with as many as 28 stacked containers, a worker ties off the pallet and moves it through one of two RFID-enabled portals at the warehouse. The reader in the portal interrogates each container’s RFID tag within seconds and workers no longer have to scan each outgoing bin separately by hand with their bar-code reader (Wessel, 2007). All information is collected and stored in the warehouse management system by the unique serial number stored on the RFID tag. This enables Thalia to track where each container has been shipped and where any missing containers might be located. Picking items has been improved by incorporating tow-motors with RFID locators, which allows for quick location of products in warehouse and reduces the possibility of picking the incorrect items. RFID also helps to ensure that items are loaded onto the correct truck and provide alerts to employees when items have been incorrectly loaded. An extended advantage of incorporating RFID into warehouse management and order fulfillment is instantaneous FOB accounting for the shipper and receiver.

Alliance Entertainment (AE) is a leading provider of home entertainment products (CDs, DVDs, videos, video games, and related merchandise). Their business model comprises both direct-to-retail store distribution and Consumer Direct Fulfillment (CDF), providing services to over 30,000 storefronts and shipping over five million individual customer orders per year. AE must run a very lean operation in order to realize adequate margins. The previous approach to order fulfillment—manual processing using barcodes—was labor intensive, inefficient, and prone to human error. James Rink, vice president of distribution, worked with Avery Dennison in their Atlantic Technical Center (ATC) to appraise RFID products in a real-world environment. AE’s RFID-enabled order fulfillment solution takes effect upon batch product selection. At this point, a dual label is printed, one of which is RFID-enabled. The RFID
enabled label is encoded with the invoice number and serves as the customer invoice, while the other is a customer return shipping label. Both labels are encased within the packaging, whereupon it is conveyed to the shipping area without any external labeling. Here, a Speedway reader identifies the package by reading the RFID label inside. Subsequently, the package is weighed and a barcode shipping label applied. Post barcode labeling, the RFID label is reread and verified against the barcode label. If a mismatch occurs, the package is diverted for rework. After initially performing verification reads at many points along the line, Alliance Entertainment realized they could reduce read checkpoints to the final verification read operation before shipping and still achieve the desired results, which, said Mr. Rink, included “significant labor and shipping cost savings.” Alliance has since expanded the RFID solution to six automated lines: four in Florida, and two in Kentucky (Rink, 2009).

Hyundai Motor Co. is joining the growing list of automakers phasing RFID into their supply chains. Its implementation centers on tracking of material orders, which takes place in two phases and overseen by Glovis, the automaker’s logistics services affiliate. The first phase employs about 130,000 RFID tags affixed to the cardboard boxes and packaging cases of automotive parts from five main suppliers. The second phase will use approximately 20 million RFID tags annually to track all boxes and containers of automotive parts moving through the supply chains, bound for factories around the world. The RFID tags are expected to help Glovis track the parts at various points in the supply chain including (1) delivery to the Glovis distribution center in Costa Mesa, California and Montgomery, Alabama, (2) repacking and outbound shipment at the distribution centers, and (3) final delivery to the $1.1 billion Hyundai Motors Manufacturing Alabama (HMMA) factory in Montgomery (Bachelor, 2007b).

Customer Service Management

Customer Service Management appears to be one of the most promising areas where implementation of RFID has the most potential to improve efficiency, transparency, and relationships. Retailers can greatly improve customer service by implementing RFID networks throughout their stores. By doing so they will have the ability to reduce stockouts with “smart shelves,” equipped with RFID readers that can detect an item each time it was removed from the shelf, purchased, and instantaneously generate a reorder request to the supplier. In addition, RFID-enabled “smart-carts” can eliminate the time and annoyance of standing in a checkout line, having each item individually scanned. Instead, wireless technologies using electronic payment methods would allow consumers to have their goods scanned automatically and their credit cards charged, and walk out of the store without even stopping at a checkout station (Prater et al., 2005).

RFID systems also offer the ability for retailers to provide accurate location information for merchandise located in their stores. Boekhandels Groep Nederland (BGN), a Dutch bookseller, tags all books with RFID tags to improve customer service and inventory accuracy. Four kiosks located on the selling floor let customers search for particular books and have their locations displayed on screen (Collins, 2006). BGN strives to improve customer service by incorporating an automatic email program that would instantaneously message customers when a book on order has arrived at the store and is available for pick-up.

Leading common carriers such as DHL and UPS have moved forward to explore RFID in their services. DHL recently began experiments with an RFID equipped van. The van is outfitted with an interrogator and seven antennas for identifying RFID tagged items in the van that is also equipped with a GPS device for tracking the van along the delivery route. Recipients of packages could log onto the DHL website to learn not only whether the package was loaded on the van, but also to see where the van is or confirm whether it was delivered. The van’s GPS tracking device pinpoints where the van is at any time in its route and the van number is linked with each package ID number (Swedberg, 2007a).

Another interesting way that customer service has been improved is at shipping ports. Several ports throughout the world have equipped their docks with RFID systems to allowing their customers, the cargo owners, to track containers traveling into and out the ports. The South Carolina State Ports Authority (SCSPA) has joined 80 ports
world-wide to provide SaviTrak Network RFID equipped terminals for tracking RFID tagged cargo for its customers. When an ocean shipment arrives at the port, interrogators deployed at each terminal will capture, then inform the SaviTrak Network server that the shipment has arrived (Swedberg, 2007b). The containers are tracked from this point on until they leave the port.

Product Developments and Recall Management
RFID has the potential to help manufacturers improve new product development and reduce time to market with real-time monitoring capabilities. Store shelf demos can transmit information to the centralized information system about changes in their state because of the usage by potential customers (Curtin et al., 2007). This will enable the manufacturer to respond quickly where defects are discovered and product redesign is required, thereby reducing the time to market for the redesigned product.

RFID-enabled retail shelves also have the ability to track the popularity of new products by monitoring the real-time quantities on the shelves or track interest in new products by monitoring the frequency new product brochures are removed from the display rack. With these technological capabilities, manufacturers are better able to strategically tailor new products based on real-time information of consumer interests. This competency is especially valuable in a time when product life cycles are decreasing and manufacturers must be able to adapt quickly to the consumers’ ever-changing needs.

Reverse logistics can be improved with RFID systems when manufacturers, retailers, and consumers are involved in product recalls. Manufacturers are involved in many routine and some non-routine recalls annually. For routine recalls, due to discontinued or seasonal products, RFID tagged items would allow the retailer and distributor to easily identify the position of ALL items in their locations. The identified items can be removed in an efficient manner from the store shelves and warehouses, returned to the manufacturer, and credits processed and issued in a timely manner. For non-routine recalls, involving defective products, the RFID tags would have the same advantages as in the routine recalls.

IMPLICATIONS FOR SUPPLY CHAIN MANAGERS
While the applications of RFID are wide-ranging, as stated in the previous section, and there is no shortage of glowing reports on the benefits of RFID, successful RFID implementations are not without challenges. Several barriers must be overcome before firms can capture the full potential of RFID technologies. In this section, we highlight some of the challenges and implications for supply chain managers.

Technical Challenges
Cost is frequently a major concern for new technology deployment. Due to the initial high cost, necessary technological adaptations, and unknown acceptance rates throughout the supply chain, there is a risk of experiencing “first mover disadvantages” in the adoption of RFID. RFID total cost of ownership is being pegged at upwards of $10 million for many companies (Hecker, 2005), which is a significant investment considering the rapid changes in the industry and technologies can soon become obsolete. In addition, current cost of passive RFID tags hover around 20 cents per tag and active tags are priced between $2.50 and $6.00 dollars. There is also a clear disparity between retailers and manufacturers, primarily because manufacturers will absorb the ongoing costs of tagging goods. Retailers have more to gain from RFID and faster ROI than manufacturers or suppliers. For item-level tagging of consumer products, the cost needs to drop to one to two cents per tag to be economic for most manufacturers.

A major obstacle in the widespread adoption of RFID technology for global supply chains is the lack of universal standards. For example, for the ultra high frequency (UHT) that is being used to identify pallets as well as individual boxes on pallets, the USA operates on 915 MHz, but his frequency is what mobile phones operate on in Europe. Thus, Europe uses 868 MHz instead. On the other hand, Japan is currently testing 956 MHz due to limitation by band that mobile phone use. The UHF is limited by power regulations governing with how much power the reader is allowed to transmit. In the U.S., regulations currently allow for transmission up to six feet. Europe, meanwhile, has striker regulations and only allows the reader to transmit up to two meters.
Other obstacles that RFID faces are privacy and security concerns, which has been a key setback for RFID deployment for many years. This dilemma in RFID rivets around personal consumer information seeping out to the public. Credit card and social security numbers are examples of the pertinent information that may be leaked when using RFID. A group called CASPIAN (Consumers Against Supermarket Privacy Invasion and Numbering) has formed to actively fight the use of RFID tags. One study showed that 78 per cent of the public are opposed to RFID on privacy grounds, objecting to the fact companies will be able, if they choose, to track every product a customer buys, how much they spend, what happens to the product after purchase (Atkinson, 2004). Just as RFID can aid security, it also puts security under threat. With more data about products, their value and whereabouts, firms need to be aware that a rival or criminal can easily access that data with a RFID reader. Therefore, elaborate coding and the use of a back end database for encoding and enhanced security may be necessary in some situations (Potter, 2005).

Managerial Challenges
RFID is revolutionizing how businesses operate. RFID technologies can drastically change the capabilities of an organization to acquire a tremendous amount of data about the location and properties of any entity that is physically tagged. Although many existing information systems can accept data from RFID scanners, not many are built with RFID capabilities in their IT infrastructure to facilitate a full-scale deployment across the supply chain (Srivastava, 2004). Realizing the full potential of RFID, thus, will require costly integration with existing enterprise systems and possible business process redesign so the vast array of data generated by RFID on a continuous basis can be more fully exploited. Without tying the RFID technology to firms’ existing information systems, organizations can be left with an incomplete understanding of the effects of RFID technology on their existing operations and business processes.

In an era of mobile commerce, the ability to engender “process freedom” (Keen and Mackintosh, 2001) is a critical organizational asset that can generate durable competitive advantage. In the context of RFID implementation along the supply chains and related logistical operations, this implies that firms need to go beyond the benefit of “convenience” and focus on the “freedom” provided by the RFID technologies. A freedom removes a barrier and creates a new space of value, while a convenience offers a new option within an existing value space, but does not add a new degree of possibility (Keen and Mackintosh, 2001). Thus, while RFID can liberate considerable human labor (and error) to improve cost-performance of organizations, how voluminous data should be aggregated and managed to the best value remains profoundly challenging and unaddressed by researchers.

Information sharing has been considered as a generic cure for various supply chain problems such as the “bullwhip effect” and the adverse impact of promotions. To enhance supply chain visibility, organizations have increasingly been sharing information (e.g., forecasts, point of sale (POS), and inventory levels) among supply chain partners for improved performance. For information sharing to engender visibility, however, the information shared must be accurate, timely, useful, and trusted (Chiu, et al., 2011, Whipple et al., 2002). Currently, point-of-sale data is not accurate because store checkout clerks do not always scan items correctly. Data entry error and theft also contribute to inaccurate inventory records. Organized retail crime causes retail loses of $12 to $35 billion a year in the U.S. (Prater et al., 2005). RFID systems can help enhance security and reduce theft, remove human errors, and ensure the information shared to be accurate and timely, thereby improving supply chain visibility and firm performance.

The more organizations continue to learn how to analyze, interpret and best utilize the huge data generated by RFID, the more they will recognize that RFID benefits will continue to be realized long into the future. As such, those characterized as “learning organizations” will be better positioned to develop the unprecedented supply chain competencies engendered by RFID systems.

CONCLUSION
RFID is experiencing rapid adoption in the world’s supply chain as a method of identifying and tracking inventory (Wyld and Jones, 2007).
Applications of Radio Frequency Identification (RFID) in Supply Chains:

Although RFID deployment in supply chains is still in its early stage, it holds tremendous potential for improving processes and may fundamentally alter the way supply chains are managed today. With continued improvement and widespread adoption, RFID is expected to lead to major reductions in logistic and other supply chain costs (Reyes et al., 2007). A recent study conducted in retail supply chains also identified RFID as a key enabler of better integration of timeliness and accuracy data flows in information systems, improved system-to-system communication, and better inter- and intra-organizational business process integration (Fosso Wamba, 2011).

Since RFID systems are readily available in the hardware and software markets, firms cannot expect it to produce sustainable competitive advantage on its own. Grounded on this strategic necessity perspective, we set forth to explore how RFID fit into the current thinking of supply chain management and where it can enhance a company’s competitive position. In this study, we have identified various stages of supply chains, including (1) Demand Management and Supplier Relationships, (2) Manufacturing Flow Management, (3) Order Fulfillment and Warehouse Management, (4) Customer Service Management, and (5) Product Development and Recall Management, where deployment of RFID technologies can be beneficial and productive. While RFID systems have the “magic touch” to provide firms with real-time supply chain visibility, successful implementations are not without challenges. Thus, this study will be of value to managers who are attempting to implement RFID technology in their supply chains.

The advantages of RFID are clear but the fit of such a technology with organizational factors will determine the success of its implementation (Singh et al., 2007). To capitalize the vast potential of RFID, the technology needs to be linked to a firm’s enterprise applications such as ERP. When integrated together, RFID technology is capable of enhancing communication with customer and providing unprecedented monitoring of supply chain activities and performance. As companies continue to gain knowledge of utilizing real-time data captured by RFID, transforming data into meaningful information, and sharing this useful information, they will be increasingly able to make informed decision enabled by better supply chain visibility. The race to successful RFID implementation appears to rest on organizations that can learn quickly and continually to fully capitalize on the new RFID-enabled capabilities and benefits.

References


