THE ECONOMIC VIABILITY OF RADIO FREQUENCY IDENTIFICATION FOR LUMBER RETAILERS

by

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Please note the correct title is:
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Abstract

The purpose of this project is to define the importance of radio frequency identification (RIFD) for major lumber retailers. This project will emphasize the cost savings and efficiencies that would be gained by transitioning out of the current bar coded method of tracking into more effective RFID technology. The focus will be to analyze the processes associated with selling lumber and wood-related products with emphasis on inventory visibility of product in retail stores and retail lumber yards. This document will show the realized losses by large lumber retailers from traditional bar coding systems versus their potential return on investment from RFID technology. Each necessary process to sell lumber in the retail environment, from receiving product to the point of sale procedure, will be scrutinized to show the optimal potential results with RFID. The results will be divided into three key areas of savings with RFID: the decrease in labour; the higher inventory visibility within the retail location; and the reduction in inventory shrinkage[1]. Speculative examples will also be discussed to give better understanding of the retail processes and their prospective economic benefits. This project has been devised to help lumber retailers realize the potential of the technology and direct them to pull the demand of implementation from their suppliers and throughout their own supply chains.

[1] (Dutta A., et al. 2007)

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Dedication & Acknowledgements

For my family and girl friend, who offered me unconditional love and support throughout the course of this thesis.

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1. Introduction

This project is written to explain and provide the real tangible and intangible benefits of using radio frequency identification (RFID) technology for lumber retailers. The purpose of the research is to provide evidence that transitioning to the new tracking technology would impact the entire lumber supply chain—from producer to retail shelf. Although all members of the supply chain will benefit from the technology, the focus will be strictly on retail operations. The motivation to present this topic comes from skepticism by the market, and the hesitance of individuals and corporations in the lumber industry to accept this revolutionary technology. Lumber producers, reload facilities, distributors and lumber retailers can find bar coding a burden to potential profits through: increased labour cost; bar coding printing and scanning capital investments; and tag and label expenditures. What this project will explain is how corporations will profit with RFID technology.

The demand for Canadian lumber and other wood-related products has been in constant fluctuation, greatly influenced by exports to the United States for housing starts and other new construction. During the 1980's and 1990's, contractors typically bought their lumber from lumber yards where large stacks of similar wood products were organized and sold on a piece by piece basis, without a great emphasis on accurate inventory or organization. As the demand for lumber rose and competition increased, the top three building supply centers—Home Depot, Lowes and Menards—expanded across North America with a mandate to sell at the lowest possible price within their industry.

The large lumber retailers have a unique inventory tracking issue with the inherent physical characteristics of many of their products. While most products at big-box stores like Wal-Mart are individually packaged and marked with barcodes for easy identification, large lumber retailers have a harder time tracking lumber, plywood, MDF and trim board, which are difficult to package and label individually.

The early 1990's brought a major North American initiative to bar code every individual piece of lumber and wood product that was sold at major box hardware stores. The lumber producers were not prepared for the short deadline given by the hardware store executives who were pressured to save money by having accurate "live" inventory counts of their lumber. Although lumber producers had to spend considerable amounts of money on bar code applicator machinery and operator education, the largest producers successfully started bar coding each piece of lumber sold to the big-box hardware stores. Since that time, the demand for accuracy in inventory has grown because of its cost-saving opportunities and the positive effects on bottom-line profitability.

The last decade has demonstrated new inventory tracking methods and highlighted problems associated with the current bar coding systems. Although bar coding has been successful for the most part, the amount of errors that can be encountered is high. Bar code labels can fall off of lumber by the time they reach retail locations; and the labels can become weathered and smudged, which reduces

the successful scan percentage at the point of sale. Additionally, piece inventory is harder to record as each bar coded piece of lumber needs to be scanned and counted visually. Because of the large size of most lumber yards and the large amount of inventory on hand, the inventory counting process is tedious and can be inaccurate. The combined costs of these issues can take a large toll on the bottom lines for retail stores that are already working on thin profit margins.

Since the mid-1990's the technology behind radio frequency identification (hereafter RFID) has become less expensive and the variety of applications with the technology has grown exponentially[2]. The advancement in RFID technology has put it into multiple practical functions, which include: its insertion in passports; transportation payments; lap-scoring applications; animal identification; library book tracking; and most importantly for business functioning—inventory management systems. Although RFID has been used in many forms since its inception, the technology has recognized its biggest potential in the inventory visibility of product in the retail industry.

Since Wal-Mart, Target, and the US Department of Defence realized the potential savings of RFID technology approximately 15 years ago, there has been a disruptive evolutionary change from bar coding that will never reverse. Companies such as Gartner Research have discovered that RFID technology sales exceeded $1.2 billion in 2008 and will rise to above $3.5 billion in 2012. Another study done by IDTech EX has concluded that there is potential for RFID technology sales to top $25 billion by

[2] (Lee, H., Ozer, O., 2007)

2017[3]. The tremendous increase of interest in RFID can be clearly explained by A.T. Kearney's study of retail efficiency, where it is cited that: 5% can be saved from a reduction in overstocking; 7.5% can be saved in store and warehouse labour expenses; and the reduction in out of stock products could save upwards of $700,000 per one billion in sales[4].

The remainder of this paper will give detail as to the nature of the lumber retail industry, providing further empirical evidence of key savings that can be seen throughout the supply chain, but with heavy focus on the retail store front. Specific examples will be presented to illustrate the immediate tangible benefits of RFID over traditional methods, while also explaining the host of valuable intangible gains.

2. Literature Review

RFID has been well studied and documented, from heavily government-funded quantitative empirical research, to qualitative benefits and opinions on RFID's safety and individual privacy. Information and statistics used in the project were strictly extracted from secondary sources such as peer reviewed journals, academic articles and online RFID dedicated websites. There were no surveys, personal interviews or other primary sources used. The evidence has become very clear that in high-volume retail operations, the benefits of RFID technology use for product traceability and automation outweigh the high initial RFID investment costs[5].

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[3] (Smith J., et al 2009)
[4] Ibid
[5] (Wu et al., 2006)

Major retailers such as Wal-Mart need the technology to maximize their efficiency and effectiveness during a constantly increasing competitive environment in the mass merchandising market. Specifically, RFID allows for numerous processes in the supply chain and at the retail location to be more efficient, streamlined and automated, which reduces labour costs and services customer needs more accurately.

Michael Porter illustrates in his book, "Competitive Advantage" that "Every firm is a collection of activities that are performed to design, produce, market, deliver, and support its product"[6]. This idea structure is called the "value chain" where Porter says that each activity in the value chain adds some value to the product and thus to the organization. As can be seen in Exhibit A below, Porter outlines the difference between support activities and primary activities within organizations. The importance of this illustration is to show how important RFID can be in every aspect of the chain to create value. RFID technology brings radical changes to all support activities, which in turn revolutionize the way primary activities are accomplished.

[6] (Porter, Michael., 1985)

Exhibit A: Porter's Generic Value Chain (Porter, Michael., 1985)

The retail industry has only been motivated to pursue RFID for the last decade, as the price for components such as RFID tags, readers, printers and scanners has dropped significantly, and the applications of using the technology have increased drastically. International Data Corporation (IDC) is confident that consulting, implementation, and managed services within the RFID market would grow 47% in 2004 and reach $2 billion worldwide by 2008. Another estimate says that RFID technology became a $4.2 billion market in 2008, and that RFID tag production increased from 1.3 billion tags produced in 2005, to 33 billion in 2010 with most going to help manage supply chains[7].

Some of the biggest RFID research is being performed with the purpose to create more effective and efficient materials management processes[8]. These studies include: finding empirical evidence of reduced labour costs; fewer out-of-stock issues; a more accurate just-in-time inventory; and the ability to increase security at

[7] (Sabbaghi A., Vaidyanathan G., 2008)
[8] (Spekman, R.E., Sweeney II P., 2006)

the retail level[9]. There have also been increased efforts placed on finding the savings that RFID can provide with reducing spoilage of perishable goods, and with the inconsistency between inventory records and the actual amount of product available on hand[10]. Although the benefits and applications of RFID are well documented, the impact that the technology can have on the retail lumber industry has been largely undiscovered.

The key focus of this project is the viability of RFID-tracking of lumber and wood-related products through the supply chain. The process of producing, transporting, storing and selling lumber has some similarities, but has some large differences compared to regular retail-boxed items. All products need: to be produced at the manufacturer; shipped via truck, train, or ship; stored and organized through distribution centers before arriving at the final retail shelf. What is different about lumber sales is: the way lumber gets handled and packaged at the producer; the environment in which it is transported; the method of storage at distribution centers (hereafter DC's); and the environmental impacts of short and long term storage at DC's and retail lumber yards. Many companies have not yet realized the losses they incur in lumber transportation and storage; e.g. evidence has been found that shows losses of over $40 billion annually due to theft of cargo in transit[11].

Lumber manufacturers and distributors also regularly create miss-shipments due to improper labeling or bad supply chain management. The biggest and most

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[9] (Lee, H., Ozer, O., 2007)
[10] (Heese, H.S., 2007)
[11] (Naden Gary., 2003)

impactful part of RFID is its ability to produce inventory visibility along the supply chain and within retail stores. The ability for retailers to better track their product leads to the largest number of profit-improving benefits. A study has found that the ability to forecast product demand has improved from 10-20% compared to the current bar coding system[12]. As will be explained further in this paper, lumber can be classified as a perishable product, and this further exacerbates the need for its accuracy in the supply chain.

The use of RFID in the supply chain also greatly reduces the costs of labour because of inefficiencies[13]. The ability of companies to decrease the amount of employee intervention has major effects on improving accuracy, timeliness and throughput in manufacturing or distribution centers. Empirical studies have shown up to 36% labour savings in order picking and 90% reduction in verification costs for shipping[14].

Although savings of RFID technology are posted and marketed in magazines, journals and at international conferences around the world, it still seems that there are many non-believers. The biggest concerns of the technology are the costs of RFID tags, reader, software and implementation[15]. Non-believers are also apprehensive because of a lack of uniform standards, market instability, complexity

[12] (McCathie and Michael., 2005)
[13] (Bapat et al., 2006)
[14] (McCathie and Michael, 2005)
[15] (Visich et al, 2009)

of integration and data synchronization[16]. Also shown by a survey done in 2004 involving RFID required suppliers of Walmart, the number one concern was ROI (42.3%), which was then followed by: RFID technology cost barriers (23.1%); no benefit to producer (11.5%); and a lack of support from Walmart (7.7%).

Empirical evidence in this paper will show that the major achievement of RFID implementation will come from the automation and improved information that managers will have to make decisions that drastically affect bottom-line profits. This research will show that RFID implementation will improve the quality of forecasting in retail and distribution, production control and decision enhancement in manufacturing, and improve the effectiveness of retail store operations. These impacts will permanently improve efficiencies and bring competitiveness in the future to a transformational new level.

3. Methodology

The purpose of this project is to shed light on the importance of RFID for lumber retailers. Lumber and wood products are perishable commodities that need to be given special attention by retailers to maximize their competitive advantage and profit margins. The process of implementing RFID in indoor retail stores with labelled and packaged products is much easier than with outdoor bulk products like lumber. Challenges for implementing RFID in lumber retail sales include: keeping labels affixed to individual lumber ends through-out product movement and environmental changes; reading RFID tags with radio waves through multiple lifts of

[16] (Sharma A., 2007)

lumber; and finding the best RFID technology that will work in harsh outdoor environments. These challenges are key to the success of the overall initiative, but the right RFID technology is currently available, and it is ever-evolving to further decrease or eliminate these inefficiencies. Once it becomes recognized that the technology surrounding the unique nature of lumber and its use with RFID can be easily overcome, lumber products then become no different than indoor packaged goods with regards to RFID tracking.

The biggest recognized issues of the technology are its high costs, and the complexity of full RFID implementation. This project will examine each component of a typical lumber inventory management system in an effort to clarify the use of RFID, its average costs and operational use within the whole RFID system. The unique composition of lumber will be explained along with other benefits that can specifically come from utilizing RFID with lumber products.

Because RFID is relatively new to retail supply chains and retail applications, an effective way to illustrate the benefits that can be accomplished with RFID technology is through peer-reviewed research studies. Estimates or general feedback on the benefits of RFID technology would not show a clear understanding of what major lumber retail chains want to see. What is clearly understood and is provided in this project, are facts and figures broken down into individual processes throughout the daily retail routine. Retail statistics and other data were found through magazine articles, inventory management related books, academic journals and the

World Wide Web. There are several useful websites dedicated to the evolution of RFID which were mined for data that helped focus research on specific topics in the retail and packaging market sectors.

The most important costs to retailers—including: inventory counts; shrinkage; out-of-stocks; inventory holding costs; and labour costs—are statistically described as to their direct impacts. These cost issues are then explored with the implementation of RFID and empirical evidence is provided to support the thesis. To further illustrate the potential cost-cutting measures that can be accomplished with RFID, simple examples are theoretically discussed on each important point. Because exact figures on individual store sales and average lumber sale prices were difficult to determine, all examples were hypothetical proposed, scaled down and simplified to clearly illustrate cost saving results. The figures proposed in the examples of this paper were strictly speculative and by no means accurate. The data presented in examples is for illustrative purposes only. The challenge of getting accurate figures was found be too difficult, leaving only educated speculations on individual store lumber and wood-product sales possible.

Proving precise figures for example purposes was a limitation that left confirming exact benefits to a retail store or retail lumber yard unfeasible. Nevertheless, the exercise was demonstrated to give a general understanding to the reader about how RFID can improve each retail process. Each example demonstrated how labour efficiency can be increased, labour costs reduced or sales

could be increased due to more accurate inventory.

4. Benefits of RFID

4.1 Product Visibility with RFID from Manufacturer to Retail Outlet

Although the conventional bar code has shown great success for many decades in the retail industry, the inventory visibility of the product through the supply chain is greatly reduced. RFID considerably improves product inventory visibility compared to the conventional bar code. As the demand for retail product grows, the scale of operations has expanded with it, and this causes major growing pains in warehousing accuracy and the calculation of inventory. The advantage with respect to product inventory visibility, is that RFID enables the same tag to be read efficiently throughout the supply chain. This can be further advantageous for distribution centers and logistics companies, as the RFID tag can be re-encoded with mid-point information like arrival and departure times, damaged inventory or special notes regarding the shipment.

The depth of RFID-tagged data has also increased as the amount of data that can be encoded into a barcode is less than one tenth of a percent relative to how much can be encoded on a typical RFID tag. This data could include: specific product condition; features; or place in the supply chain. Additionally, as the cost of RFID tags continue to decrease as the manufacturing of the technology becomes more economical, the level of tagging begins to grow to the pallet, box, and individual item level. This increased product awareness based on more information

on singular items eliminates problem variables for procurement executives and managers[17]. In many of today's heavily conventional bar code focused retail centers, the only individual product identification happens as the barcode is applied during manufacturing, and then when it is scanned while being sold to a customer.

At the distribution level, there are increased potential gains in granularity of product information when supplementary RFID data collection and encoding points are added. As the individual product's data is read more often and in different locations, there is better understanding of product's process and quality failure points. Additionally, with RFID's ability to be constantly "live", the tag read intervals in the supply chain can be adjusted to be read daily or hourly, and thus giving constant real-world feedback. This type of information has vast procurement and financial advantages. Executives and managers have a clearer image of their products in the supply chain with RFID-tracking, allowing them to make more accurate decisions.

This is also beneficial to retail outlets, as the costs of inventory tracking in a localized environment are drastically reduced. Some of the major areas where the cost of RFID can be recouped are: reporting of real-time stock levels, which can lead to reduction of out-of-stock situations; the ability to locate misplaced items; a potential automation of product reordering; better inventory replenishment; deterrence and prevention of theft; and better customer service with increased sales volume.

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[17] (Melski, A., 2008)

4.2 The Need for Precision in Lumber Sales

Lumber, unless chemical-treated and well packaged, could be considered a perishable product. Home center type stores such as Lowes, Home Depot and Rona serve the do-it-yourself building project market where lumber is a key component. Although most products in home center stores are non-perishable—such as home furnishings, screws/nails, tile, flooring, concrete products, etc.—a large portion of sales revenues come from selling wood products. These are mainly stored outdoors due to their large size and inventory quantities. If lumber is not stored properly outdoors for an extended period of time, most untreated lumber will begin to crack, develop fungus, and swell and bend as water, humidity, and fluctuations in direct sunlight and temperature begin to age the lumber. For example, if a Canadian lumber mill sells one lift of 2x4 dimensional lumber to a home center in Florida, the amount of time it takes to arrive to its final point of sale, in combination with a multitude of temperature, humidity, moisture changes can drastically reduce the life of the product. Additionally, because most lumber is transported through multiple distribution centers and is potentially reloaded from trains to semi trucks, and transported in open cargo trailers, the possibility of additional damage, especially to the exterior facing lumber pieces, is high. While this slightly damaged lumber may be structurally sound for building, the customer has the ability to pick and choose their lumber in the retail environment, and therefore the damaged inventory may ultimately be more difficult to sell, if at all. For these reasons, lumber should be treated as a perishable product within the home center retail market, and this concern needs to be carefully considered.

It is clear to see why it is advantageous to have RFID in a multi-billion-dollar annual business of perishable goods. RFID can give up-to-the-second live inventory updates on individual products; this can provide tremendous benefit for accurate forecasting of product along with better tracking of orders through the supply chain. This up-to-date knowledge can help procurement managers keep a more effective system of ordering with: less stock outs; smaller inventory buffers; accurate information on delayed shipments; and instant knowledge of shrinkage.

4.3 Opportunities of RFID for Lumber Retailers

In the commodity market of lumber and wood-related products, the importance of minimizing losses and increasing profits is vital and always a forefront issue. Lumber producers around the world are only as strong as the customers that purchase their products, so identifying weaknesses in the supply chain and store inventory management systems is essential to giving the customer what they need. Research shows that for every dollar made in retail sales, 35.6% is lost due to four broad categories: Shrinkage 1.5%; inventory holding costs 5.0%; out-of-stocks 6.6%; store and warehouse labour 22.5%[18].

4.3.1 Shrinkage

Shrinkage is the loss of merchandise through breakage, spoilage, pilferage or shoplifting[19]. Lumber is particularly vulnerable to these types of losses because of the products: simplicity; its exposure to the elements; and its vulnerability due to

[18] (Kleist, R.A, Chapman T.A., et al., 2004)
[19] (Dictionary.com, 2011)

inadequate surveillance. Although individuals trying to steal lumber may not necessarily try to take it without paying completely, the ease of deception, and the difficultly to identify lumber, can make it easier for customers to take advantage of front-line cashiers. E.g. a customer could bring a 2"x4"x120" piece of lumber to the checkout and tell the cashier that he/she is buying a 2"x4"x96" length, thus shaving money from their bill. The species and grade of lumber is also difficult to identify, and a mis-identified piece of lumber could even potentially save an honest customer half off their purchase. While it cannot be said that RFID would eliminate this issue, RFID tags could act as a deterrent and catch some customers leaving the store with more lumber than they purchased. This is especially true when some individuals purchasing lumber buy large volumes, thus making it easier to disguise higher-quality lumber within the order or miscount large orders. The use of RFID readers at the store's front door and lumber yard entrances would identify if an item was not scanned and accounted for, and could set off an alarm or activate surveillance cameras to identify the individuals.

The main concept which continues to make RFID viable is its inventory visibility in the supply chain. If a large retailer identified that one particular product was often experiencing inconsistency in its inventory counts, the product could be traced back from its store shelf to the manufacturer. If lumber was incorporated into an entire RFID supply chain, then every piece would be serialized (given a unique code). As the product moved from the manufacturer to distributors, and then eventually to the retail store, it would be immediately identified if it did not move to its

next intended point. The system of bar coding is not conducive to inventory visibility and once products leave the manufacturer, in most cases it is unknown where the product is in the supply chain. According to a study done by Ernst & Young, losses due to theft alone are expected to be $30 billion per year and account for 1.7% of overall sales. Researchers at AMR Research estimate that on average, 18% of shrinkage can be reduced having RFID in place[20].

With lumber, shrinkage can also come from spoiled or weathered product. While products that are stored indoors and individually packaged are typically safe from the elements, much of the lumber sold at retailers like Home Depot, Lowes and Rona are stockpiled in unprotected lumber yards. Retailers do try to protect the lumber using lumber wrap or protective canopy structures, but the product is still highly susceptible to moisture and sun damage. When lumber retailers don't have accurate inventory, the result can be overstocks. When a customer shops at a retail location like Home Depot, they have the right to pick through an entire lift of lumber to choose product which they think is straightest, has the least amount of knots, and is of the best appearance. The problem then begins when individual pieces are pushed to the sides, leaving more surface area exposed to scorching summer heats and/or heavy rains. The longer this lumber stays unsold and picked through, the more wood gets exposed. This can leave large amount of lumber undesirable and unsellable. This combination of theft and spoilage can amount to large losses and decreased profit margins.

[20] (Roberti, M., 2006)

4.3.2 Inventory Holding Costs

The accuracy of inventory within the retail space and retail supply chain are central reasons for high inventory holding costs. The inability to accurately forecast sales, order and replenish stock, or follow product shipments from manufacturer to store shelf, creates undesired increases in inventory holding costs. When distributors and retailers have inaccurate inventory counts the consequence can be the procurement of too much of certain stock keeping units (SKU's), and this can result in no retail space for other SKU's. Then, customers looking for a particular product are forced to shop elsewhere to get what they want, leaving profit for the competition.

Studies have found that procurement managers only have accurate inventory counts on approximately 35% of their products[21]. Another study done by Raman, DeHoratius, and Ton on the accuracy of 370,000 products within a single retail supply chain found 65% inaccuracy; 20% of which fluctuated by six or more units[22].

Research shows that most companies base their ordering processes on inaccurate inventory resulting in estimated net profit losses of 10% in the retail sector[23]. When retail employees discover that their inventory is not accurate and they cannot find the product quickly, they are forced to manually over ride the inventory system with a zero input. Although this temporarily restores inventory to what is believed to be true, in many cases the product is simply lost in the store and

[21] (Raman, A., DeHoratius, N., et al, 2001)
[22] Ibid
[23] (Heese, H.S., 2007)

the attempt increases inventory. Although this may be a good measure to counter out-of-stocks, it increases inventory holding costs, and warehouse labour costs which can already be inflated. In the lumber retail industry, these costs can be magnified due to the similarity in product and the lack of organization in lumber yards. An indoor retail space typically has clean and accurate placement of where product will be until a store is either re-arranged or the product is put into promotional areas around the store. However, retail lumber is typically placed outside and can be not properly labeled. Locations for certain SKU's can also change when more new product arrives. When procurement managers do not have access to proper inventory counts, the result is possible overstocking of lumber which cannot always be stored together in the same place. In contrast, when retail products stored indoors don't have space on the shelf, the product can be stored in the warehouse where it can be easily counted and replenished. In lumber retail, because of the sheer size of lumber, the retail space and warehouse space is in essence the same thing. This causes increased disorganization and can make inventory counting much more difficult.

Inventory holding costs can occur because product is manually counted or not found. This can result in employee's over-riding inventory counts and even inputting 'zero' into the inventory system that shows a valid quantity. Procurement managers can then take this inaccurate sign that it is time to re-order, ensuing an excess and unnecessary inventory. The use of RFID in these situations would help reduce inaccuracy of inventory and decrease inventory holding costs. A study done by Lee

has found that RFID technology decreased the amount of inventory holding costs by 16% and added that back orders decreased by 22% when decisions were made with the help of RFID supply chain management[24].

4.3.3 Out-of-Stocks

Retail chain stores like Lowes and Home Depot are warehouse style operations that base their business on low operating costs and high product availability. The importance of keeping shelves full and inventory on-hand is crucial in a market that runs on small profit margins within a very competitive market. Customers in today's market can be very savvy, and loyalty to retail chains in this competitive market can dwindle quickly when customers cannot get what they want. The costs can become two-fold as the immediate loss of one sale is followed by a decrease in loyalty and traffic to the store for future sales of any product. Although large retailers spend millions of dollars annually on providing clever loyalty programs that customers can earn points and discounts on future purchases, the lack of product on shelves can quickly diminish the effectiveness of these programs.

By employing an RFID solution in warehouse, lumber yard and retail floor locations, a single store may recoup the costs of implementation very quickly. A study done by the University of Arkansas found that as much as 30% reductions in out-of-stocks have been achieved for products selling between 0.1 and 15 units daily[25]. Another study focusing on Wal-Mart established a 16% decrease in out-of-

[24] (Lee et al., 2004)
[25] (Roberti, Mark,. 2005)

stock items with RFID tags. The study also concluded that Wal-Mart replenished its out-of-stocks three times faster on RFID tagged items than items with bar codes[26]. Wal-Mart does not currently tag all of its items, but does require that its top 100 suppliers tag their products. Although Wal-Mart's savings in lost revenue at the retail level and increased efficiency throughout the supply chain cannot be confirmed, the statistics provide clear evidence that the direct and in-direct costs will be in the millions.

4.3.4 Store and Warehouse Labour

Store and warehouse labour are one of the biggest costs that are faced by retail chains. With an average of 22.5% of every dollar in sales revenue being spent on store and warehouse labour, one can see why large retailers are constantly trying to reduce expenditures while maintaining customer service. Labour costs are all the wages, taxes and benefits that an employer needs to pay to maintain productive employees. Wages and benefits can vary per location, job description, part time or full time employment, tenure etc. The automation of processes within the store and warehouse that can eliminate redundancy and increase efficiency is something all retailers are striving to achieve. A major study done by *Visich et al.* shows drastic empirical evidence of reductions in labour costs and efficiency increases. Their evidence shows that receiving of inventory, breaking down pallets into their individual SKU's, and accepting them into inventory can be reduced from 17.75

[26] Ibid

minutes to 2.7 minutes[27]. Inventory management once it has been received may also become much more efficient. Understated perpetual inventory (PI) has been shown to be reduced by 13% while overstated PI has been reduced by 50%[28]. The time to count inventory in the warehouse can be reduced by 80% and locating the accuracy of product increases to 99.9%. These figures can translate into large revenues and cost reductions with studies showing increases of sales of promotional product increasing by up to 30%, warehouse labour reduced by 14%, stock availability increases by 11% and lost goods reduced by 18%[29]. Whether applied to small retail locations or large warehouse retail chains such as Lowes, Home Depot or Wal-Mart, the empirical evidence provided clearly shows that ignoring the benefits of this technology could be detrimental to a company's market competitiveness.

5. RFID Implementation Costs

Creating a cost estimate to purchase, install, integrate and operate an entire RFID system is very difficult to do. Because the technology is still in its growth stage, the product costs involved in operating an RFID system are in constant fluctuation as new products evolve from their predecessors creating new demand. More importantly, the cost of RFID equipment and consumables fluctuate heavily with higher volume and application type. Every RFID installation may be completely different depending on the square footage of the location, the amount of loading and shipping doors needed to be outfitted, the network system which may need to be upgraded, and new electrical requirements needed by each piece of equipment.

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[27] (Visich et al., 2009)
[28] Ibid
[29] Ibid

Although entire RFID system costs cannot be easily calculated, prices on individual pieces needed for an application can help give clarity on a 'ballpark' figure. A standard RFID application is made up of four main elements: tags; encoders; readers; and computers with software that hold and analyze collected data.

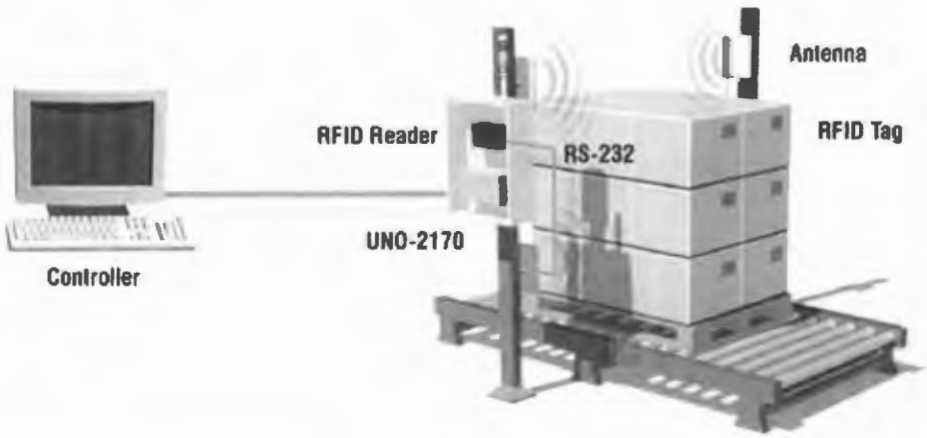

Exhibit B: RFID System Diagram (Advantech, 2007)

5.1 RFID Tags

A typical RFID tag consists of a small integrated circuit(IC) attached to an antenna. The antennae are manufactured from silver or copper and made to be flexible to conform to odd shaped product. Each antenna is placed onto a substrate much the same way that a printer applies ink to paper. The amount of material used to print the antenna will later show its strength in receiving and transmitting information to the readers. The final process of creating a tag is sealing it in a plastic inlay and most commonly incorporating it into a label to be applied manually or through an automated process on individual products or skid quantities.

Tags come in three main forms including: active tags; semi-passive tags; and passive tags. Active tags and semi-active tags not only have an integrated circuit and antenna, but also have a built in battery. The battery's primary function is to boost the signal carrying information back to the reader. Passive tags, which are the most inexpensive and commonly used, do not have any power stored within them, but rather use the radio frequency energy that is sent from the readers to power the tag and transmit information back. The tags used by Wal-Mart are called UHF-RFID tags which operate in an 866-956Mhz frequency level and allow for information to be retrieved up to 6 meters (20 Feet) away. The electronic product code(EPC) incorporated into RFID tags has a 96-bit storage capability which allows for 268 million companies to use 16 million object classes and 68 billion serial numbers in each class[30]. The amount of storage capacity in today's bar code technology is less than 1% of an EPC which will cause problems for the future of the bar code as more companies and SKU's emerge.

Electronic Product Code Type					
01 • 3 • 5	•	0000A89	•	00016F	• 000169DCO
Header • O Type • Partition • EPC Manager • Object Class • Serial Number 8 bits 3 bits 3 bits 28 bits 14 bits 36 bits					

Exhibit C: Electronic Product Code Description Type (Murphy, Cliff., 2004)

As the demand for RFID is expected to grow exponentially and more manufacturers begin to compete in the RFID consumable business, the overall cost

[30] (Murphy, Cliff., 2004)

of RFID tags will continue to drop. While the current bar code tag or label applied by manual or automated applicators to the end of dimensional lumber costs approximately $0.005 per unit to the lumber producers, the alternative RFID tag would cost approximately $.10 per unit. Nevertheless, just 5 years ago RFID tags cost $0.50-$0.80 each, and now with the rate of progression in RFID tag production and new manufacturing technologies, a $0.02-0.05 RFID tag is not a distant realization.

5.2 Encoders

Most tags used in the retail environment are passive tags and need to go through a process of getting a serialized number encoded into their microchip processors for later retrieval. The easiest and most widespread method of encoding on RFID tags is through a thermal transfer printer with an encoding attachment. The RFID labels which are typically in rolls or fan folded, are fed through the printer where thermal transfer ink rolls apply information to the label that may be necessary for future inspection such as shipping addresses or bill of lading numbers. These labels also pass through an encoder device that applies much of the information that is printed on the tag into the RFID chip. The encoder works by powering the tag's microchip long enough to send and record the desired data onto it. RFID printers are another technology that has seen a drop in price now averaging from $4,000USD to $8,000USD depending on print speed, print width, and encoding capabilities.

5.3 Readers

The RFID reader sends out radio frequency signals through the use of an antenna which allows for the reader to send information out to the tag, and for the frequency waves to charge the tag enough to send a signal back for processing. Readers are now available with different capabilities and in several different devices including mobile hand held, mobile fork lift mounted, or fixed mounted. Most readers are used at entrance/exits of warehouses, nearing the end of production lines or mobile units for locating individual products in a warehouse. The most important aspect of a reader's job is to gather all tag information in its path. In many high traffic areas, where hundreds of tags are passing by simultaneously, readers need to manage the signals they want to receive. A reader has the capability to tell multiple tags to not send their information while it processes other tags before them allowing for a seamless data streaming and a potentially major reduction in errors while transmitting. RFID readers and antenna are usually two separate pieces where a typical loading dock in a warehouse will typically need only one reader, but use several antennas to maximize the information that can be captured with one pass. Readers alone can in today's market be found in the price range of $800-$2000 while antenna's, depending on their capabilities are $500-$1500 each. Properly outfitting a single loading door could cost upwards of $10,000-$15,000 with professional installation.

5.4 Host Computers

The most important and unifying parts of the RFID system are the computer, middleware, and software which hold and analyze the incoming information. The function of middleware is to receive, filter, format and send tag data in an understandable configuration to software that will process the information for the end user. The software then compiles the information, generates lists of usable data, correlates shipments with purchase orders and receives product automatically. Many inventory tracking systems or warehouse management systems now come with RFID capabilities or are modular so bar code only software can be updated without replacement of the system. Although most inventory software will allow for shipping and receiving, ordering, and looking up inventory counts, RFID software has the capability to be much more. Software for warehouses that mainly use RFID allows for individual products or skids to be pin-pointed live on a mapping style system for constant feedback to management. The accuracy of these programs increases productivity, effectiveness of shipping and receiving while also providing valuable knowledge for setting accurate reorder points. Integrated warehouse management systems with multiple computer licenses with advanced options such as pallet tracking and live inventory feeds can cost upwards of $150,000-$2,000,000 depending on system size and options needed.

It is clear to see that entire RFID systems can become expensive to implement in larger spaces. Although the replacement of equipment may seem

expensive, it is imperative that only the difference in cost between a new bar code only system and RFID enabled system be determined. This is especially true as both systems would require many of the same components including software, hand held scanners, printers and network connectivity.

6. Example RFID Lumber Retail Sales Scenario

Many executives in the retail industry have a difficult time proposing RFID into their business strategy for a variety of reasons. One of the biggest drawbacks heard is the price of RFID tags being on average $.05-.10 each and labels only $.005. The truth of this cannot be hidden as consumable costs are 90-95% higher than traditional methods of tracking. It can also be said that a pedal bike is much cheaper than a car, but you can argue that travelling to your desired location takes 90-95% less time. This example illustrates that although the initial costs may be substantially more for comparable products, the value that they bring is what makes the choice more clear. Nevertheless, the balance of costs and gains must be weighed accurately to determine the best alternative at the present time.

As an example, let us suppose a lumber retailer such as Lowes or Home Depot is considering switching to RFID for their lumber sales operations but are uneasy about costs. And, let us assume for this example that when this company demands its suppliers to start applying RFID tags onto every piece of dimensional lumber, the entire cost of the tag will not be passed onto the store. In reality of course, the largest retailer in the world, Wal-Mart, does not pay for its RFID tags but

rather demands that its supplier absorb the costs. For this case, let it be envisioned that to help realize the goal of implementation of RFID tags onto each piece of dimensional lumber, stores like Lowes and Home Depot would subsidize the costs 50/50 to reduce the burden on the already suffering lumber producers.

The example presented will be a scaled down version that will apply strictly to the use of RFID in lumber sales at the store level. An assumption will be made that the producing company and their distribution process has integrated a piece level lumber RFID system. The retail store is only looking to increase their efficiency in lumber inventory visibility which they hope will help with shrinkage, inventory holding costs, out-of-stock inventory and reduced store and warehouse labour. In creating an example for demonstration purposes, it was very difficult to find accurate store level unit sales figures so estimations were scaled down and rounded for ease of calculation. In fact, Lowes was the only one of the big three lumber retailers to separate its sales figures into categories with lumber totalling $3.243 billion in 2009.[31]

Initial theoretical estimates of lumber units sold for each retail location is 1,000,000 pieces per year assuming an average price of $2.50 per piece. Retail store A and B are thus expected to have revenues of $2,500,000 annually. If retail store A and store B sell 1,000,000 pieces of lumber each per year, the current total price for traditional bar code labels is $5,000 annually ($0.005 x 1,000,000) while RFID labels cost $50,000($0.05 x 1,000,000). If the assumption is made that

[31] (Lowes, 2009)

turnover is 10 times annually, it can be said that approximately 100,000 pieces will need to be counted at any one time. With both tracking methods, we would like to have at least 98% accuracy on inventory which means employees will need to count inventory once every 5 days to maintain accuracy. Assume that the lumber yard is 50 meters (164 feet) by 50 meters (164 feet) in size not including the interior retail space of one aisle that is 25meters (82 feet) x 3meters (9.84 feet). This is an approximate total of 2,573 square meters (27,703 square feet) that needs to be counted.

Retail store A is using a traditional bar coding system which will require them to have three working hand held mobile scanner computers and one spare. The cost of each unit including additional batteries, charging dock and communication dock, collection software and other accessories is $5,000. The total expenditure for hardware and software for this basic manual batch mode scanning is $20,000.

Retail store B has replaced its mobile scanner computers with high powered RFID enabled mobile scanner computers. Because scanning speed is approximately 10x faster with RFID enabled devices, the store opts for buying only one device and one spare. The cost of these units including all necessary additional spare parts, batteries, software and accessories is $10,000 each. Total expenditure for hardware in the RFID enabled data collection system is also $20,000 (Table I).

6.1 Inventory Count

Every fifth day, retail store A needs to use three employees at $15 per hour and a total of 27.78 hours of productive time to manually count inventory one scan at a time or a variation of scanning and manual input. Over the necessary 73 inventory counts per year, the total cost to manage the desired inventory accuracy level is $30,919.10. Retail store B with RFID enabled hand held scanners can scan 10 times more inventory in the same allotted time and so can finish the entire job with one employee in 2.78 hours. This change in time and amount of employees needed reduced the annual cost of counting to $8,044.10. The change in inventory management from traditional bar code to RFID has initially saved this store potentially $22,875 annually (Exhibit D).

Exhibit D: Bar Coding Inventory Count vs. RFID Inventory Count

	BARCODING – RETAIL STORE A	RFID – RETIAL STORE B	DIFFERENCE STORE B - STORE A
PIECES ON HAND	*100,000*	*100,000*	**0**
PRICE PER TAG	*$.005 (100,000 x .005) = $500*	*$.05 (100,000 x .05) = $5,000*	**-$4,500**
INVENTORY COUNT	*365 days/5 day cycle = 73*	*365 days/5 day cycle = 73*	**0**
LABOUR	*3 men = 33,333 scans*	*1 man = 100,000 scans*	**66,667 scans**
LABOUR/HR	*33,333/1 sec per scan = 9.26 hrs*	*100,000/10 sec per scan = 2.78 hrs*	**6.48 hours**
TOTAL LABOUR HRS	*9.26 hrs x 3 employees = 27.78 hrs*	*2.78 hrs x 1 employee = 2.78 hrs*	**25 hours**
TOTAL LABOUR COST	*27.78 hrs x $15.00/hr = $416.70*	*2.78 hrs x $15.00/hr = $41.70*	**$375**
TOTAL COST OF INVENTORY COUNT	*$416.70 x 73 times/year = $30,419.10*	*$41.70 x 73 times/year = $3044.10*	**$27,375**
TOTAL COST	*$30,419.10 + 500 = $30,919.10*	*$3,044.10 + $5,000 = $8,044.10*	**$22,875**
TOTAL SAVINGS	$22,875.00		

6.2 Shrinkage

Shrinkage is one of the biggest problems facing companies worldwide. External theft is only one small part of shrinkage that retailers are worried about. A large portion of shrinkage can also include employee theft, internal errors, and supplier discrepancies. According to the Centre for Retail Research's annual Global Retail Theft Barometer report were 1,103 companies were surveyed in 2010, the total shrinkage was $107.284 billion US dollars[32] (Figure III). The same survey concluded that the highest global sectors affected by shrinkage are hardware, "do it yourself" and building material suppliers with an average shrinkage of 1.81%[33].

Retail store A is using the traditional method of tracking and has an estimated shrinkage of $37,500 annually (1.5%) based on assumed yearly revenue of $2.5 million[34] (Exhibit E). Retail Store B has upgraded their inventory system to included RFID enabled scanners which has helped realize an 18% reduction in annual losses[35]. This amounts to savings in lumber shrinkage alone of $6,750. The figure presented is an average for all retail sales with the use of RFID, but it is highly probable that lumber shrinkage, with its perishable qualities could experience much larger savings with increased supply chain and store level inventory visibility.

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[32] (Checkpoint., 2010)
[33] Ibid
[34] (Kleist, R.A, Chapman T.A., et al., 2004)
[35] (Roberti M., 2006)

6.3 Inventory Holding Costs

The cost of holding inventory for retail stores is a major sacrifice to revenues and profits. These costs come in the form of warehousing and logistic costs, opportunity cost with capital tied up, write-offs due to obsolete inventory, insurance costs, and depreciation. With increased inventory visibility in store inventory, along with more accurate supply chain management, decreases of up to 16% can translate into $20,000 dollar savings annually based on the sample $2.5 million sales revenue[36]. This figure is again an average for the retail industry but can be estimated higher in lumber sales. Wood is a heavy, cumbersome, generally outdoor stored perishable product that needs to be rotated with forklifts and other heavy machinery which can increase depreciation, insurance costs and warehousing costs more than average retail boxed items.

6.4 Out-of-Stocks (OOS)

The cost of not having an item on the shelf hits retail bottom lines two-fold. Firstly when the item is out-of-stock, 40 percent of the time the retailer loses the sale as customers either do not buy the item (9%) or buys from a different store (31%)[37]. As a consequence, loyalty of shoppers drops for their next purchase, an increase in operation cost in trying to initially find the OOS item and providing rain-checks. This further decreases customer satisfaction and encourages loyal shoppers to try buying

[36] (Lee et al., 2004)
[37] (Gruen, T., 2007)

at the competition. Overall worldwide out-of-stock OOS rates are estimated at 8.3% while promotional product OOS rates are 17.1%[38]. For customers, this translates into an average of 1 in 13 standard inventory products not being available, and 1 in 7 promotional goods not in stock. The underlying reasoning behind the causes of OOS is visibility throughout the supply chain and in the retail store. In the sample scenario, it has been found that inventory out-of-stocks cost retailers 6.6%[39]. For every dollar they sell: $165,000 annual with a traditional inventory tracking method based on $2.5 million while with RFID in place, the reduction of 16% generates a sizable annual sum of $26,400[40] (Figure V).

6.5 Store and Warehouse Labour

Labour costs in the retail sector are the biggest reason companies should look to implement RFID systems with several studies showing that a large percentage of every dollar made is spent on labour costs in store fronts and warehousing. The efficiency of automation that can be accomplished by integrating RFID into store and warehousing areas is the key to success.

With a well-executed RFID infrastructure, nearly every aspect of employee labour can be reduced drastically or made noticeably more efficient. Examples include: the reduction of time needed to receive product at retail loading docks; the

[38] Ibid
[39] (Kleist, R. et al, 2004)
[40] (Roberti M., 2005)

decreased time needed to find items in the warehouse; the drop in hours needed to count inventory; and the decreased time needed to restock shelves.

Companies with RFID integration can see labour cost reductions of 20% in warehouse operations alone[41] up to 90% labour cost cutbacks associated with inventory counts[42], and up to 20% decreases in labour relating to restocking.

Exhibit E illustrates that an average of 14% savings in labour costs can be realized with implementation of RFID[43]. When basing the figures on projected annual lumber revenue of $2.5 million, the labour cost savings amount to $78,750 (Exhibit E) over traditional labour processes. The combination of savings throughout the retail environment including labour costs can create a very reasonable ROI on the investment needed for implementation. Many retail chains have already heavily integrated their businesses with RFID solutions and seen many positive tangible and intangible benefits in their human resource management.

[41] (Malesherbes, B., 2008),
[42] (Salmon K., 2007)
[43] (Visich, J. K. et al, 2009)

Exhibit E: Sales Profitability: Bar Coding vs. RFID

	BAR CODING – RETAIL STORE A	RFID – RETAIL STORE B	Δ
SALES (QTY)	1,000,000	1,000,000	**0**
AVERAGE SELLING PRICE	$2.50	$2.50	**0**
TOTAL SALES	$2.50 x 1,000,000 = $2,500,000	$2.50 x 1,000,000 = $2,500,000	**0**
SHRINKAGE	*$2.5M x 1.5% = $37,500/yr*	*$37,500 x 18% = $6,750* *$37,500 - $6,570= $30,750*	**$6,750**
INVENTORY HOLDING COST	*$2.5M x 5.0% = $125,000/yr*	*$125,000 x 16% = $20,000* *$125,000 - $20,000= $105,000*	**$20,000**
OUT OF STOCK	*$2.5M x 6.6% = $165,000/yr*	*$165,000 x 16% = $26,400* *$165,000 - $26,400= $138,600*	**$26,400**
STORE & WAREHOUSE LABOUR	*$2.5M x 22.5% = $562,500/yr*	*$562,500 x 14% = $78,750* *$562,500 - $78,750= $483,750*	**$78,750**
TOTAL LOSS	$2.5M - $890,000 = $1,610,000	$2.5M - $758,100 = $1,741,900	**$131,900**
TOTAL SAVINGS	$131,900.00		

Wal-Mart is the single largest retail supply chain using RFID. Although RFID has only been implemented into a portion of their top suppliers' products, the full implementation to all products is coming as the benefits become increasingly tangible. It is estimated that with full implementation, Wal-Mart can save approximately 15% or 6.7 billion dollars on labour costs[44]. The manual scanning of bar codes in receiving/shipping and tedious inventory management through manual processes is currently a tangible expense Wal-Mart is looking to decrease. The automation of these processes will help give the company the continued competitive edge others are trying to attain.

[44] (Roberti M., 2003)

7. Challenges of RFID

While the benefits of RFID technology have been well documented and proven the challenges faced by companies looking to replace their current bar coding systems have to do so carefully. The complexity of implementation can be very difficult to overcome if not properly planned and executed. Integration of a full RFID supply chain system at one time will cause havoc on current internal local processes, company information systems and supplier requirement regulations. Changes such as the information that will be collected from RFID tags being considerably more than from traditional bar codes will require larger customized data storage hard drives and better infrastructures. Other challenges include: the amalgamation of supplier information systems and hardware changes for suppliers, distributors and retail checkouts; security and privacy issues for customers and suppliers from unsuspecting eavesdropping of signals; and constant evolutionary technological changes that require costly modifications or upgrades to RFID tags, encoding/reading hardware and enterprise software.

RFID added to lumber production processes so that mass production can be accomplished will be another major challenge. The equipment being currently used in high speed production lines can be fussy with basic bar code labels and with the addition of high speed RFID encoders, the process can be further complicated. Because RFID chips and their antenna's are very delicate, only strong adhesive or additional hot glue can be used to affix RFID labels to lumber. Lumber is also heavily

comprised of water which absorbs radio waves making it difficult to get strong scanner reads if the RFID chip is too deep into a lumber pile.

The development of technology to surpass many of these issues is already being tested and implemented. It is believed that as RFID chip becomes more prevalent in retail supply chains the standardization of consumables, software and hardware is reaching a point where decades will go by with very little change. Time will show that the biggest advocates and the ones who invest the most into one version of the technology will lead the rest of the retail world into a common standardized template RFID implementation.

8. Conclusion

The purpose of this project was to examine the potential efficiencies and challenges that can be faced by lumber retailers with a well integrated RFID system. The technology has been used for several years in places like asset theft protection, building access cards and car toll collection, but very little research has been focused towards the lumber retailers. Lumber and other wood products are unique to retailing because of their perishable composition, strong similarity in product attributes causing misidentification, limitation on storage due to size and the need for unique measures of transportation with exposure to environmental hazards. Although strong challenges present themselves, the research shows that the potential return on initial investment can make implementation in medium and large supply chain operations worthwhile. The project further discussed that yields can be

enlarged in the wood products industry due to the fragile composition, limited shelf life, and large bulk size. These characteristics cause expenses in inventory holding costs, shrinkage, and labour costs to be higher than average boxed items within an indoor retail environment.

Five commonly found major expenses in retail environments were scrutinized with a hypothetical implementation of a simple RFID system. Expenses were described as they would apply to retail lumber sales and shown how RFID benefits can target and reduce each challenge with real world empirical evidence. The use of RFID revealed considerable strategic value in its ability to enhance efficiency, lower costs, increase effectiveness, allocate accountability and respond much faster to customer needs. If large lumber retailers such as Lowes, Home Depot or Rona can integrate RFID into suitable processes within their organizations and leverage the gathered intelligence, then the repayment of systems costs can be shortened significantly. As large retailers begin to see benefits at the store level, it will be in their interest to persuade producers and distributors that not complying with RFID demands will simply hurt their business, while accepting it into their own systems will create value, profit and better continued communication.

Although companies typically start with very small RFID systems for certain process improvement, it was recommended that a modular infrastructure be put in place. This would ensure that a company can expand its system as needed, gradually from its supplier to store shelf. As utilization of RFID in the lumber system

grows, and more retail locations are incorporated, the supply chain inventory visibility will increase and will lead to exponential returns.

The points that ultimately need to be extracted from this project are that lumber retailers are in a unique market which has huge opportunities for improvement. Lumber is a one of kind product and needs special RFID requirements. The acceptance and progression in implementation of the technology must come from retail companies with strong initiatives concentrating on the benefits to all users in the supply chain.

9. Bibliography

Advantech. (2007). RFID System Diagram. *RFID in US Supermarkets*. Retrieved March 10, 2011. Website: http://www.advantech.gr/eAutomation/applications.aspx-doc_id=%7B14A3BF81-B8B7-4B01-A7EB-0189625A4E6.htm

Arunava, Banerjee and Ashok, Kumar Jha. (2006). Radio Frequency Identification Based Manufacturing and Distribution: An Exploratory Overview. *National Institute of Technology,* Jamshedpur. Retrieved December 29, 2010 from UNBC Index & Journal Database.

Bapat, Vivek, Andreas Somogyi, Alfonso Gutierrez and Raj Veeramani. (2006). On the Radio. *ProQuest Science Journals; Material Handling Management,* 53, 6, 30-34. Retrieved January 6, 2011, from ProQuest Database.

Checkpoint. (2010). Making Progress in Preventing Shrink. Improving Economies, Renew LP Investments Help Stem the Tide. *Checkpoint; the Shrink Management Partner.* Retrieved February 12, 2011. Website: http://www.globalretailtheftbarometer.com/pdf/grtb-2010-summary.pdf

Dictionary.com, LLC. (2011). Shrinkage. (n.d.). *Dictionary.com Unabridged.* Retrieved February 26, 2011, from Dictionary.com website: http://dictionary.reference.com/browse/shrinkage

Dutta, A., Lee, H.L., and Whang, S. (2007). RFID and Operations Management: Technology Value and Incentives. *Production and Operations Management*, 16 (5), 646-655. Retrieved December 19, 2010 from UNBC Index & Journal Database.

Gruen, Tomas. (2007). Retail Out-of-Stocks: A Worldwide Examination of Extent, Causes and Consumer Reponses. *University of Colorado at Colorado, USA.* Retrieved February 19, 2011. Website: http://www.sensormatic.com.mx/Tomas%20Gruen%20UCCS.pdf

Heese, H.S. (2007). Inventory Record Inaccuracy, Double Marginalization, and RFID Adoption. *Production and Operations Management*, 16 (5), 542-553. Retrieved December 14, 2010 from UNBC Index & Journal Database.

Kleist R., Chapman T., Sakai D., Jarvis B. (2005). RFID Labeling: Smart Labeling Concepts & Applications for the Consumer Packaged Goods Supply Chain. *Minneapolis: Eaton and Associates Design Company.* Retrieved December 19, 2010 from Google Scholar Database.

Kleist, R.A, Chapman T. Sakai D. Jarvis B. (2004). RFID Labeling: Smart Labeling Concepts & Applications for the Consumer Packaged Goods Supply Chain (2nd Edition). *Irvine, California: Printronix inc.*, 15.

Lee, H., & Ozer, O. (2007). Unlocking the value of RFID. *Production and Operations Management,* 16 (1), 40–64.Retrieved December 19, 2010 from UNBC Index & Journal Database.

Lee, Y.M., Cheng, F., Leung, Y.T. (2004). Exploring the Impact of RFID on Supply Chain Dynamics. *In: Proceedings of the 36th Conference on Winter Simulation,* 1145–1152. Retrieved December 30, 2010 from UNBC Index & Journal Database.

Lowes. (2009). There is No Place Like Home…Still. *2009 Annual report.* Retrieved March 7, 2011, Lowes Corporation. Website: http://investor.shareholder.com/lowes/annualTrack.cfm

Malesherbes, BD. (2008). RFID Technologies for Cold Chain Applications. *International Institute of Refrigeration. Paris, France.* Retrieved February 15, 2011. Website: http://www.iifiir.org/en/doc/1191.pdf

McCathie, Luke and Katina Michael. (2005). The Pros and Cons of RFID in Supply Chain Management. *Proceedings of the IEEE International Conference on Mobile Business.* Retrieved December 29, 2010 from UNBC Index & Journal Database.

Melski, Adam; Mueller, Juergen; Zeier, Alexander; and Schumann, Matthias. (2008). Assessing the Effects of Enhanced Supply Chain Visibility Through RFID. *AMCIS 2008 Proceedings.* Retrieved February 28, 2011 from UNBC Index & Journal Database.

Murphy, Cliff. (2004). Managing the EPC Generation Gap: An Overview of EPC Standard Migration from Generation 1 to Generation 2 RFID Tags. *Zebra Technologies: Application White Paper.* Retrieved March 3, 2011. Website: www.webermarking.com/images/Managing%20EPC.pdf

Naden, Gary. (2003). Going the Distance: Power Supply Management in an Asset Tracking Device. *GPS World: Design Challenge – Asset Tracking.* Retrieved March 8, 2011, from GPS World Database. Website: www.tadiranbat.com/pdf.php?id=gps_world_asset_tracking

Porter, M.E. (1985). Competitive Advantage: Creating and Sustaining Superior Performance. *Free Press, New York.* Retrieved March 9, 2011, from Wikipedia. Website: http://en.wikipedia.org/wiki/Competitive_Advantage

Raman, A., DeHoratius, N., and Ton, Z. (2001). Execution: The Missing Link in Retail Operations. *California Management Review Journals*, 43 (3), 136-152. Retrieved January 9, 2011 from Google Scholars Database.

Roberti, Mark. (2003). Case Study: Walmart's Race for RFID. *BSSinSight.* Retrieved February 16, 2011. Website: http://www.bssinsight.com.au/PDF/Casestudy_RFID_Walmart.pdf

Roberti, Mark. (2005). 30% Out-of-stock Reductions from RFID. *RFID Journal.* Retrieved January 6, 2011 from RFID Journal Update. Website: http://www.rfidjournal.com/article/view/6486

Roberti, Mark. (2005). Walmart: RFID Reducing Out-of-stocks. *RFID Journal.* Retrieved January 6, 2011 from RFID Journal Update. Website: http://www.rfidjournal.com/article/view/6358

Roberti, Mark. (2006). The ROI of RFID in the Supply Chain. *RFID Journal.* Retrieved January 6, 2011 from RFID Journal Update. Website: http://www.rfidjournal.com/article/articleprint/2602/-1/1

Sabbaghi, A., Vaidyanathan, G. (2008). RFID. *Journal of Theoretical and Applied Electronic Commerce Research*, VOL 3 / ISSUE 2 / 71-81. Retrieved December 14, 2010 from UNBC Index & Journal Database.

Salmon, Kurt. (2007). Retail Market: RFID Solutions. Industry Brief. *Motorola.com.* Retrieved on February 16, 2011. Website: http://www.motorola.com/web/Business/Products/RFID/_Documents/_Documents/_staticFiles/RFIDRET_IB_0108.pdf?localeId=33

Sharma A., Citurs A. and Konsynski B. (2007). Strategic and Institutional Perspectives in the Adoption and Early Integration of Radio Frequency Identification (RFID). *In: Proceedings of the 40th Hawaii International Conference on System Sciences.* Retrieved December 30, 2010 from UNBC Index & Journal Database.

Smith, Jeffery S., Mark Gleim, and Sung-Hee Park (2009). Consumer Acceptance of RFID: A Test of Competing Models. *Southeast Decision Sciences Conference Journal.* Retrieved January 10, 2011 from Google Scholars Database. Website: http://www.sedsi.org/history/2009/proceedings/proc/p081001001.pdf

Spekman, R.E. and Sweeney II, P.J. (2006). RFID: From Concept to Implementation. *International Journal of Physical Distribution and Logistics Management*, 36 (10), 736-754. Retrieved December 14, 2010 from UNBC Index & Journal Database.

Visich, J. K., Suhong, L., Khumawala, B. M., & Reyes, P. M. (2009). Empirical Evidence of RFID Impacts on Supply Chain Performance. *International Journal of Operations & Production Management*, 29(12), 1290-1315. Retrieved December 14, 2010 from UNBC Index & Journal Database.

WU N.C., Nystrom M.A., Lin T.R. and Yu H.C. (2006). Challenges to Global RFID Adoption. *Technovation*, 26, 1317 – 1323. Retrieved December 29, 2010 from UNBC Index & Journal Database.

York, Chris. (2003). Auto ID in the Supply Chain of Today and Tomorrow. *ProQuest Science Journals; Material Handling Management,* 58, 11, 33-35. Retrieved January 6, 2011, from ProQuest Database.

10. Tables

Table I: Initial Cost of Basic Inventory Collection Equipment

REQUIRED	BARCODING	RFID
SCANNERS	3 scanners + 1 spare	1 scanner + 1 spare
EXTRA PARTS	Spare batteries, mobile software + software	Spare batteries, software, accessories
TOTAL COST	4 x $5,000 = $20,000 est.	$2 x 10,000 = 20,000 est.
Δ	$0.00	

Table II: Total Summary of Cost Savings – Bar Code versus RFID

	Inventory Count	Shrinkage	Inventory Holding	Out-of-Stock	Store & Warehouse Labor	Total
Bar Code	$30,919	$37,500	$125,000	$165,000	$562,500	$920,919
RFID	$ 8,044	$30,750	$105,000	$138,600	$483,750	$766,144
Savings	$ 22,875	$ 6,750	$20,000	$ 26,400	$ 78,750	$154,775

11. Figures

Figure I: RFID versus Bar Coding

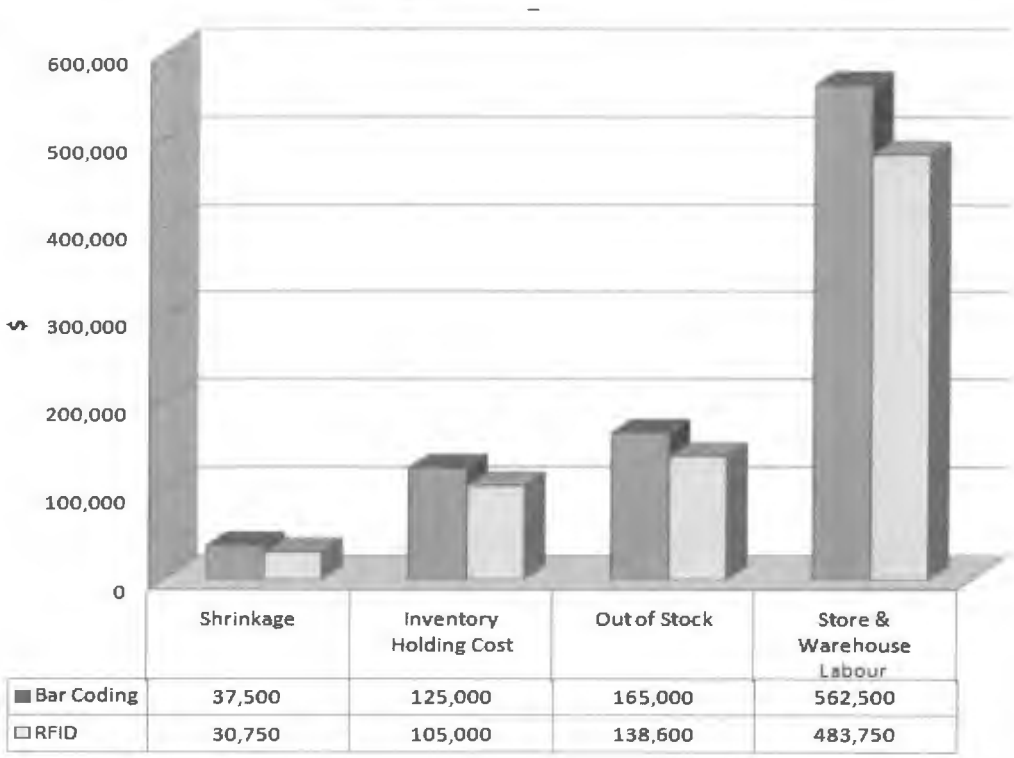
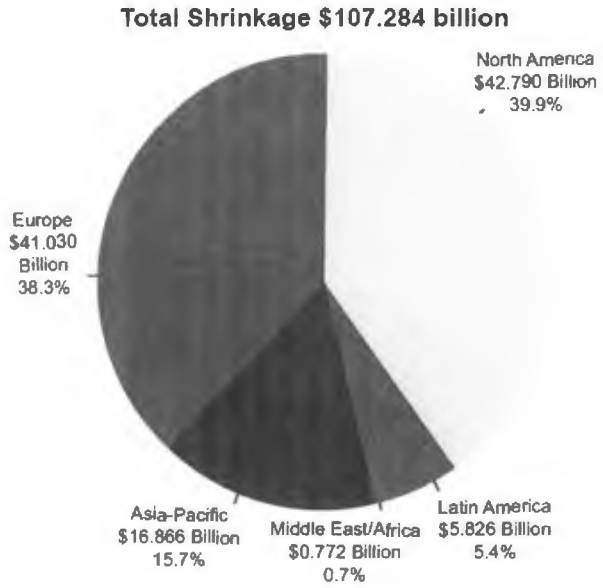


Figure II: Retail Shrinkage 2010 by Region

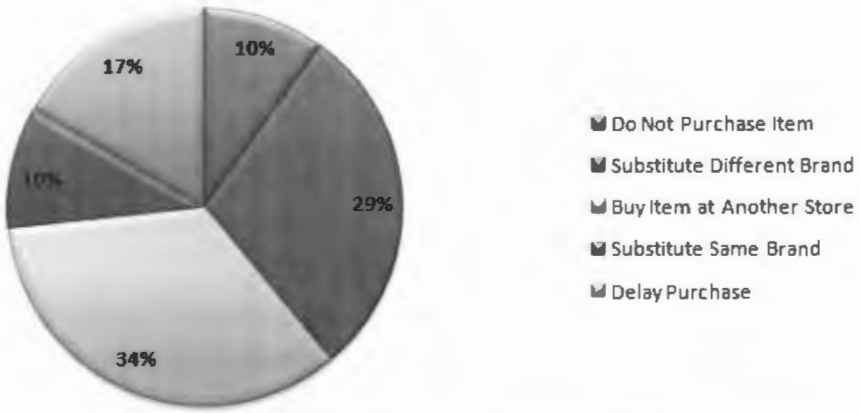


Checkpoint. (2010). Making Progress in Preventing Shrink. Improving Economies, Renew LP Investments Help Stem the Tide. Check Point; the Shrink Management Partner. Retrieved February 12, 2011. Website: http://www.globalretailtheftbarometer.com/pdf/grtb-2010-summary.pdf

Figure III: Global Shrinkage by Business Sector

Checkpoint. (2010). Making Progress in Preventing Shrink. Improving Economies, Renew LP Investments Help Stem the Tide. Check Point; the Shrink Management Partner. Retrieved February 12, 2011. Website: http://www.globalretailtheftbarometer.com/pdf/grtb-2010-summary.pdf

Figure IV: Response to Out-of-Stock Items (OOS)



Gruen, Tomas. (2007). Retail Out-of-Stocks: A Worldwide Examination of Extent, Causes and Consumer Reponses. *University of Colorado at Colorado, USA.* Retrieved February 19, 2011. Website: http://www.sensormatic.com.mx/Tomas%20Gruen%20UCCS.pdf

Table VI: Summary of Findings of OOS Causes (Worldwide)

Checkpoint. (2010). Making Progress in Preventing Shrink. Improving Economies, Renew LP Investments Help Stem the Tide. Check Point; the Shrink Management Partner. Retrieved February 12, 2011. Website: http://www.globalretailtheftbarometer.com/pdf/grtb-2010-summary.pdf