Perspectives on RFID Readiness

A Comparative Analysis Between Skanska and Datema

Written By:

Thanaporn Charupa 1983-12-12

Tie08tea@student.hig.se

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Examiner: Lars Bengtsson
Supervisor: Lars Bengtsson
Preface

This paper is a Master thesis report in Logistics and Innovation Management, written for the department of Department of Technology and Built Environment, part of the University of Gävle, Sweden.

This thesis is based on RFID technology and how firms use their resources to evaluate RFID readiness within the confines of their operations. Two distinct case companies will be evaluated to draw some conclusions based on the analytical findings.

I would like to thank firstly my thesis supervisor Lars Bengtsson for his time and guidance for this report. Also, I would like to show the deepest of gratitude for Kristian Thisted and Oskar Josefsson for sharing their time and wisdom from their busy schedule. Their knowledge was critical for the completion of this thesis.

Thanaporn Charupa

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Abstract

In global supply chain management, radio frequency identification RFID has emerged within the last decade and became a superior technology for information storage. However, the technology has not yet been widely accepted or used in comparison to the barcode.

The underlying interest is to explore RFID technology, to understand the benefits and drawback that this innovation brings. Once functionality and application comprehension is overviewed, specific models such as SWOT analysis, Real Option Theory, Technology Push-Pull model and RFID Implementation stages can be applied to evaluate a firm’s RFID readiness.

The findings are based on two Swedish case companies Skanska Maskin AB and Datema. Information from the case companies are consolidated and aggregated to analyze and derive the methods used to discover the firm’s ability to adopt RFID. The analysis will discuss the factors involved with the technology and recommendations for future studies are given.
1. Introduction

Radio Frequency Identification technology has been an emerging method compared to the barcode system. This technology involves the use of sensor networks to identify objects by the means of radio frequency waves. The revolutionary innovation was created and expected to replace that technology of the barcode because of superior information storage, retrieval capabilities, and data analysis methods.

This technology has been widely adopted in many industries, whether it is in race timing, passport control, transportation and toll services, libraries and various warehouses. The paper will deal with the usage of RFID in product tracking of supply chain logistics, product tracking, inventory management, transportation and warehousing activities. Retail giants such as Wal-Mart and Procter & Gamble have implemented this technology while other small or medium players lack the resources to cross over (Raveendran 2008). Keeping the economic crisis in mind, it is interesting to explore how and when RFID will become common technology for all players to adopt.

For corporate competitiveness, the supply chain is a linkage for planning and control process. Supply chain management involves integrating all decisions that affect the design flow of materials and services into a finished product. The players must be able to consider and learn the effectiveness of RFID to implement best class performance, improving their network efficiency to be above the average companies in their industry. First world countries have often saved millions on this technology alone (Mehjerdi, 2009).

In decision making on large scale investments in more advanced technology, many issues have to be reviewed and analyzed before management can be implemented in all processes of the supply chain. Many companies used different methods to evaluate whether or not to implement RFID. A common tool is the discounted flow technique or the real option analysis, which provides calculations of expected costs and profit of the RFID project. Models such as SWOT analysis, Real Option Theory, Technology Push-Pull model and RFID Implementation stages are more complex in nature and may need to be modified according to that company’s business or operations to reap the most benefit for evaluation. These tools will be used to identify the decisions made when dealing with RFID implementation processes.

1.1 Research Problem

Within the last decade, RFID technology has emerged as an innovation for supply chain logistics. However, since the discovery, the innovation has not taken off as a common tool for tracking of items or products and database management. Despite showing tremendous improvements in inventory efficiencies, warehousing, distribution, logistics and security, many firms still have not considered themselves ready to embark on this innovation. New research are still being studied to hedge the risk of high initial investment cost, the motivation is to learn, explore and investigate how firms derive this decision and what method as applied use in doing so.
1.2 RFID Readiness

To differentiate from the other studies conducted in RFID technology, the scope of this thesis will be defined. RFID readiness is described as a firm’s capability, after internal and external assessment, to successfully implement this technology. The paper will not deeply focus on implementation of the technology, but more in terms of the decision-making process and tools used to reach that verdict. This will explain why some firms have not opted to utilize this technology.

2. Purpose

The aims of the study are in relation to RFID and the readiness of a company before adoption. It will review the driving forces behind this innovation and the obstacles and drawbacks as of today. From a supply chain perspective, technical operations in a supply chain and the impact on businesses with regards to RFID technology will be explored. The research questions are:

1. What industry-specific factors are involved to push a company to determine whether or not to implement an RFID project?

2. How to evaluate RFID readiness in a company?

3. Background & Related Work

3.1 RFID Components

There is a need to achieve RFID status for certain supply chains, to be low cost effective and enhance data storage. When there is an increase in inventory levels, it is essential to tag, categorize and track. The weakness of barcode is in its capabilities. As both 1-dimensional and 2-dimensional barcode (62-249 characters) still contain very little descriptive information. Barcode is strained in being able to read products from a far away distance. (Janecek et. al. 2007)

RFID consists of transponders (tags) and interrogators (readers), transferred through wireless communication (see fig. 1).
The process consists of the reader, sending out a signal via radio frequency. Tags then receive this from antennas, or silicon chips. Selected tags then transmit their stored data. Reader receives tag’s signal with antennas and decodes the data. Finally, the reader transfers data to application systems.

### 3.1.1 Tags

Tags carry serial number, model number, location of assembly and other data vital to any operation can be programmed to store. These tags are small items attached or imprinted on papers, which are then juxtaposed onto other items or products. Giant retailers Walmart and Target are the first movers to implement this technology (Janecek et. al. 2007). Tags can contain small amounts of information to 1024 bits. Tag size can range from a grain of rice to two-inch squares. New tags are easy to hide, with some being invisible to the human eye. Tags can also be easily detached or removed.

Tags with microchips can store more than chipless tags. Chips can process data and contain internal power source costing around ($0.01-.02) per bulk order of 100,000 tags (Janecek et. al. 2007) Chipless tags are less expensive per bulk. The prices of both tags are expected to decrease in the future as learning curve is increased and manufacturing costs decrease. Chipless tags are for small range, needs an external power, and are read-only. Chip tags are heavier and have more usage in application as they can be read-only or read-write, allowing memory to be rewritten many times.

Similarly, there are three kinds of tags: passive, active and semi-passive tags. Passive tags do not contain an on-tag power source, have shorter range, are smaller, lighter and less expensive. They are powered by electromagnetic induction, which consist of a coupling between the coil of the reader and the coil of the tag. Active tags contain a small power source, have both on-tag power source and active transmitter and contain a longer range for radio signals. A
capacitor is used to store energy until there is enough energy to transmit the data. This makes them better suited for tracking of shipments or containers in transit as they can range over 100-feet away. Active tags are being used over long periods of time and reusable as well. Semi-passive tags are similar to active tags, only in the sense that they still employ passive response from the tag to the reader (Janecek et. al. 2007).

3.1.2 Readers

Readers are devices that ‘reads’ tags. They consist of antennas, used for sending or receiving signals, a transceiver, used for encoding and a processor, used for decoding data (Janecek et. al. 2007). Readers resemble circuit boards or handheld devices mounted or strategically positioned in warehouses to read inventory. Readers function to provide power to passive tags and chips. They receive a radio’s transmission from a tag, conduct error checking, and communicate all the data to an application system. Examples of readers include library book sensors, security exit sensors and sorters. Readers have a finite range described as an interrogating zone, where active tags have larger zones than passive tags. A reader must be able to read multiple tags in its range but often the presence of other readers interfere when they are in the same range.

3.1.3 Operational Frequency

In terms of operating frequency, the governing body is in charge of the regulation of the tags. For example in the US, the Federal Communications Commission (FCC) is responsible for publicly determining the appropriate frequency. The four different frequencies are low frequency (LF) 15Hz, high frequency (HF) in 13.56MHz, ultra high frequency (UHF) in 868-915 MHz and microwave in 2.45 and 5.8GHz (Janecek et. al. 2007). An LF tag is a passive tag with short range, expensive, because a longer copper antenna is needed. LF has high performance, and some basic applications include access control and vehicle immobilizers. An HF is also a passive tag and its applications include smart cards, item-level tracking and libraries. UHF tag is an active tag with a battery, good performance and range, and multiple tags can be read at the same time. UHF tag applications include pallet tracking, electronic toll collection and baggage handling. Lastly, microwaves are the worst in performance level and rarely preferred to compare to the others.

3.2. Logistic Functions

To understand and comprehend how RFID technology and its benefits on supply chain logistics, firstly the basics of SCM must be identified. In supply chain logistics, there are 5 major departments, which are all positively enhanced with the successful implementation of RFID technology (Chung & Jones, 2008):

Demand Planning and Forecast- The first step of an organized supply chain entity is to strategically develop a solid business plan about all processes from start-to-end of the product or service. Demand planning will aggregate the resources needed to provide an overview of all tasks in the business. RFID can provide a more in depth calculation and accuracy as it produces more input data for computation. With up to dated real-time information and data,
planning is done with clear transparency and input data makes forecasting of resources more precise.

**Procurement**- Procurement function involves in the buying or purchasing of resources. This entails negotiation of prices and verification of shipments and arrivals. RFID technology can bring about more automated processes, decreasing procurement costs and increasing efficiencies in time. The procurement processes can be shortened with better application systems program to buy or acquire essential resources.

**Manufacturing and Assembly**- Manufacturing and assembly are critical parts in any supply chain. In a complex network, manufacturing and assembly are done by many different companies. RFID will provide automation process in organization, design, control and information sharing. Manufacturing processes will be incorporated, with simplification and linkages toward other partners.

**Distribution**- Some of the functions under this category includes warehousing, delivering, invoicing and payment collection. Point of sales such as sales store and warehouse have automated processes as information transfer becomes faster and easier. Inventory levels are reported systematically and replenished, avoiding stock-outs. This lowers the cost of safety stock and shelf space, adding to a better customer experience.

**Returns**- After-sales services are also critical to ensure that customers are satisfied and also for receiving feedback for marketing or manufacturing purposes. Defective merchandise can be spotted and returned back to manufacturers easier with the help of RFID. Other processes such as returns and management credit accounts are done more efficiently.

### 3.3 Benefits & Solutions

According to Wyld (2006), the RFID market is estimated to grow to over $25billion by 2015, with estimated around tens of trillions of tags by that time. The acceleration is propelled by increasing new usages for tags and applications, new ways of doing businesses, new conveniences and new opportunities. Below is the current RFID project undertaking for application by area (see graph 1). Notice that supply chain management and manufacturing applications represents the largest portion of the pie chart at 35%.
3.3.1 Increased Accuracy in Forecasting

Reducing uncertainty and increasing information flow are essential to the adoption of RFID. According to Khumawala et. al. (2006), economists believed that increased accuracy in forecasting is acceptable to a certain point. Beyond that point, it is more effective to tolerate uncertainty and stock up on inventory. Other benefits of new technology will allow deeper and thorough statistical analysis and correlation, in addition, offering more modernized solutions to business opportunities. More global data will be integrated, as all parties have increased awareness in traceability and forwarding. The customers will benefit as all transactions become faster and more accurate (Ranky, 2006).

RFID is an essential part of tracking technology in production and manufacturing to support logistics planning and execution. RFID can improve statistical forecasting, saving costs and portraying a clearer picture of the scope of manufacturing or production operations. For manufacturers, RFID plays an essential role where parts are in the assembly line. Tags can be tracked and retrieved at ease, despite being stored in a large or cluttered warehouse (Khumawala et. al. 2006).

3.3.2 Inventory Reduction & Management

One benefit of RFID reduces stock-outs, from warehouses to distribution centers to actual retail shelves. Reducing inventory levels can lower cost of inventory, such as cost of space, utilities, insurance, shrinkage and opportunity cost of invested capital. Shrinkage is a concern as inventory held for long periods of time maybe lost, spoil, become obsolete or stolen. RFID can also help improve environmental conditions and security, by providing information about location, environment and evidence of tampering (Erickson & Kelly, 2007).
In trying to search for new solutions, business processes are configured in design or improved to rewrite existing programs or knowledge. RFID technology will revolutionize point-of-sales and retail markets, but at a slow pace (Smith, 2005). RFID seems to benefit retailers the most, with increase in inventory returns and improvement in customer service. RFID will also enable some changes in transportation. For example, suppose a shortage of inventory or stock is detected on an air cargo haul. With RFID, earlier detection of this problem can result in correction of quantity, and thus alternate transportation technique such as trucking can be utilized to save costs and minimize losses. International air cargo is an issue as there are no viable substitute because it those most costly method of transportation. With more increasing complexity in RFID requirements, 3rd party logistics industry is expected to grow at a steady rate as many companies need advice on their logistics strategies (Twist, 2004). Lastly, common technology such as Electronic Database Interchange (EDI) and web-based technology have significant increased in productivity and capabilities (Chung & Jones, 2008).

3.3.3 Traceability

Some advantages that RFID provide include improving the speed and accuracy for tracking pallets, boxes and containers for logistical services. Reducing stock levels is keen in reducing operating costs, which enhance overall inventory management and total operating costs. Work-in-process (WIP) reporting and visibility in Just-in-time (JIT) systems are apparent and becomes easier with successful implementation (Mehjerdi, 2009).

The tagging of products, for example, in healthcare supply chain logistics can reap great benefits. It can establish faster movement in both downstream and upstream. It will enhance capability in scheduling and checking availability of equipment. Collaboration and relationship management in RFID are long term projects in the healthcare industries, because major investments are needed (Kumar et. al. 2009). This industry represents products in high value and also high demand in short time as patients need their medication or treatment.

There are still problems when researching the end-to-end traceability, as the ‘combine and split function is overlooked, causing incomplete traceability in the process occurring on the big four tiers, supplier, manufacturer, wholesaler, and retailer, but mostly it is crucial in the manufacturing tier (Lee & Park, 2008). The need for more dynamic RFID is needed to reconfigure this dilemma, also refer to as dynamic tracing task mode (DTTM). DTTM is better suited since it not only traces the end product, but the components involved. The bill of materials are incorporated in the system into sets and then used to create certain rules for connections to final goods and subparts involved. Without DTTM, large amounts of raw RFID data will fail to be linked to the items or parent items (see appendix 1).

RFID data management have suggested to clearly filtering unorganized raw data, into presentable data model that can be processed effectively. Better yet, the key is to transform the data into more meaningful and valuable information to support management and supply chain decisions. For example, a store sells thousands of items per day, and that each item can be scanned thousands of times before being purchased, leaving a trail or path generating millions of megabytes of data. These paths are critical information as they provide insight and pattern of the flow within the system, for example location, duration, time-in and time-out. In
the four tiers involved, supplier, wholesaler, and retailer tiers are all products transported in
the end item. However, the manufacturing tier are combined and divided during production to
create the final product. The three tiers existing path will be used with DTTM to be applied to
create a full view of traceability (Lee & Park, 2008).

3.3.4 Collaboration

A supply chain is a complex network of working relationships and business processes to
achieve the task at hand by using resources, such as technology, technical knowledge,
equipment, personnel and capital. Some firms in a supply chain may opt to look for
collaborative resource sharing to enhance competitiveness to tackle specific strategic goals.
For example, in the packaging industry, customers have multiple requirements for the design
and development of packaging, including commercial, logistics and environmental concerns.
The supply chain must work together, from producer to consumer, to establish a common
ground in which to fulfill these requirements. RFID is a tool that strengthens this dilemma as
tags can help with marketing issues on pricing or shelf space within stores. As firms battle for
profits, achieving technological advancements in IT infrastructure, they seek to reap benefits
of investments for their initial technology. With future reduction in RFID costs at stake and
new applications emerging, a renewed sense of motivation for improving efficiency has
become apparent (Rundh, 2008).

3.3.5 Warehousing & Distribution

RFID technology is associated with the global supply chain and its control of shipments, to
secure the best quality of products. An RFID tag can stay active with a lifeline of 40 years of
operation, recording important knowledge and history of the particular product or component,
which includes features of shock sensitivity, temperature, mishandling issues and overall
environmental impact (Ranky, 2006). Recycling options is a valid solution as cost savings are
increased. Also in terms of process, more cost savings in terms of paperless transaction can be
seen as automation. According to Chung & Jones (2008), RFID can enhance the following
warehouse tasks:

- Inventory Accuracy
- Space Utilization
- Picking Information
- Slotting
- Order Picking
- Order Accuracy
- Returns
- Vendor Coordination
- Performance Reporting
- Strategic Planning

Within the warehousing industry, cost savings can be found in labor and space saving.
Functions such as pick, pack, shipping and receiving can be enhanced with less error rates
(see appendix 2) with competence in space utilization. Specifically instead of moving items to
an area for verification, RFID readers can verify items without movement, which can be
directly loaded to lorries and trucks, ready for outbound transportation. This function will increase the importance of cross-dock facilities (Twist, 2004).

3.3.6 Asset Management

As tags provide identification of product with distinctive information storage, data such as configuration settings, inspection records and service information can be stored for enhanced asset management. Without a staff to manually read or to record information, this task often saves time and are seen as accommodating to auditing and inventory control. Asset management can be strengthened to track and record automatically the location of the tag, and alerted if the assets are moved from the specified area. In many cases returnable containers are never returned after shipping to customers, resulting in a cost deducted from corporate profit. The RFID system can tackle this problem as containers or pallets are usually stored or stacked with thousands of other items belonging to various companies. The value of the application brought about organized audit trail and also can be used to adjust to the bill to a customer, if the materials are not returned.

3.3.7 Customer Relationship Management

Based on CRM the concept, Smith (2005) stated that RFID helps the ability to anticipate the future and act on it to create loyal customers. Customer relationship management has increased significantly with the added functions of RFID technology. Traceability across the supply chain becomes apparent in terms of customer satisfaction and loyalty, in terms of enhanced services such as automation in check outs, returns or warranty issues. The speed of responsiveness and transparency with real-time data feedback can identify customers’ demands. Improved customer service is evident as responsiveness shows an increase in correlation with RFID. Delivering value to customers will reap long term competitiveness and earn market shares within the industry (see fig. 2).
3.4 Drawbacks & Challenges

The existing challenges may be the battle versus the popularity and accepted worldwide usage of barcode (see table 1). Many companies are content with this technology and changes in organization for setting up RFID systems may be difficult to initiate, for example, setting up RFID in a typical convenient store. Investment costs are high and know-how specifics require expertise in technical familiarity. This drastic measure requires great deal of loyalty, patience, cooperation and feedback from suppliers, 3rd parties and customers.
### Table 1. RFID vs. Barcode
Source: Chang et. al. (2008)

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>RFID</th>
<th>Bar Coding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading capability</td>
<td>Wireless—line of sight not necessary (some environmental exceptions).</td>
<td>Optical—line of sight required.</td>
</tr>
<tr>
<td>Reading speed</td>
<td>RFID can read multiple tags in a single pass.</td>
<td>Bar coding can read a single label per scan.</td>
</tr>
<tr>
<td>Durability</td>
<td>RFID tags are capable of storing several thousand characters, or several kilobytes, of information.</td>
<td>Labels tend to be damaged in harsh processes. Etching directly onto part has increased durability.</td>
</tr>
<tr>
<td>Amount of information</td>
<td>RFID tags are capable of storing several thousand characters or several kilobytes of information.</td>
<td>A 1D bar code can store 20 alphanumeric characters, while a 2D bar code can store roughly 2,000 characters.</td>
</tr>
<tr>
<td>Flexibility of information</td>
<td>To update information, many RFID tags can have their memories updated with new information through wireless communication.</td>
<td>To update information, a bar code label must be replaced with a new bar code label.</td>
</tr>
<tr>
<td>Security</td>
<td>RFID tags have manufacturer installed identification codes that cannot be changed, thus making counterfeiting difficult.</td>
<td>2D bar codes provide encryption capability.</td>
</tr>
<tr>
<td>Cost per label or tag</td>
<td>RFID tags cost from $0.25-$0.50, up to $250.</td>
<td>Bar code labels typically cost less than $0.01.</td>
</tr>
<tr>
<td>Standards</td>
<td>RFID lacks complete standardization, especially in the global environment</td>
<td>Bar coding is standardized and widely accepted.</td>
</tr>
<tr>
<td>State of infrastructure</td>
<td>RFID is minimal. Users would have to invest in additional equipment to support RFID.</td>
<td>The infrastructure to support bar codes is in wide existence.</td>
</tr>
</tbody>
</table>

#### 3.4.1 Technology Compatibility

A certain obstacle is the adjustment or integration of new technology to replace old legacy system in terms of data warehouse business systems. Certain adjustments in IT compatibility will have to be restructured or reorganized to fit all players in the supply chain, to show close to real time inventory, as well as cross reference products and items. In terms of updating computer systems or software, there are some concerns as the compatibility of not only one entity within the supply chain, but other entities, in regards to what systems to use.

Giant retailers such as Walmart have forced many of their suppliers to change to the new RFID system. This may present a dilemma in terms of technology readiness and willingness as companies are forced by suppliers, customers or changes in the market to adopt new technology. Moreover, smaller details such as design options and chip size are essential criteria, when it comes to mass production. Some other technical concerns are availability of tags in the market, failure rate and disposability.
3.4.2 Investment Costs

Another obstacle is the need to register or apply for the identification codes or registry. Within the United States, a registry is required with Electronic Product Code Registration (EPCR). This costs about $200,000 (Smith, 2005).

RFID costs are major issues as implementation costs have skyrocketed. It requires investment costs in tags, readers, hardware, software, maintenance costs and additional costs. RFID standards also present another dilemma. To gain maximum utility, supply chains need to operate on common tags, readers and frequencies. This will require standardization and costs associated with it to drop, so compatibility and synchronization can be achieved. The key here is the selection of tags and readers, so they are well-equipped and opted for best performance possible. For example, this can include size of the chip, design, frequency and antenna characteristics (Khumawala et. al. 2006).

With new technology implemented in the organization, training costs for staff are costly as there is less personnel working and training costs are needed to ensure the understanding and usage of RFID. Other technical costs included are testing costs and application upgrades.

3.4.3 Traditional & Global Challenges

For early European adopters, there were supply chain problems with on-shelf availability in retail stores, poor customer service reports from manufacturing and logistics companies and excessively high stock of inventory in storage (Johnson, 2008). With increased globalization in processes, outsourcing and procurement, the need to establish competitiveness in a supply chain became a determinant for adoption of RFID technology to combat traditional logistics constrains of temporal and geographical boundaries due to separation of materials and information flow.

In many industries the need for chips have not yet been established as a common tool, thus presents the need to build demand for chips. There are few suppliers who can foresee the demand accurately, enabling them to take advantage on pricing selection. This entitles the IT infrastructure of a global supply chain to be modified or upgraded to cater the specifics of RFID technology. Knowledge flow needs to be apparent in terms of application and implementation to successfully maximize the return on investment. Many different markets may not be interested as their market produces cheap or low cost goods, thus sometimes the tags itself may be too costly to be attached to the final goods. Lastly, data sharing and security needs to be transparent across the entire supply chain, which currently cause many entities to avoid RFID (Twist, 2004).

3.4.4 Environmental Concerns

Another factor slowing down the readiness is that the fact that low-cost tags does not perform at a satisfactory level, conveying that there are errors in misread or no-read at all occurring. Environmental concern such as radio interference is another issue. Some chips can’t be used on products, especially for food products due to environmental specifications, take for
example, cold environment (Smith, 2005). Radiowave interference such as metal or fluids is a problem as many companies use these materials in their production or manufacturing phase.

Another obstacle is associated with incorrect reading of scanners and tags due to the fact that UHF waves are absorbed by water and other liquids and also waves are often reflected by metals. The solution to this obstacle is plausible but quite expensive, so suppliers may refuse to comply with the development of the corrective technology (Rundh, 2008).

### 3.4.5 Importance of Stakeholders

There are also certain hindrances related with this kind of new technology in the business sense and also the global scale. As RFID is a type of investment, assessment is needed to ensure that both stakeholders and customers are well informed and satisfied with the technology (see appendix 3). Openness and transparency in practice of business conduct is essential for collaborative purposes. Limitations on certain uses or functions of RFID, is needed to be specified to ensure agreed understanding as well as accountability or liability.

Skepticism still remains as the growth of global standards are still growing and regulations and integration and still being developed (Chung & Jones, 2008). Strong leadership will be a determinant to promote such incremental or radical changes. The risks involved without implementation is lost of competitiveness, as if the competitors implement the technology first. Vision, strategy and purpose all have to suit the stakeholder’s best interest.

### 3.4.6 Consumer Concerns

Challenges in RFID include consumer concerns as tags can be monitored once the product has left the stores (Juban & Wyld, 2004). Despite legal and ethical standards already established by the U.S. and Europe, the issue is still of dire importance as the lines are not precisely clear cut. Suppliers are keen to implement the tag in the package, while consumers are worried about the risks of monitoring the actual usage or consumption of product itself. Introduction of RFID technology seems to be slowed down by the lack of world-wide industry standards. Privacy or proprietary information, in relation to which information should be disclosed or tracked is another issue.

Social impact of consumers’ backlash has caused companies to cancel implementation of this technology due to customers’ concern. The best way to combat this is to strive for education to customers, that tags can only be read for several feet away, and that they can’t be tracked all over the world. A good example is the acceptable uses of 'kill switch’ or disabling RFID chip at point of sales to ensure that consumers are not tracked once they purchase the product is a main concern.

### 3.5 Inter-organizational Factors Influencing RFID

RFID in the supply chain involves many parties, and nowadays, spreads all over the world in terms of teamwork and collaboration. In order to effectively implement or adopt RFID technology, certain business relationships need to be considered. RFID technology may have a positive influence in collaboration beyond physical boundaries, but it can have some
negative impact on buyer-seller relationships. From Boeck & Wamba (2008), key issues that would have impact on buyer-seller relationships include:

**Communication/Information Sharing** - Communication is essential part in any business venture, especially for large or complex supply chains. The flow of information is critical to all parties, as there is a need to share knowledge, downstream and upstream, about product specifics and to verify shared understanding.

**Cooperation** - This includes working together in small or big teams, externally or internally, upstream and downstream and cross-departmental are a part of collaboration in RFID implementation. This can enhance productivity and it speeds up the learning curve and increases benefits for all parties.

**Trust** - A sense of trust needs to be maintained, as partners heavily demand on time delivery on product or service specifically requested. Long term partnership is the key in exchanging and sharing selected and private information. This will lessen constant verification procedures, and increase transparency, accountability and reliability between all organizations.

**Commitment** - Long term commitment is an agreed ideal for all parties as financial investment becomes large scale. Effort and resources are needed to ensure RFID adoption. In the project completion, all parties expect the relationship to last and become profitable and add value.

**Relationship Value** - As the business relationship grow and prosper with time, collaboration may lead to new opportunities such as networking. The value the parties involved in the final product can ensure the high expectations the customer has.

**Power Imbalance and Interdependence** - In collaboration, there are a variety of sizes from different entities. This presents some issues with power and dependencies with supply chain. There is a tradeoff, as in give and take is a must in working together. For example, suppliers can suffer in sunk cost investments. Buyers should be concerned and aware that the suppliers will gain more advantage from competition with the installment of RFID. Personal interests are needed to be explained in order to find mutual interests and reach a win-win outcome.

**Adaptation** - Adaptation or changes will need to be addressed as the product moves down the supply chain. Here manufacturers will face pressure to adopt or react to certain technological changes. Effective adaptation can minimize disruptive issues in terms of compatibility and secure business continuity. There is a need to look deeper at the specific changes with regards to company culture.

**Conflict** - Conflict resolution or problem solving are needed to brainstorm as certain unexpected issues that may arise. Positive reinforcements for trading partners can be an example of resolution to battle confliction views or disagreements.

### 3.6 The Future of RFID
RFID will be more effective in future usage in terms of coordination and controlling the enterprise in resource planning on a global level, tackling issues such as e-commerce initiatives and continuous resource replenishment (vendor management). RFID exerts similar demands so that infrastructure on materials planning, computer integrated manufacturing systems and reconfiguration of processes to fully reap the benefits. RFID can also be used to simply add incremental innovation that only requires minor reconfiguration of core competencies. New applications are emerging, rewriting the laws of supply chain dynamics (see appendix 4).

In terms of the differences in each country’s global radio spectrum, meaning different countries approve usage of different RFID frequencies according to the government or controlling body. Also tags need to be correctly attached to correct items at the correct time, so that tags can track or transfer data efficiently. Ideally, the tags should be attached as early as possible within the supply chain. This correct time, correct place dilemma needs to be established by the logistics function so that the tags maximize the potential benefits accordingly. Information can be readily available and exchanged through different departments. The technology can be used to focus on reusable tags, pallets, totes and containers, which will have new advantages as new applications are developed in the future (Smith, 2005).

Readers are required to be strategically placed within the warehouse to provide the best visibility. Solutions are needed not only for the price of readers and tags, but the investment needed on infrastructure, in software and hardware installation. There is plenty of RFID-generated information, which will be useless without the aid of Enterprise Resource Planning (ERP) or Warehouse Management System (WMS) integrations. The expectation is that barcode and RFID will coexist for some time in the future before barcode technology becomes obsolete (Twist, 2004).

The next wave of readers will involve multi-frequency readers or agile readers, which can be more compatible with many manufacturers’ specifications. Currently many companies are reluctant to invest in significant resources due to uncertainty of the benefits of the technology. In future supply chains will be enhanced in manufacturing automation, logistical control, e-commerce applications, mass production, wireless interaction, tracking of consumer goods and diffusion of tags around the world.

4. Methodology

‘Research is a systematic investigation of a question or resolution of a problem, based on a critical analysis of relevant evidence.’ (Walliman, 2005)

4.1 Literature Review

This paper plans to outline the intricacies of RFID usage and the readiness of this particular new technology to logistics companies. There have been numerous journals and articles on this topic, but the main focus is to further explore to understand why this technology has not yet emerged within the business arena. Firstly, understanding the principles of RFID is
necessary as the functions and applications provide a framework of how RFID is used within supply chain logistics.

The scientific journals and books are collected with the purpose to read and analyze, in order to summarize the different perspectives on views of RFID. Using previous studies as references, RFID technology will be discussed in-depth more of the present and expected future performance. This will help answer questions concerning challenges and opportunities. The paper will not deeply cover all the processes and functions of how RFID works as it can be found in other literature reviews and journal articles. The technical processes and mechanics have already been studied and are merely used as a stepping stone to explore more critical logistics issues.

4.2 Connections of the Literature Review

The literature reviews were broadly chosen based on the diverse global perspectives and different viewpoints that are present with regards to RFID. This describes the international standpoint on RFID with respect to supply chains across boarder. It is interesting to see how different countries, markets and industries view RFID technology and its benefits and drawbacks. Most of the articles were chosen based on their knowledge on discussion of Logistics functions and RFID applications. Due to the lack of literature review on Swedish firms, the need to assess the global viewpoint is important as it provide examples for decision making to other firms.

4.3 Qualitative Data

The qualitative data are collected in the Emerald database found on the University of Gävle. Also some articles are found in the internet are searched by keywords such as RFID ‘readiness’ and ‘adoption’. The data derived from these literature reviews provided a holistic framework of RFID structure and its impact on global businesses.

Another part of the qualitative data collection is gathered by interviews with the case company. This is essential to adding new data to the already abundant information available on RFID evaluation.

4.4 Quantitative Data

The quantitative data gathered was given by Skanska, in terms of internal company reports. This described the cost calculations and findings of different possible technologies and with comparison. Datema did not provide quantitative data for analysis as the company had privacy agreements with their customers concerning legal disclosure.

4.5 Case Company & Interviewing Process

First-hand experience was gathered through interviews with case companies, to find out the positives and negatives of this technology, which can demonstrate the readiness for new technology adoption. It was more interesting to interview Swedish companies, rather than other companies around the world, since it was convenient to travel and have face-to-face
interview sessions. Also after the first preliminary interview, a follow up interview via telephone was also conducted to clarify or reemphasize certain points that were raised during the first interview.

The first interviewee was Kristian Thisted, system developer at Skanska Maskin AB. During the research on Swedish firms, Skanska was one of the leaders in construction. Since the company was not a traditional manufacturing and assembly company, many appealing ideas could be learned if they have decided or not to implement RFID technology.

The second person interviewed was Oskar Josefsson working at Datema. This company was known for implementing RFID and was recommended by thesis advisor Lars Bengtsson. The company seems to have been an innovator of technological advancements and is a perfect candidate for an in-depth interview.

The two companies were chosen due to their distinct characteristics. Despite the differences in industry and market, some comparisons could be made with regards to RFID readiness. Please note that both companies are not conventional retailers or manufacturers. This is also an attractive point as many studies have already been conducted on traditional large manufacturing and production companies in the supply chain. It also provides the different viewpoints on concerns regarding the expertise on industry-specific issues.

### 4.6 Analytical Process & Data Analysis

From the global perspective, RFID technology was thought of as the breakthrough invention that will change the way businesses operate from the traditional sense. From the initial research before the interviews, both companies were not retailers or traditional-manufacturing companies, which could result in a comparative or correlation analysis between the two.

Most of the theories relating to the analysis such as the ROA, RFID implementation stage, and the technology push (TP) and need-pull (NP) strategy were selected as secondary data. Despite the many different model of calculating or evaluating RFID readiness, there are no models that can be directly to apply to this concept. RFID adoption models are then used to provide a foreground of how does a firm decide their readiness for RFID adoption. In terms of coverage, RFID adoption has been widely studied (see appendix 5), thus the main focus is on the readiness of the company on how they evaluate their operations based on RFID compatibility.

The models for evaluating RFID readiness by using firstly, SWOT analysis. The SWOT analysis is used a basic ground work to assessment the internal and external factors underlying RFID. More in-depth analytical tools such as real option theory, the technology push-pull concept and RFID implementation stage models will be applied to investigate the findings and draw conclusions related to the research questions at hand. Results of the research will be concluded as readiness of a company in implementing RFID is discussed.

### 4.7 Limitations
In terms of quality of work, the paper was written based on information found in the literature review and the interviews with regards to Swedish firms. The reliability of the information gathered from structured interviews, are opinions of individuals within the organization, who are closely linked with RFID technology and research. This only represents a section in the supply chain. Disclosed information were generalized as not all proprietary information given, leaving some generalization in comments regarding specific details on calculation and assumption.

Additionally, data from supplemental external sources found online were analyzed, because not all scientific journals provided good references to consolidate the data. However the online articles are not as conclusive as it does not portray or cover in-depth the research problem.

5. Theoretical Framework

5.1 SWOT Analysis

The SWOT analysis was developed in the 1960’s and has been used widely by many private companies to evaluate the present and future situations in terms of strengths, weaknesses, threats and opportunities. Since both firms interviewed were Swedish firms, the study has to identify specific areas in strengths, weaknesses, threats and opportunities present for RFID market perspectives. This is done to establish the standpoint in different businesses and provide framework to firms. It is highly unlikely that firms can benefit through item or product tracking, due to diversity in structure and sectors, it’s important to notice that certain benefits can be gained through automation. A summary of SWOT analysis is described below:

<table>
<thead>
<tr>
<th>Strengths</th>
<th>Weaknesses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Efficiency in logistics and supply chain functions</td>
<td>Costly in terms of infrastructure</td>
</tr>
<tr>
<td>Reduce labor costs</td>
<td>Cost of implementation (tags, readers)</td>
</tr>
<tr>
<td>Up to the minute inventory count and optimization of the distribution process</td>
<td>Metal and water can interrupt the frequency of the chips making them defective on some products.</td>
</tr>
<tr>
<td>Monitor theft</td>
<td>It is a new technology resulting in limited information on trials.</td>
</tr>
<tr>
<td>Network superiority</td>
<td>Lack of application in many industries</td>
</tr>
<tr>
<td>Patents</td>
<td>Very volatile and unstable in terms of predictions</td>
</tr>
<tr>
<td>Technology as competitive advantage</td>
<td>Lack of well established standards</td>
</tr>
<tr>
<td>Technology market is well developed (mature)</td>
<td></td>
</tr>
<tr>
<td>Large scale and volume provides valuable feedback</td>
<td></td>
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<td></td>
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</tr>
</tbody>
</table>
Table 2. SWOT Analysis of RFID

**Opportunities**
- Technological revolution by shaping the market
- Policies would be created to relieve privacy threat issues.
- Timely feedback from changes in distribution and supply problems are caught early.
- Inventory Management
- In-depth marketing research
- Smaller companies find new ways to aggregate and compete against larger companies.
- Enhancement of quality and production due to automation in monitoring
- Customer Retention

**Threats**
- People believe that their privacy has been violated.
- Suppliers or manufacturers from poorer countries may not be able to afford the technology.
- Small enterprises could not afford RFID may go out of business.
- Glitches or errors in the system. For example, the ease of detaching a tag can result in theft.
- Labor Unions will strongly disapprove of loss of jobs.
- If a poor analysis on RFID application is made, the risk of missing real benefit is apparent. For example, under-evaluation of non-technical issues.
- Patents are constantly changing.

As noticeable, market integration is a barrier in relation to individual businesses, are perceived. The opportunity is consequential from developing high-end product or large volume production, added value market applications and accurate database which boosts convenience. The opportunity for European firms is to integrate the physical world and the virtual world to aggregate and interact with one another, back and forth, creating a continuous stream of information.

As Rundh describes in 2008, the RFID implementation in Sweden, “Examples in Sweden shows that big grocery retailers like ICA, Axfod and Coop have made a few trials, but are hesitating to implement the technology due to investment costs and general uncertainty. Trials have been made with IKEA. Firms within other industries have implemented RFID to some extent for example, VOLVO Technology (for tracking purposes) and SSAB Oxelosund (to identify and track material). The implementation of the technology has not been without problems especially in relation to the industrial environment causing problems with tags and disturbance of radiowaves.”

### 5.2 Real Option Theory

Real Option Theory is a technique developed in the financial services industry to analyze certain decisions or corporate investment that consists of high uncertainty and have many possible outcomes. The theory was made famous by Martha Amram and Nalin Kulatilaka of Boston University (RFID Gazette 2005). This approach can be applied to technological
investments such as RFID. The value of taking advantage of RFID opportunities are considered ‘the option’ is a given value and it takes in consideration when evaluating return on investment.

Also known as Real Option Analysis (ROA), it has gain credibility and supporters at the same time, as it accommodates for time progression and unknown factors. As they become known, these factors can be used to determine project investment decisions, as it provides for future flexibility. Traditional capital budgeting approach such as Return on Investment (ROI) or Net Present Value (NPV) has been used previously for evaluating investment in RFID projects. However, it is more accurate to use ROA as the scope of the application and embedded options are more complex within the supply chain.

ROA has higher option value of a project than NPV, because it takes in to account high uncertainty and volatility. ROA allows adjustment in risk and probabilities scenarios, over the project’s life. Management can respond appropriately or decide effectively, allowing them to predict or foresee the future more accurately, and deal with the changes or uncertainties with high complex investment projects. Some companies use this technique to analyze whether to implement or adopt RFID as an investment.

5.2.1 Walmart’s ROA- Case Study

In 2006, Walmart has made an announcement for their top 100 suppliers to comply and use RFID tags in their cases and pallets (Venkatesan, 2009). The manufacturer applied ROA directive, as there was great uncertainty in technology standards and protocols. The learning curve proved more steep with possible corrections along the way as value of these investments were based on the growth opportunities, rather than current cash flow. By using a decision-tree technique (see fig. 4), hidden sources of value were revealed.

![Fig. 4 RFID Decision Tree for a Large Manufacturing Company](source: Venkatesan, C. (2009))
These benefits were option to expand aggressive, to realize benefits of reduction in unsalable goods, out-of-stocks, labor and inventory costs. Walmart found that indeed the option value of RFID project was positive in measurement and the pilot project should be undertaken. In addition, critical decision points also provided insights such as criteria for decision making at a certain point, to determine the target should be moved along the investment path or not. The ROA proved beneficial as it was a comprehensive plan, offering a variety of options.

### 5.3 The Technology Push-Technology Pull Concept

The technology push (TP) and need-pull (NP) strategy can be used to explain the behaviors of organizations as they attempt to adopt RFID technology (Zmud 1984). The model exemplified the usefulness in diffusion of complex organizations and networks. The TP force comes from the realization that there is a need to achieve better performance through new technology (Perceived Benefit). The NP concept differently states that there are other key needs in order for adoption to occur (Perceived Barrier). Other studies have argued on either side, with even previous studies like Munro & Noori 1988, who stated that integration of both models could bring the most innovativeness.

![Factor Analysis of RFID Systems Adoption Model](source: Chang et. al. (2008))

Fig. 5 Factor Analysis of RFID systems Adoption Model

From the research conducted, a clearer theoretical model can be seen above. Chang et. al. (2008) have specified some results of the perceived barriers and benefits from their research. The study showed that three main factors were operational efficiency, manufacturing efficiency and supply chain efficiency. The drawbacks were market environment in terms of stability, investments costs and technological concerns such as compatibility and efficiency. Despite the fact that the model have some limitations in research, the factors involved allows possibility in comparison with Swedish firms.
5.4 RFID Implementation Stages

Based on a model adapted from Cooper and Zmud in 1990, Cho, S. et. al. (2008) derived a modified useful in attempting to analyze RFID in its implementation stage. The processes are divided into 6 different steps. The first step is the initiation stage is the planning phase. Secondly, the adoption stage follows as RFID is agreed on as the solution and slowly introduced in the organization. The third step is the adaptation stage where certain issues or processes are adapted to increase operational efficiency. The fourth step is the acceptance stage, where the organization uses RFID technology as a common tool. Lastly, are routinization and infusion, which are techniques used after successful implementation to assure that RFID becomes a reoccurring process within the supply chain. The 6 steps are then generalized by evaluation; adoption decision and integration (see fig. 6).

![RFID Implementation Stages](source)

Fig. 6 RFID Implementation stages
Source: Cho, S. et. al. 2008

6. Description

6.1 Skanska’s Profile

Skanska Maskin AB is renowned for their knowledge in machinery, equipment and services. Knowledge based is a key trait of their company. Cost control is essential as most construction equipment is expensive. Skanska has a wide portfolio of businesses such as cranes, electrical equipment, drying equipment and maintenance services. Consumer goods are also offered in terms of drilling steels, saw blades, electricity cables, petrol and other assorted products.

Skanska is also considered a forefront in construction, manufacturing and renting. Their business varies from construction of homes, offices, commercial properties, industrial sites
and even civil engineering projects. The material flow is relatively smooth with the end-customers being able to request material issue or rent to customers. The additional services included are reparation for defected items and development or manufacturing of new items or products. Operating in 16 cities around Sweden, the company is considers itself top of the line in mechanical leasing.

Skanska’s strategy for achieving the operatives and financial targets are:

- Focus on core businesses in construction and development
- Strive to be an international company with leading position in selected home markets
- To take advantage of the Group’s collective resources – in regards to brand, employees expertise and financial strengths
- Anticipate and systematically manage risk
- Enhance green expertise throughout all operations
- Excel to be industry leader in green building and sustainability, particularly in occupational health and safety, ethics and environment
- To successfully recruit, develop and retain competent employees and to achieve a greater diversity
- To capitalize on urbanization trends

6.2 Datema’s Profile

Datema offers tailored and standard IT-solutions for Enterprise Resource Planning. The ERP systems and mobility that gives the companies increased returns, smaller work load and competitive force. Datema creates solutions for their customers from existing routines with added simplifications to offer flexibility. Experience in-businesses processes allow better service to accommodate customer’s systems and needs. With 30 years of experience with technical software such as iScala/Scala in ERP systems. The solutions provider also works with Epicors, who is the world’s sixth largest software manufacturer in the world.

Datema also offers businesses with critical applications. In terms of retail logistics, adaptations of applications are integrated to ERP systems to provide better efficiency. Working with Motorola for more than 20 years, the company is a leader in handheld devices and wireless networking. Other solutions include self-scanning systems installation for customers such as ICA and Coop in Sweden.

Recently, the company has elevated their positioning in RFID in the Nordic area with 30 installations where we combine RFID and barcode technology. Successful implementation with companies of Gothenburg Harbor and Laxbutiken in Sweden have benefited resulting in Datema receiving ‘The Golden Tag’ on Nordics RFID in 2006 for best RFID solution.
7. Results

7.1 Skanska’s Findings

Currently, Skanska uses barcode that is printed on a hard plastic for identification purposes. Most barcodes are fixed and attached to machines with some exceptions to certain machinery such as scaffolding, which have certain physical limitations and are not handled in the stores. Skanska plans to switch to RFID technology if the supplier produces machineries that are RFID compatible, and the company believes that there is possibility in a mixture of RFID/barcode in the future. The RFID tags also are almost compatible with every type of machine, thus obtaining a reduction in time and reporting for rental fees.

For the results of the RFID readiness, the company used the findings reported by Lars-Olof Thåström. The report presented many positive and negative sides of the different technology used, which were: 1. barcode and engraving, 2. Plastic-only strips, RFID-only and a combination of RFID/barcode. The cost analysis identified the different options and compared the results with costs. Per graph below (see graph 2), the total cost calculation during implementation period, from a supply chain perspective. With several warehouse locations, the sum are representative of 3 different regions in which Skanska operates in, which are Fosie, Linnarhult and Upplands/Vasby.

Graph 2. Total Cost Calculation during Implementation Period
Source: Thåström 2004

However as noticeable, the implementation of RFID-only and RFID/barcode are relatively high when compared to the other options. The start-up cost is quite high in costs as tags and

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1 Translation:
Streckkoder och gravering = Barcode & engraving
Enbart plastremor = Plastic-only
Enbart RFID = RFID-only
RFID och streckkoder = RFID & barcode
readers are needed to be calculated, and also systems software and applications. The mixture of RFID/barcode is the most expensive during the implementation period. Below is how much it will cost in four years after implementation (see graph 3).

Graph 3. Cost After 4 Years of Implementation
Source: Thåström 2004

The figures for implementation after 4 years are calculated by the maintenance fee such as tag replacements, hand held equipment, plates replacement and label machines. Notice the cost for 4 years of RFID-only maintenance was relatively low and the best choice when compared. Lastly the implementation costs per year are calculated below in (see graph 4). The overall implementation costs for RFID-only technology is significantly the best choice in this category as the other choices are relatively higher in expenditure.

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2 Translation:
Streckkoder och gravering= Barcode & engraving
Enbart Plastic= Plastic-only
Enbart RFID= RFID-only
RFID och streckkoder= RFID & barcode
Due to the nature of the site construction business, many physical contact or pressure can be caused, resulting in tags breaking or malfunctioning. For example, a drilling machine is a powerful tool often used in construction, where tags would not be able to withstand the vibration caused by drilling. The Barcode durability is also a great advantage as parts of barcodes can still be read even though some parts of the barcode maybe damaged. The solution here is to put the RFID tag inside the machines for protection, causing them to drill a hole in the machine and cover it with plastic. Per Kristian Thisted, this particular installation, it would cost 10 Euros per tag to be installed inside the machine, while it would take only 1 Euro to attach to the exterior of the machines. Skanska views the market as not yet matured, thus resulting in no immediate importance of RFID is not yet a must, but a luxury.

7.2 Datema’s Findings

Datema is a service provider of IT solutions for a variety of companies. There is a need to look at the individual customer’s business portfolio and create a solution or process uniquely catering their technology.

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3 Translation:
Streckkoder och gravering= Barcode & engraving
Enbart Plastic= Plastic-only
Enbart RFID= RFID-only
RFID och streckkoder= RFID & barcode
7.2.1 Door Manufacturer-Case Study

For example, Datema provided an RFID startup for a door-manufacturing company. This particular door company was manufacturing a large array of custom-made unique doors in the south of Sweden. The different specifications or options of doors were color, design and materials such as wood, metal and glass. The two door products are for doors within the house (kitchen, bathroom) and the front door (entrance), as demonstrated in see figure 7.

![Fig. 7 Example of Final Door Product](image)

Source: Datema 2009

The production line of the company included:

Typical production flow
1. Drill a hole of UHF tag
2. Place the tag, and lock the tag-ID until orders are purchased
3. Fill with insulation
4. Glue plates or boards to front and back of doors
5. Drill all slots (windows, door hinges, locks, etc.)
6. Inspection
7. Paint
8. Inspection
9. Packaging

For attachment, the small hole is cut in the door so the tag can be placed inside the hole. A special installation tool is used then to secure the tag properly inside the hole (see fig. 7). Once installed, the tags can be read through the scanner to retrieve information about door-

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Translation:

4 Innerdörrar= Doors inside the house- kitchen, bathroom, bedroom etc.
Ytterdörrar= Front and Back doors (main entrance and exit)
specification, as the item passes through the assembly line. Glue is then applied to both sides of the door to attach wooden or metal frames depending on the customer’s specifications.

The reasoning behind this chosen process was that barcode tags could not be read once it is placed inside the door. The logic is that barcode, if attached to door exterior, can’t be read once it is painted over. Also other modifications could be made to the door such as paint, without disrupting the flow of production. Furthermore, the barcodes needed to be almost perfectly positioned to be scanned, according to their manufacturing process, where as RFID chips can be easily read. For this particular company was a closed loop manufacturer of the supply chain, all the tags had ‘kill switch’ function once it left the warehouse. The RFID solution was then implemented as Datema and the case company worked together in RFID adoption.

8. Analysis & Discussion

As stated by Chung & Jones (2008), ‘In order to rationally and consistently select an RFID project, the organization must select what is known as a project selection model. The project selection model is a means by which the organization can rank competing processes for the application of RFID technology. This describes that all firms must derive a model to evaluate RFID factors. Project selection models can be both numeric and non-numeric, with associated factors generalized as production, financial, personnel and marketing issues.

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Translation:
Specialtag= RFID tag
Rambalk= glue
Monteringsverktyg= installation tool
Ordernummer= order number
Kundorder= customer order

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From the results from the interview, Skanska’s profile falls into the category of slow adopters, as they are not keen into highly investing in new technology. The old system of barcode still is prevalent in the company, as plans to opt RFID once the suppliers have crossed over in the near future.

Datema can be described as an early mover, due to their IT knowledge and expertise in the technology forefront. The history of Datema shows that they acquire their knowledge from working with a group of companies in the Datema chain, thus forcing the company to take risks and investment to capture the market profits, acquiring knowledge through many years of experience.

8.1 Real Option Analysis

For Skanska, The factors used in determining project investment was calculated and proved unfruitful as RFID was evaluated as a tool too costly at the current moment. In terms of efficiency and benefits were not incorporated into the equation, leaving some profit margins computations missing. The industrial construction industry is not volatile and uncertain, thus there is no need to adopt the technology as barcode technology is sufficient.

In the future, if Skanska does decide to adopt RFID technology, many factors influencing ROA will be in terms of suppliers’ requirements and specifications. The calculation will be adjusted accordingly as suppliers actions will highly impact the company and its objectives towards RFID usage. Also the sharing of ROA between the suppliers and Skanska will need to be reassessed again as it represents a volatile variable in terms of calculation.

Datema, real option analysis can be used to calculate the changes or implementation once RFID is introduced in the manufacturing or assembly phase. For most cases however, RFID may or may not be the answer as the capacity of the company or the supply chain comes into question. For only some customers who are at the advanced in IT and infrastructure, RFID are recommended as a suitable option. At the moment, there are is no comprehensive studies on RFID infrastructure that exist, making calculations on ROI not as accurate.

There are two main drawbacks from Real Option Theory model. Firstly, the model usually portrays a highly positive outlook regarding RFID implementation (RFID Gazette, 2005), meaning that the result is positive in value. Secondly, the mathematical computation models used to obtain the figures or statistics are usually complex and intricate to understand for corporate usage.

To overcome such drawbacks, a hybrid of ROI and ROA should be adopted to take full advantage of both models. The platform should be viewed as a guiding platform, not a pilot or compliance exercise. Traditionally calculation or justification models nowadays rarely capture and communicate value. The company can collect data to yield base-level benefits, which has a modest return and payback period between three to four years (Parker, 2005). To graph the results of the data collection, for example, tag prices are x-axis, and read rates are y-axis. The benefits depicted in the graph can then be discounted back to the current year and added to the base-level of benefits, creating a more sufficient model for investment. Application of this
alternative is merely a stepping stone, as management needs to be overseeing the company’s data acquisition platform wisely. It’s complicated to intuitively invest and exercise option value to create competitive advantage.

8.2 Analysis of Technology Push-Technology Pull Model

From Skanska’s perspective, the investment cost in RFID technology as calculated by their cost-analysis shows that RFID presents a huge investment cost but lowered yearly maintenance fee. The company works in the construction industry, which means they are relying on durable and resistant forms of technology. Skanska views this technology as not matured, so there is not an eminent need to adopt this technology as they still maintain a relatively competitive positioning in their market. This perceived market conditions fall into the perceived barrier.

Skanska’s analysis of the different options available for product identification was an initial start to evaluating technology push and pull. There is no plan for them to start RFID systems themselves, as it is not their core business, as they are expertise in construction rather than manufacturing. Skanska expects the supplier to incorporate RFID technology in the near future, when their suppliers start to manufacturer machines with tags already embedded. They have specified that the combination of both RFID and barcode is the most expensive but with most superiority. Another benefit of RFID is that can be read through concrete where barcode technology can be corrupted and not useful in retrieving data.

Datema is a flexible company that chooses more tailor made solutions to their customers. The solutions may not always be RFID, depending on the nature of the business or industry. In this particular case the customer wanted a manufacturing process which could assemble a variety type of doors. With RFID implemented, superior manufacturing and supply chain efficiency can be achieved. It was critical that the unfinished doors contained the specific coding to identify the order once passed through the assembly line, even when painted or attached with other materials. Mass production of differentiated products was the goal as they needed different unique doors to be assembled on the same production lines. This technical aspect proved to be the perceived benefit that resulted in the change of RFID adoption.

8.3 Analysis of RFID Implementation Stages

From Skanska, they use cost analysis of all costs. Included is running cost, operating cost, standard cost, service cost. The company has done the RFID evaluation at the initiation stage and decided not to adopt the technology, based on the running figure, for 1 to 4 years to simulate the costs involved. Although high in initial costs, tag costs are predicted to decrease in the near future (see graph 5).
In the future, the cost of RFID chips will fall. As the chips becomes cheaper, Skanska are expecting their suppliers to originally embedded the RFID tag in the machinery, thereby avoiding RFID chip installation and additional costs relationship to installment. The interesting note here is that suppliers in their chain may use the chip in their own management of their products, enhancing cooperation and knowledge linkages. This will be a critical factor if Skanska decides to switch to RFID technology in terms of integration and synchronization.

For Datema’s door company, the evaluation concluded that due to technical aspects, RFID was the technology to adopt within the company. However, the model does not clearly portray the role of Datema as the company is a systems provider, thus only the two steps of the implementation stage of initiation and adoption are undertaken. The processes are then created or adopted to where both companies are partners and help in working together on a shared process.

RFID implementation is then adopted or adapted to fit the operations of the manufacturing company, as Datema is positioned as the advisor to oversee the progress of the RFID integration project. A cross-function team is usually appointed to help advise and resolve any problems or issue that may arise. However, Datema specifies that the remaining steps of the implementation stage, which are adaptation, acceptance and routinization and infusion are helped by the company with the appointment of a cross-functional team, to help advise and resolve any problems or issue that may arise. This presents a relationship as a partnership and also a service provider to ensure successful. The final goal is to produce mass customized doors easily, with standardization.

8.4 Industry-Specific Factors impacting RFID

As stated in the methodology section, both firms do not fall into the manufacturing-type of company. The manufacturing or production of consumer goods will have clear-cut benefits
that have been studied earlier. Specifically, narrowing down both industries can help find some factors and determinants:

8.4.1 Construction Industry

In terms of construction and heavy equipment, one must doubt the usefulness of tags being operational when there are metals and other materials involved. Test fields have proven successful quite recent experiment in terms of Generation 2 type tags, which are more resistant to these construction materials (RFID Connection, 2007). New intelligent tags are being tested to ensure that certain subsurface markers, which use low-frequency, can be buried, but still have the read and write function on that tag, making the future of construction looking brighter. Asset tracking and management is highly critical when there is expensive machinery like that used in the construction industry. Large construction sites are often cluttered, with changing environmental conditions, security issues.

In terms of procuring heavy machinery or equipment, RFID can bring about speed in acquiring this equipment, which can help save costs up to ten fold. The construction industry is now focusing on on-site storage and management, which will also cut costs further down.

8.4.2 IT Solutions Provider

In this type of market, players such as Datema have all the solutions available for their clients, whether it is RFID or not. The only problem is which professional solution best enhances the customers’ experience and operations. Knowledge of a company’s infrastructure, operation capabilities and logistics are an important attribute for Datema to possess if they are to design or concept or project plan to be implemented in a manufacturing or production company. Requirements of functionality, software and hardware issues, implementation and adaptation are needed to be analyzed thoroughly before offering RFID applications to a customer.

To ensure such that high solutions are provided to their customers, as Datema stated, a wide array of knowledge is required to keep up with different markets and industries. Datema has a variety of customers range, but their goals are all the same for all customers, to simplify business process, innovate and drive business efficiencies. Often to do so, the solutions provider must be a leader in technological advancement, to clearly sit down and work with the customer, side by side, to produce the best solution possible for the customer’s business or demands.

8.5 RFID Readiness in an Organization

Readiness in organization has flaws in measurement. As Datema describes, it is extremely difficult in trying to sell RFID to a whole entire supply chain. Due to the complexity, it will include the types of tags that are needed, how many and what type of memory should be stored on the tags. Certain products required specific tags and certain amount of reading distance, which often creates processes to be too tedious or costly to implement. For a closed loop scenario, RFID is a suitable solution as one company can use the RFID technology in their many warehouses. But once it leaves the company and the tags are then obsolete, preventing the information to be read by others and protecting proprietary information that is critical to the business.
It is both agreed by Datema and Skanska that RFID is a superior technology once in practiced. The rate of adoption will be slow during the implementation phase as the learning curve grows. As noticeable by Skanska’s views on RFID, there are interdependencies and commitment issues that are hard to calculate in terms of readiness for adoption. Due to the nature of the industry, the company will still need to rely on the supplier to make the first move into the RFID frontier.

Datema also describe from their perspective, the problems with RFID readiness is belongs to the customer’s capability and decision making. Many of the customers in general have the most problems with technical specifics and costs. For example, a customer who wanted to tag shipments or containers stored in an outdoor location, which will not propel the customer to accept RFID as it may not be read in stringent physical environment. The company advises on offering small solutions with short project life cycle, for example, RFID automation in one single factory or warehouse. According Chung & Jones (2008), the RFID Project Life Cycle is described as the conceptual, planning, installation and start-up phases (see fig. 8). Datema works with the customers in all of the phases until the start-up phase, where the testing of the software and hardware is finalized, thus the project manager or team can handover the project to operational personnel. In short, if the customers are satisfied, they will contact back for other extended or new business proposals.

![Fig. 7 RFID project life cycle](source)

**8.6 Impotency in Findings**

Although the models are used to evaluate adoption of RFID, they are still not comprehensive to compare different companies and different industries. As Datema stated, the solutions or models are needed to be custom fitted for each individual entity within the supply chain. Based on the complexity or size of the supplier chain logistics, the network intricacies will create barriers in RFID adoption.
The cost analysis identified the different options available, however as mentioned, the profit analysis or the operational efficiency have not been calculated for comparison. This does not represent many benefits that are brought about once a company implies this modern technological solution. Although the company has stated that cost and profit analysis was analyzed, Datema also did not disclose quantitative data for this study as that information is private, and is kept proprietary between them and their customers.

There are limitations that may arise in this study due to the methodology chosen. The companies interviewed had different roles in the supply chains. The industry of construction and IT solutions are quite unique in their own characteristics, so certain comparisons or benchmarking could not be drawn in terms of warehousing or construction between the companies. It was interesting to see though, the different perspectives across the two industries and how RFID can be used in a non-retail production company.

Also Skanska rejected to adopt RFID technology, meaning the models for RFID adoption was not undertaken. Certain models were not chosen in the methodology to the fact that some models were industry specific or custom fitted. Many of the models were formulated on adoption principles, and therefore did not assess readiness of the company. Using specific models catering to the requirements to a certain company may not fit.

8.7 Recommendations

For Skanska, one recommendation for future evaluation of RFID capability will be the company’s relationship with its suppliers. This entails that Skanska keeps a close range commitment with its suppliers in R&D, constantly updating their feasibility studies to be at the forefront in industry specific news and innovations. Supplier requirements may vary in the level of RFID usage. Moreover, long term commitment should be developed as stakeholders can help guide Skanska to improve on their RFID.

For Datema, the suggestion is to record and track the progress of their customers. The benefits brought by RFID readiness and implementation should be consolidated into case studies so that benefits are visible, showing a concrete return on ROI. This knowledge can be shared and transferred within their organization chain. Furthermore, the success of their customers may spread by networks, so that new clients may employ their services in the future.

For further studies, new questions could be deeply covered:

- Subcontracting role and RFID
- RFID and third party logistics
- Closed loop and open differences in RFID
- Generation 2 type tags

9. Conclusion

As discussed, many issues deal with the readiness of a company to implement RFID technology. Many models can be used to further evaluate a firm’s readiness before actual implementation is conducted. Successful methods and feasibility studies can obtain both
internal and external factors that will affect the firm’s decision for new technology adoption. It is interesting to distinguish different uses, especially in a subcontractor or service provider, and the different factors that influence a firm’s decision to whether or not to partake. Not only does technology capability need to be assessed, but also the industry specific factors are required for analysis as it presents critical and technical aspects in terms of RFID readiness. RFID should be analyzed in terms of at which point should a company implement this technology to gain the highest value. It’s not quite conclusive to state that all firms can follow one model, since different firms have unique characteristics.
References


Kristian Thisted, system developer, Skanska Maskin AB, interviewed 2009-11-13 during 40 minutes.

Oskar Josefsson, associate, Datema, interviewed 2009-11-20 during 60 minutes.


Zebra’s RFID Readiness Guide: Ensuring A Successful RFID Implementation. 


Appendix 1: DTTM process
Source: (Lee & Park, 2008)
Appendix 2: Warehousing & Distribution Efficiency
Source: (Twist, 2004)
Before RFID implementation:

After RFID is implemented:
Appendix 3: Diagram of Value of Stakeholders
Source: (Chung & Jones, 2008)
Appendix 4: Traditional vs. Emerging Applications
Source: Khumawala, et. al. (2006)

<table>
<thead>
<tr>
<th>Traditional RFID applications</th>
<th>Emerging RFID applications</th>
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<tbody>
<tr>
<td>Security/access control</td>
<td>Warehouse management</td>
</tr>
<tr>
<td>Electronic article surveillance</td>
<td>Supply chain management</td>
</tr>
<tr>
<td>Asset/fleet management</td>
<td>Reverse logistics</td>
</tr>
<tr>
<td>Mass transit</td>
<td>Shipment tracking</td>
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<tr>
<td>Library access</td>
<td>Asset tracking</td>
</tr>
<tr>
<td>Toll collection</td>
<td>Retail management</td>
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<tr>
<td>Animal identification</td>
<td>Document tracking</td>
</tr>
<tr>
<td></td>
<td>Anti-counterfeit</td>
</tr>
<tr>
<td></td>
<td>Advance access control</td>
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<tr>
<td></td>
<td>Mass transit – monthly and single trip</td>
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<tr>
<td></td>
<td>Airline baggage handling</td>
</tr>
<tr>
<td></td>
<td>Aircraft parts and tools</td>
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<td>Health care applications</td>
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<td></td>
<td>Regulatory compliance</td>
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<td></td>
<td>Payments</td>
</tr>
</tbody>
</table>
Appendix 5: Contributing Factors in RFID adoption
Source: Cho, S. et. al. (2008)

<table>
<thead>
<tr>
<th>Theory</th>
<th>Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT adoption</td>
<td>• Perceived benefits</td>
</tr>
<tr>
<td>(Beatty, Shim, and Jones 2001)</td>
<td>• Complexity</td>
</tr>
<tr>
<td></td>
<td>• Organizational compatibility</td>
</tr>
<tr>
<td></td>
<td>• Top management support</td>
</tr>
<tr>
<td>Innovation theory</td>
<td>• Entry timing</td>
</tr>
<tr>
<td>(Beatty, Shim, and Jones 2001)</td>
<td>• Organizational readiness</td>
</tr>
<tr>
<td></td>
<td>• External factors</td>
</tr>
<tr>
<td>Technology, organization, environment (TOE)</td>
<td>• Technology competence</td>
</tr>
<tr>
<td>(Zhu, Kraemer, and Xu 2003)</td>
<td>• Firm scope</td>
</tr>
<tr>
<td></td>
<td>• Size</td>
</tr>
<tr>
<td></td>
<td>• Consumer readiness</td>
</tr>
<tr>
<td></td>
<td>• Partner readiness</td>
</tr>
<tr>
<td></td>
<td>• Competitive pressure</td>
</tr>
<tr>
<td>Industrial organizational</td>
<td>• Firm performance is enabled or constrained</td>
</tr>
<tr>
<td>(Porter 1981)</td>
<td>by industry structure</td>
</tr>
<tr>
<td>Resource-based view</td>
<td>• Presence of resources that meet certain</td>
</tr>
<tr>
<td>(Barney 1991)</td>
<td>conditions, such as value, rarity, imperfect</td>
</tr>
<tr>
<td></td>
<td>inimitability and lack of substitutability</td>
</tr>
</tbody>
</table>