Master’s degree thesis

LOG950 Logistics

Measuring the Return on Investment of RFID in the Smartrack project

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Number of pages including this page: 100

Molde, 2nd December 2, 2013

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1.0 Acknowledgments

This Master thesis is the final requirement for the Master program in Logistics in Høgskolen i Molde (Molde University College). The Master thesis is based on the topic of "Measuring the return on investment of RFID in the Smartrack project".

We would like to express our gratitude to our supervisor Bjørn Jæger for his continues help and motivation throughout the writing of the master thesis, and for helping us defining the research topic and also for his feedback and productive suggestions.

We would also like to thank Petter Thune-Larsen from GS1 for his help, his fast response to our questions and generally for letting us work in the Smartrack project. As well as a special thanks to Vegard Jensrud for his great help from the period of January to May 2013 during his work in GS1.

Moreover special thanks to Christian Uzlastiran and Øyvind Haugen from TollPost Globe for finding the time to meet us in January in TollPost Globe headquarter and for supplying us with data and explaining how logistics operations take place in TollPost Globe.

Furthermore, we would like to pay our tribute and our deepest sympathies to the family of the late Professor Ola Bø, for without him we would not be working on this project, may his soul rest in peace.

Last but not least we would like to thank our families and friends for their unlimited support during our studies of the master program, and especially during the writing of the master thesis.

2.0 Abstract

Nowadays technology plays a crucial part in our lives, one of these technologies is the Radio Frequency Identification (RFID). Currently there is an array of different applications of RFID in different industries for instance in retailing and tracking. One of the major and most popular applications of RFID is in asset tracking and that is the reason GS1 is promoting the use of RFID through the Smartrack Project. The Smartrack project targets the effects of better regularity and punctuality, better management and tracking which increase the efficiency of goods transportation through the application of RFID.

This research paper is a part of the Smartrack project, the paper aims to estimate, calculate and measure the potential benefits and return on investment of the application of RFID regarding two of the Smartrack partners: TollPost Globe and Coop. The results of this research can be used for the Smartrack project final report.

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6.0 Introduction

6.1 The Smartrack Project

This thesis is part of the Smartrack project, and was carried out in Cooperation with the owner of this project which is GS1 Norway and other actors in the project, namely TollPost Globe which is a transportation company and the service provider. TollPost Globe is a large player within intermodal transportation in Norway. Coop Norge Handel is another part of the Smartrack project, which its subsidiary Coop Faghandel in Trondheim is acting as the customer and the owner of the goods. The project purpose is to identify opportunities by finding and sharing tracking information in an intermodal transport chain.

Intermodal freight transport is the transport of intermodal containers by several transportation modes like, rail, ship and truck (Heller 1999). The tracking system will track the cargo through an intermodal transportation chain through rail and truck by electronic tracking devices with RFID technology. Electronic Product Code Information Services (EPCIS) is a GS1-standard which will be used as an infrastructure for maintaining and sharing the tracking of data between all the actors in the project.

GS1 Norway is the organization that owns the Smartrack project. They are members of GS1 a global non-for-profit. GS1 design and implement global standards for efficient goods and information flow between trading partners worldwide (GS1 Systemet 2013). These standards improve the efficiency and visibility of supply and demand chains. The GS1-system is their main activity. This system is the series of standards that improves efficiency of the supply chain. It is composed of four standards: Barcode, GDSN, EPCglobal and RFID. There are five organizations that are linked to this transport chain:

1. Coop Faghandel AS, (Coop). They are the owners of the cargo and clients for the transport organizations.
2. TollPost Globe AS, (TG). TG is Coops freight forwarders and carry the transport on behalf of Coop.
3. CargoNet AS, (CN). Has the responsibility for the rail transport of a segment.
4. Jernbaneverket, (JBV). They are responsible for the rail infrastructure throughout Norway.
5. Trafikverket, (TV). They have responsibility for Swedish rail and road infrastructure.

Other actors that are involved in this project are: Høgskolen i Molde and Møreforsking Molde as research partners. Sitma which is a transport and logistics consultancy company Finally

RFID-Huset provides RFID hardware and complete systems for data collection with software. (GS1 u.d.)

6.2 Background

Many years ago, the transportation of goods was mostly in bulks. Bulk is goods transported on pallets, in boxes, crates, barrels and so on. Trucks and trains were transporting stacks of boxes along the highways and rails. Owners of transportation businesses around the world have always tried to find better and cheaper ways to move their freight. Using ships as a part of the transport chain was a potential money saver, but the labor and time spent to load and unload the cargo were a major cost (Levinson 2006). Malcom McLean, an American entrepreneur pioneered and invented the idea to stack the cargo into bigger standard boxes which would reduce the loading time and in pursuit of that containers where implemented. (Levinson 2006) (Cudahy 2006)

A container could mean a lot of different things back then. They came in all kinds of different sizes and material, some were designed to be carried by cranes and others by forklift, but the main idea of a container was to gather all the goods in one big box to make it easier and faster to handle.

All sizes of containers were tried out to better utilize different means of transport on ship, rail and truck. There were a lot of diversity, both transport companies and customers had their own preferences in type of container. Ports and terminals had different types of equipment like cranes and forklifts to load and unload all types containers onboard the boat and further onto trains and trucks. They wanted to use the space onboard boats as efficient as possible, but containers with different height and width made it challenging. They also had to take into consideration legal limits and load carried on road and on rail (Levinson 2006).

Organizations were made trying to standardize much of the containers to solve the problem the problems they were having. Standardization would mean that containers could be stacked and allow more efficient use of space on ships, rails and trucks. It would also mean much faster load and unloading in an intermodal transport chain. An intermodal transport chain is cargo transported using more than one type of transportation like ship, rail and truck. International standards organization (ISO) is an organization that was trying to set up standardized guidelines for containers. Standardized containers have same dimensions and structure. It will save them time to load and unload containers which also saves costs (Levinson 2006).

Over the years the volumes in container shipping has grown (Lemper and Zachcial 2008). With more containers in motion the transportation companies face new challenges. Many transportation companies like TollPost Globe use standardized containers to deliver goods to their customer. Having a system where you have good control on a large container fleet and knowing where your containers are located at all times is hard to achieve.

The expression “Container fleet management” can short be described as numbers of containers available for transport to the right customer at the right time and that they are in good condition to deliver the necessary services which are to be expected. It can also be said that it means to keep control of the container fleet and using the containers the most efficient way. (Hultén 1997)

A container can be seen as a resource. An important goal for every transport company is to use their resources as effective as possible. Some of the costs that the companies are facing are: fuel consumption, handling costs and other costs related to service (for example security). Thus it is important for a company to use their container fleet as efficient as possible to keep costs down and at the same time have a good customer service. For this they need data and information. With data information they can make faster decisions and have much more control. (Hultén 1997).

The reason of this long background of containers and containerization is -as mentioned before in the previous section focus of- the Smartrack project on intermodal transport. (Stopford 2003) defined Intermodal transport as “An Integrated Transport System consists of a series of components (e.g. road, sea, rail) which are designed for the efficient transfer of cargo from one system to another” that being said, this system –the intermodal transport system- is better managed when managing a standard unit of transport i.e. the container.

6.3 Purpose of the study

The actors that are involved in the Smartrack project wants first and foremost to gather and process data from the tracking technology and turn it into useful information and share it throughout the supply chain leading to improving the operations in the supply chain by making it more efficient while at the same time improve quality and customer service. (Geir Berg, Petter Thune-Larsen, Harald M. Hjelle, Bjørn Jæger, Hans F. Nordhaug 2013). Over time the actors hope that the investment in implementing a tracking system with RFID can solve some of the problems that they are having in areas where they presume can make some potential improvements, which will be discussed later.

Associate Professor Ola Bø at Molde University College conducted a study where he found potential possibilities for improvements by implementing tracking system with RFID, GPS and EPCIS in the supply chain. His study was based on observations and interviews from Jernbaneverket, Coop Faghandel, TollPost Globe, CargoNet and other actors involved in the Smartrack project.

In this study we shed light and focus on some of the problems Ola Bø encountered, and calculate the benefits regarding implementing an RFID solution concerning these problems:

1. Container and inventory management from TollPost Globe perspective.
2. Cost of not having information in COOP.

TollPost Globe s controls their container fleet by manual and partial registration of container movements. IT-systems provide information on the fleet, where the identification of containers is gathered by manually identifying and register the container ID in the IT-system. IT-systems register the traffic that goes through the main gate and the traffic between TollPost own terminals. So if the container is outside, in the district, they have to call TollPost other terminals to locate the container if needed. In other word their control of the container fleet is based on manual routines. With the use of tracking technology like RFID and GPS, one of their goals is to make the container fleet more manageable and reduce the uncertainty for the customer in terms of delays amongst other benefits.

As mentioned a container can be seen as a resource. Research and previous studies have been conducted on the savings by having a system that register and keeps track on the container fleet. According to Ola Bø's report (Bø 2012) a lack of control can make it difficult to handle the correct billing for storing containers at their own and on others terminals. A lot of these resources can be misused which may lead to unnecessary costs. Storing empty containers can be expensive depending on the storage costs (storage costs are defined in the TollPost Globe case as explained later). The containers can be rented by a third party and to be used for long term storage over time. Containers tend to be forgotten, dropping out of the control system. The more efficient the containers are being used the more value they create. It can also be time and labor consuming to gather the information manually on containers location and arrival time back to the terminal depot (at Alfaset). This may result in a lack of containers. It causes a need for unnecessary buying new or leasing additional containers. Another problem could be the unnecessary workforce used to find the location of containers at local terminals. Automating container tracking that takes away manual routines and limits the possibilities for human errors can be used so that TollPost Globe can better manage its fleet and thus save money by using less resources controlling the fleet manually.

In the interview that Ola Bø made with Coop they revealed some different types of causes of deviations. The most common one was delays of freight trains carrying the containers. When the train doesn't arrive on time it creates problems for Coop and the process that follows with trying to find out what has happened is long and complex. The information handling is slow. It has to go through several different actors before they can find out what happen, and then take the necessary actions that to handle the delay. We will precede with calculations estimating how much Coop can save if the delays and other deviations are removed.

6.4 Return on investment (ROI)

Our thesis is to find the effects on implementing tracking system like RFID. To be able to find a result on these effects we will be using the model Return-On-Investment (ROI) to measure the end results. As it is going to be explained later on in the research Methodology section, we follow a five step Return on Investment tool:

1. The first step in this model is to collect all data on the effects of implementing the tracking system. Of the effects of implementing RFID we are going to focus on reduced labor (unnecessary hiring), reduction of shrinkage and better management of containers leading to higher profit due to more effective use.
2. The second step is to convert the effects of the implementing RFID into a monetary value.
3. The third step is to calculate the total cost of implementing RFID.

4. After finding the effects of implementing RFID we calculate the net costs of RFID implementation.
5. The fifth and last step we calculate the return of investment.

This return on investment model will be later explained in details in the “Empirical Model” section under the “Research Methodology and Data collection” chapter.

7.0 Research Problem

Our general research problem is to try to realize and compute the different benefits of applying RFID solution (Smartrack project) for TollPost Globe and COOP, and to compare these benefits against the costs related to the RFID tracking system.

Any other challenges faced by the transport chain in the Smartrack project such as management of freight wagons, damage on railcar wheels, possibilities of an alarm system for delays, and any other problems specific to another participant of the project besides TollPost Globe and COOP are not included in our research.

8.0 Research questions

We formulate four specific research questions from the research problems described above.

RQ 1: What are the costs related to a RFID tracking system in the Smartrack project regarding TollPost Globe and Coop? These costs are the combined total cost derived from the implementation of RFID in TollPost and Coop to calculate the return on investment in RQ4.

RQ 2: What are the potential estimated benefits for using RFID tracking for TollPost Globe container fleet?

RQ 3: What are the potential estimated benefits for using RFID tracking to gain control and visibility for COOP?

RQ 4: What is the return of investment for TollPost Globe and COOP?

9.0 Literature review

In this chapter we review the previous research, studies and cases done on measuring the return on investment of applying RFID technology in tracking containers.

The chapter should be a backbone for this work, as it backs the methodology, analysis and some of the estimated data related of this research. First we lay ground for the RFID technology, and then we discuss the return on investment of applying RFID, with the related benefits and costs.

Publications	Most used approaches	Main topics
Practical papers	Pilot projects	Inventory management
	Case studies	Logistics and transportation
	ROI analyses	Assembly and manufacturing
		Asset tracking and object location
		Environment sensors
Academic papers	Analytical approach	Inventory inaccuracy
	Simulation approach	Bullwhip effect
	Case studies	Replenishment policies
	ROI analyzes	
	Literature review	

Table 1Literature publications (Sarac, Absi and Dauzère-Pérès 2010)

In our research attempt of writing and formulating this chapter (literature review) we have come to find that table 1: "Literature publications" by (Sarac, Absi og Dauzère-Pérès 2010) is of actually great factuality and relevance to the body of work related to RFID. As the chapter goes on reviewing and studying different publications, the more this table will come to be more realistic.

9.1 Radio Frequency Identification (RFID)

In this section we discuss and define the RFID technology and other related topics as type of tags, its relation with other technologies as barcoding and GPS.

9.1.1 Definition

RFID technology is a wireless automatic identification technology which is composed of three elements: an RF tag (with antenna), a reader (that emits and receives signals from/to tags) and finally middleware (software) that bridges the RFID hardware and the enterprise applications (Domdouzis, Kumar and Anumba 2007), (Sarac, Absi and Dauzere-Peres 2009) and (Violino, RFID system and costs 2005) and (Saygin, Sarangapani and Grasman 2010).

9.1.2 RFID Tag types

General there are two types of RFID tags; Active and passive. From the first view, we can notice that barcodes and RFID tags are similar in that both use labels (tags) and scanners to read those labels, also, both need software to be able to interact and transfer the data embedded in the labels, the following table summarizes the differences between barcodes and RFID tags

Feature	**Barcode**	**Passive tag**	**Active tag**
Cost	Low	Medium	High
Line of sight	Yes	No	No
Multiple reading	No	Yes	yes
Read/write capability	No	Yes	yes
Speed of reading	Slow	fast	Fast
Communication range	Very close scanners	Up to 3 meters	up to 100 meter
Line of sight	Yes	No	No
Reader or tag collision	No	possible	possible
Interference	Barriers between barcode and reader	Environmental effects on radio waves	Limited interference
Labor intensity	Very high	Very low	Very low
Security	Low	Medium (can be changed)	high
Memory capacity	Very limited	Up to 64 KB	Up to 8MB
Life span	Short	Indefinite	Depends on battery
Power supply	No power supply	Radio waves from reader	Battery powered

Table 2 RFID vs. Barcode Self, (Adaptalift Hyster 2012), (Clampitt 2006), (Gaukler and Seifert 2010) (Atlas RFID Solutions 2013) (Wadhwa and Lin 2008), (Cisco Systems, Inc 2008), (Violino 2005).

Table 2 shows a comparison of RFID (active and passive) and Barcode, according to different sources. It is remarkable to mention that according to (Adaptalift Hyster 2012) they calculated that around “40 RFID tags can be read at the same time”. In case of “Reader and tag collision” it can happen due to two signals overlapping each other or when many tags in the same zone respond at the same time. (Atlas RFID Solutions 2013) In their website, they mentioned that more than 100 RFID tag can be read at once, also, virtually no labor is needed “Once up and running, the system is completely automated.”

As a matter of fact we can see that the Passive RFID is a middle ground between Barcode and Active RFIDs, as it provides a better solution than that of barcodes yet with a relatively low cost if compared to the costs of active RFID tags.

9.1.3 Closed and Open loop RFID application

Generally speaking, the RFID application is categorized into two basic applications: a closed loop and an open loop. This depends on whether the application of the RFID solution is within one signal facility (one party in a supply chain) or across different parties within a supply chain. (Zhang and Wensheng 2007)

For instance, the application of RFID solution within a retailer’s premises is considered as a closed loop. While the application of an RFID solution, within different parties of the supply chain is considered as an open loop.

In an open loop application, it is necessary to have a global identification standard in order to be able to have a standard code that identifies the tag. For instance different users in an open loop will use the GS1 EPC code. On the other hand, in a closed loop RFID solution, where the tags and readers are controlled and only specific to this premises, any code will work as there is no need for a global standard code. (Traub 2012)

In a wider perspective, it seems that the usage of a global standard code is easier as it minimizes the risk of any multiplications and most importantly to unify all the tags codes uniquely.

9.2 *Alternative tracking technologies:*

Kandel, et al. (2011) summarized tracking solution in two main branches; Discrete which is an event tracking as RFID and Barcode, and Continuous as in GPS.

In a white paper published by IBM, (Hanebeck and Lunani 2008) stated that for a short and medium term solution to track returnable containers in the automotive industry, a passive RFID will provide an efficient solution (compared to active tags and GPS). While for a long term period, active tags may be economically feasible[1]. A comparison shows the differences between Active and passive RFID and GPS is shown in Figure 1 (Hanebeck og Lunani 2008)

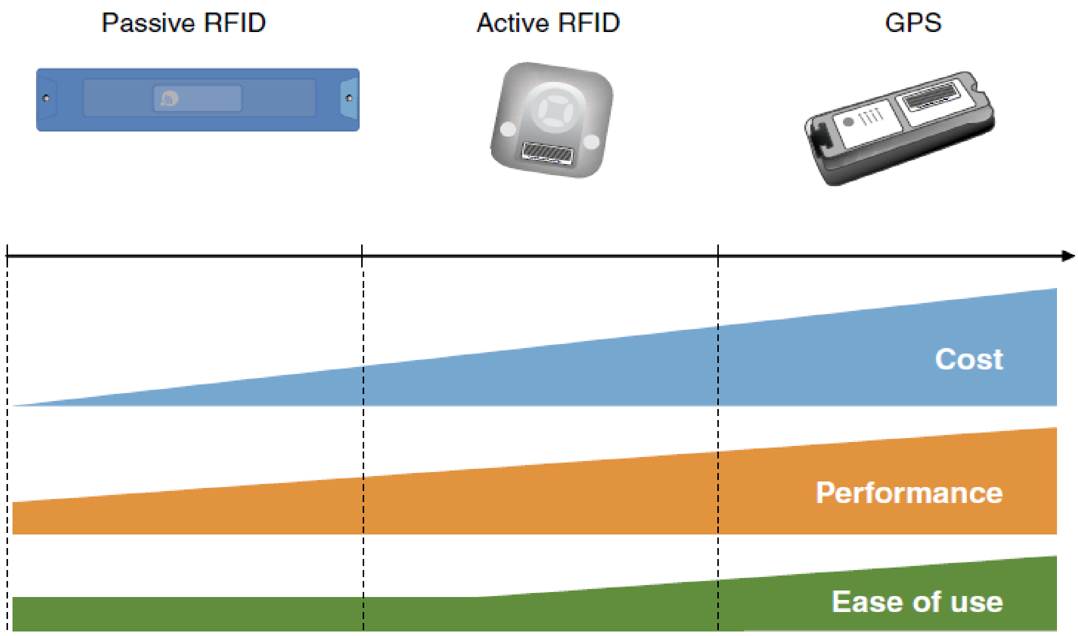


Figure 1comparison between RFID types and GPS (Hanebeck and Lunani 2008)

It is possible to see figure1 from a return on investment scope, meaning that we can see the "performance" level and "ease of use" as benefits of the application of the related technology. While the comparison of the "costs" (can be called investment costs) to the benefits (performances and ease of use) as the return of investment.

[1] It is important to mention that the mentioned returnable containers differ from the shipping containers (Twenty Equivalent Unit) and so the economics of such application can differ from one applications to the other

On the other hand (Kandel, Klumpp and Keusgen 2011)addresssed real issues (disadvantages) to RFID against the –in the openion of the paper's authoers (Kandel, Klumpp and Keusgen 2011) GPS solution. They discribed the RFID soultion as "discrete" and "event monitoring" since RFID cannot provide a real time geographical position, except when the tagged shipments are near the reading point. So, mainly the shipment is only traceable in pre-defined locations (i.e. locations of the RFID readers).

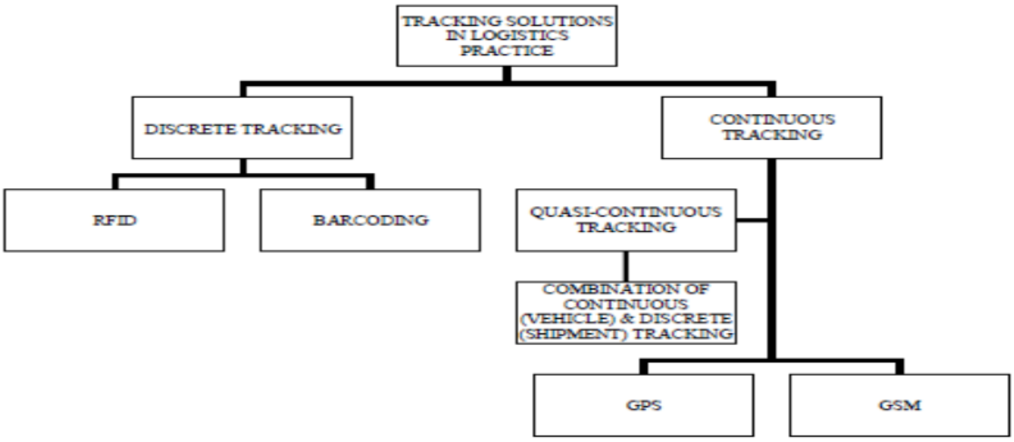


Figure 2 Tracking solutions (Kandel, Klumpp and Keusgen 2011)

The Authors Kandel, et al. (2011) was in favor of a continuous tracking system, a GPS for instance, over a discrete one. As they were considering a scheduling/planning point of view, it was important for them to have information as early as possible to help solve any incidents (delay in this case) as fast as possible.

(Basha and Reddy 2012) propsed a hybrid terminal system composed of RFID, GPS and GSM. RFID was for containers to be tracked when entering or leaving the terminal, GPS to trangulate its location wherever the conatiner is, while the GSM module can send the location of the container based on the GPS information to the assigned person.

But, although this system is very helpful, and can integrate both the advantages of the RFID and GPS technology, the authors of the paper Basha and Reddy (2012) did not mention or calculate any costs relted to the system, as costs are really an important factor for any company which wants to apply such a solution. And also apparently (Kandel, Klumpp and Keusgen 2011) favored the availability of information over costs of acquiring such technology.

9.3 Return on investment (ROI) of RFID

On this section of the literature the we try to grasp the benefits and costs of having an RFID solution.

9.3.1 ROI

As mentioned before, the application of RFID solution can provide different benefits. Yet, an analysis should be done in order to measure the profitability of applying the RFID solution, since it requires substantial investment (depending on the size of deployment of the RFID solution). Thus comes the role of a Return on Investment (ROI).

Basically, ROI compares between the benefits and costs of an investment, in our case RFID investment. It can be defined as:

"*The ratio of money gained or lost on an investment relative to the amount invested. The amount gained or lost may be referred to as interest, profit/loss, gain/loss or net income/loss, while the money invested may be referred to as the asset, capital, principal or cost basis of the investment. ROI is sometimes also known as "rate of profit" or "rate of return*." (RFID Journal)

It can be quantified in the mathematical equation as:

$$\text{ROI}=\frac{Gains\ from\ investment - Total\ costs\ of\ investment}{Total\ costs\ of\ investments}\times 100$$

Equation 1 Return on Investment Equation

In the Methodology chapter we will explain in details how we are going to apply the ROI in RFID for TollPost and COOP.

9.3.2 RFID Benefits

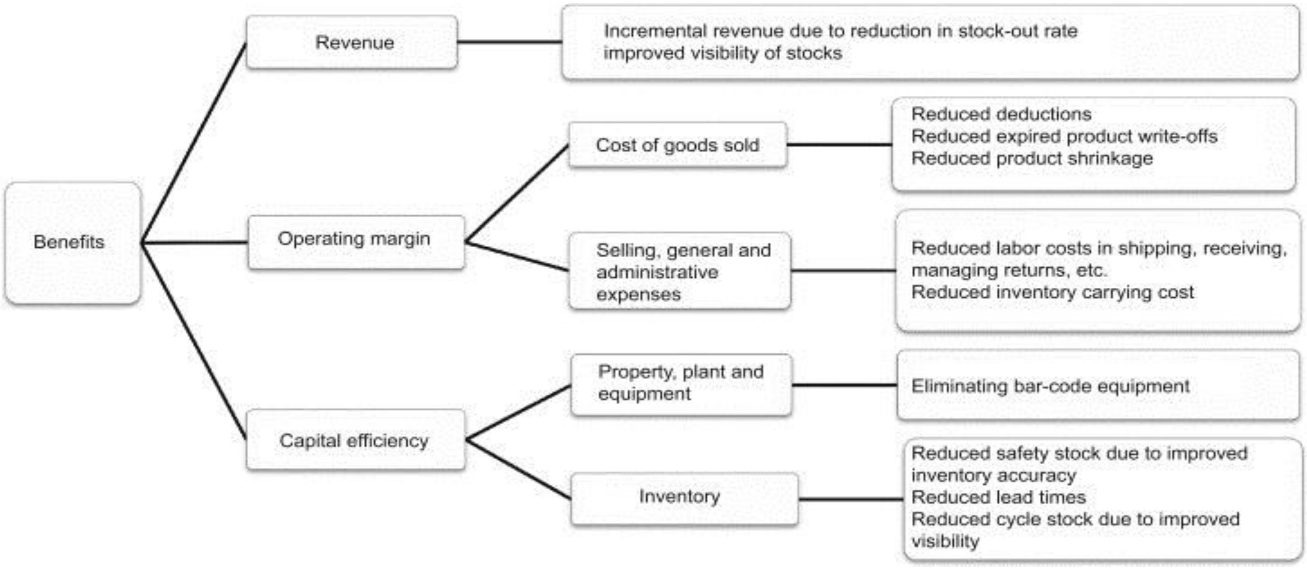


Figure 3 RFID Benefits (Leung, et al. 2007)

In the RFID benefits figure, we can see the (Leung, et al. 2007)have categorized the benefits into three categories; Revenue, Operating margin and Capital efficiency. We can comprehend that the benefits are realized by an increase in the revenue (as a matter of reduction in stock outs), a decrease in the operating margin (notice here reduced costs related to labor, shrinkage, and inventory) and finally an effective capital management (as mentioned in figure 3)

In our TollPost Globe 's and Coop's case we can relate to some of the benefits mentioned in figure 4: revenue due to reduction in stock-outs, reduction in product shrinkage, reduced labor costs, reduced inventory carrying cost, inventory related benefits as reduced safety stock.
On the other hand benefits as reduced expired product write offs, reduced lead times, and reduced deductions are not taken in considerations in this research as they are either out of focus of this research, and/or there is not enough data and information regarding the current situation in these specific areas.

(Ustundag 2013)mentioned that generally speaking RFID is still considered an evolving technology especially regarding the availability of information related to benefits and costs except for a very few applications on retail and manufacturing industries (Chao, Yang and Jen 2007)

(Griebenow 2006) calculates the ROI of applying active RFID tags on trucks, containers and entry and exit points. The author assumed an only 1% reduction of lost containers against a typical 2% in the time of the research. In this case a dramatic 652% Internal Rate of Return (IRR)[2] for savings was reached, while there was a reduction of 44% of assets used.

(Sarac, Absi and Dauzere-Peres, 2009) provided a comprehensive and extensive literature review of RFID and its impact on supply chain management. The study concluded that RFID technologies can actually offer a numerous advantages in the supply chain, by providing better tractability and improved visibility of products across the supply chain: increase of speed and efficiency, better information accuracy, and reduction in loss of inventory.

(Wu, et al. 2006) mentioned that when considering the ROI from RFID, benefits can be divided into two parts:

1. Cost reduction, e.g. labor cost reduction, inventory cost reduction, process automation, and efficiency improvements, etc.
2. Value creation, e.g. increase in revenue, increase in customer satisfaction due to responsiveness, and anti-counterfeiting)

(Pisello 2006) stated the following benefits and ROI of RFID

1. Improving warehouse and distribution productivity from 7% to 40%
2. Reduce out of stock by up to 50%
3. Reduce shrinkage (loss and theft) by 18%.
4. Improve capital asset tracking and management (optimized by 20%)

(Pisello 2006) mentioned the following RFID benefits regarding the reduction of operating expenses and improved margins:

1. Reducing labor costs via automation
2. Lowering required inventory levels
3. Improving production asset visibility
4. Meeting customer mandates, and improving customer experience and satisfaction.

[2] Internal Rate of Return is defined as the "return which can be earned on the capital invested in the project" (Mark Withers 2010)

In conclusion of the upper mentioned paper, it is demonstrated that a ROI of at least 200% is achieved. So with even the related costs that might raise depending on the context (Ustundag 2013) it is still profitable to apply RFID solution.

(Maleki and Meiser 2011) Pointed out the advantages of applying RFID solution with passive tags to:

1. Automatically scans tags reducing manual labor, cost, time and error
2. Lighter and smaller tags than Active RFID and Wi-Fi technologies
3. No need to monitor and change batteries
4. Low cost of tags from $0.2 to $3 per tag
5. Line of sight not required to read tags

But, they also mentioned some disadvantages:

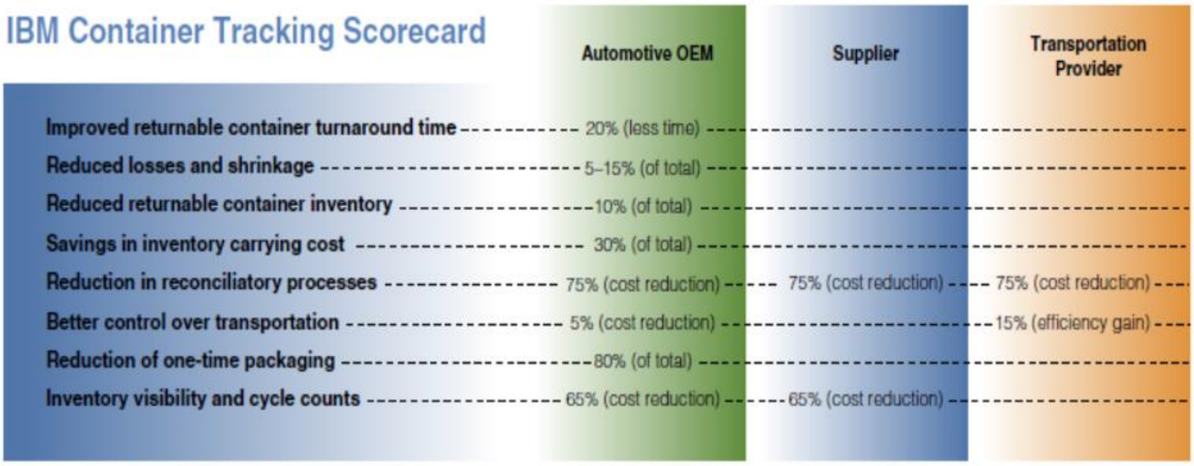
1. More readers necessary
2. Communication read range is only 3 meters
3. Max speed of 3 mph past reader to read tag
4. Limited multi-tag reading capabilities

In our case (Smartrack project) when applying readers on traffic terminals in TollPost for instance to track the inbound and outbound of containers, we can neglect the disadvantage of "more readers" since they need no more than one reading point for tracking in and outbound units at each end of the transportation chain (Oslo and Trondheim as will be later explained in the TollPost Globe case section).

In the IBM paper mentioned before (Hanebeck og Lunani 2008), the following list of benefits was mentioned:

1. Improved cycle time the faster the container cycle time the fewer is needed.
2. Reduced container losses and shrinkage by 5% to 10%.
3. Reduced cost recovery of lost containers.
4. Minimized purchase of extra containers.
5. Saving in inventory and labor costs.
6. Reduction on the number of containers by a 30% in value terms.

These benefits can be shown in the following figure:



IBM Container Tracking Scorecard

	Automotive OEM	Supplier	Transportation Provider
Improved returnable container turnaround time	20% (less time)		
Reduced losses and shrinkage	5–15% (of total)		
Reduced returnable container inventory	10% (of total)		
Savings in inventory carrying cost	30% (of total)		
Reduction in reconciliatory processes	75% (cost reduction)	75% (cost reduction)	75% (cost reduction)
Better control over transportation	5% (cost reduction)		15% (efficiency gain)
Reduction of one-time packaging	80% (of total)		
Inventory visibility and cycle counts	65% (cost reduction)	65% (cost reduction)	

Figure 4 IBM Container Tracking Scorecard (Hanebeck and Lunani 2008)

(Gaukler and Seifert 2010) listed two main benefits of RFID in Logistics, Transportation and Warehousing, those are: (1) Labor and timesaving and (2) benefits from increased visibility. They stressed on the labor and timesaving benefit as an automated RFID solution has the potential of enabling a faster flow of goods in the supply chain and at a lower cost. While for the second benefit they connected visibility with "knowing what is in the replenishment pipeline and when it is expected to arrive." This will allow a reduced safety stock and minting or increasing the current service level provided.
Most importantly (Gaukler and Seifert 2010) stressed the fact that even though "in popular literature, the cost of tags is usually seen as the most important determined of RFID profitability" the cost of RFID is overemphasized. They also stated that actually in all the implementations and studies they conducted and observed the RFID costs are actually paid off even by only the most basic RFID benefit (labor savings).

(Lee and Ozer 2007) have argued that RFID two main values of RFID, namely visibility and prevention that leads to better management and reduction inventory and inventory inaccuracies. Also they argued about RFID helping in better demand predictions and planning.

(Sabbaghi and Vaidyanathan 2008) claimed that RFID can be used in areas as demand management, order fulfillment, manufacturing flow management. They have argued that data acquired from an RFID solution can eliminate inaccuracies in data due to human error or absence of data. Likewise that RFID will reduce logistical mistakes as sending an item to the wrong destination, also RFID will lead to better management of inventory and improved forecasting.

(Varila, Seppänen and Suomala 2005) mentioned that through automatic data collection such as data collected from RFID solution permits a large scale of data collection without human errors and improved data accuracy.

On the white paper issued by (SATO 2010) a technology company that focuses on data collection, it is stated that RFID provides better accuracy in data retrieval and a reduction in data error in regard with human intervention.

(Zhou 2009) Argued that the benefits gained from RFID item-level visibility actually increases with the increase in the scale of information system used.

(Bottani and Rizzi 2007) debated that RFID technology has the potential to reduce the standard deviation of the demand in Fast Moving Consumer Goods supply chains. They also argued RFID result in improved visibility of the whole supply chains resulting in reduction of the demand variability which benefit in cost savings especially in the manufacturer's distribution centers.

(Atali , Lee and Özer 2009) stated that by deploying RFID, the RFID will provide visibility and error prevention that can help an inventory system reduce stock-out rates without carrying excessive and costly inventory. They also stated that RFID visibility removes the need of inventory related information correction.

(Dai and Tseng 2011) stated two main RFID benefits, First visibility that provides accurate inventory information. Second is prevention which further reduces inventory errors. They also stated that the information distortion in the form of order variance is reduced by deploying an RFID system along the supply chain.

(Lapide 2004) has stated that the application of RFID will help in better demand and consumption forecasting, better, improved and accurate data generally and specifically for inventory, shrinking and stock-outs.

(Michael and McCathie 2005) have mentioned that RFID offer visibility that can help reduce stock-outs costs through the reduction of waste, lowering inventory levels and improving safety.

(Rekik 2010) mentioned that RFID can lever the inventory inaccuracy problem in the supply chain by detecting errors from supply chain unreliability, reducing inaccuracies from shrinkage errors, reducing misplacement errors and prevention of loss during transportation by means of visibility over the flow of goods, and finally improving shipping accuracy.

We can relate this to our research as we tackle some of the aforementioned inventory accuracy problem as later on will be mentioned and explained.

(Rekik, Sahin and Dallery 2008) considered using a Newsvendor model to detect inventory misplacement type[3] errors in a retail store, then using this model in comparing between before and after applying an RFID technology. The benefit (profit) equation was based getting information on the errors (distribution, mean and variance) and then eliminating these errors based on the implementation of RFID technology. They remarked that getting information on misplacement errors can lead to important savings.

We noticed in the upper paper is that the (Rekik, Sahin and Dallery 2008) only considered misplacement as a source of errors, yet their approach was valid, and is close to what we trying to accomplish in the TollPost case as it will be explained later on.

(Lee, Cheng and Leung 2004) simulated the benefits of RFID regarding inventory reduction in a manufacturer-retail supply chain. They concluded that since data and information will be available by deploying an RFID technology, better replenishment decisions can be taken, which will reduce inventory.

[3] According to the author of the paper, they describe misplacement errors as products not being on the shelf to satisfy customer's demand

(Information Technology Research Institute 2008) issued a working paper named: “Does RFID improve Inventory Accuracy? A Preliminary Analysis” which concluded that RFID can reduce Inventory inaccuracy and “supply chains are expected to operate more efficiently, resulting in lower costs”

(Bagchi, et al. 2010) stated that RFID impact on inventory “should reduce variance of lead time and would be enough to reduce the variance of demand during lead time, and, consequently of safety stock requirements”.

(Hozak 2012) said that by using RFID continuous data collection can enable business to use quantitative lean and Six Sigma[4] tools to respond to the change in operating condition.

A Six Sigma process means that process variability should be aimed at a ±6 standard deviation (3.4 million defects per million opportunities) (Linderman, et al. 2003). One of the popular and influential variation reduction tools within the six sigma concept is the known as DMAIC methodology (Chakravorty 2009). The abbreviation of DMAIC stands for: Define Measure, Analyze, Improve and Control (De Mast and Lokkerbol 2012).

The DMAIC process can be more defined as (Yeh, Cheng and Chi 2007):

Define: Define the core focus or the main goal that is aimed at.

Measure: gather related data, establishing a base for improvement.

Analyze: Analyzing the cause of a problem(s) that is to be eliminated.

Improve: Improve by developing or suggestion a solution for the problem(s).

Control: control and insure that the improvements done are sustained.

In a UPS white paper (six sigma RFID 2005) it is mentioned that RFID can help the process insights and visibility that can help identify issues early in the life cycle which can help in the six sigma process.

(Southard , Chandra and Kumar 2012) have simulated the use if benefits of applying an RFID solution to the improve phase of the DMAIC in the Healthcare industry. Their findings showed significant estimated annual cost and time savings.

[4] Six Sigma is defined as “…an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates.” (Linderman, et al. 2003)

The combination of RFID and Six Sigma is yet in its earliest introductory phase, as there is no application of both, nor the literature related to this area is developed.

9.3.3 RFID Costs

(Pisello 2006) mentioned the following costs and and consideration:

Tags: In 2006 a tag costs 10 cents compared to the 25 or 30 cents in 2004.

Readers: between 2000 to 3000 USD

Software: 500000 to 2 Million USD from small to large installations. Plus an additional 18% to 20% maintenance and support costs.

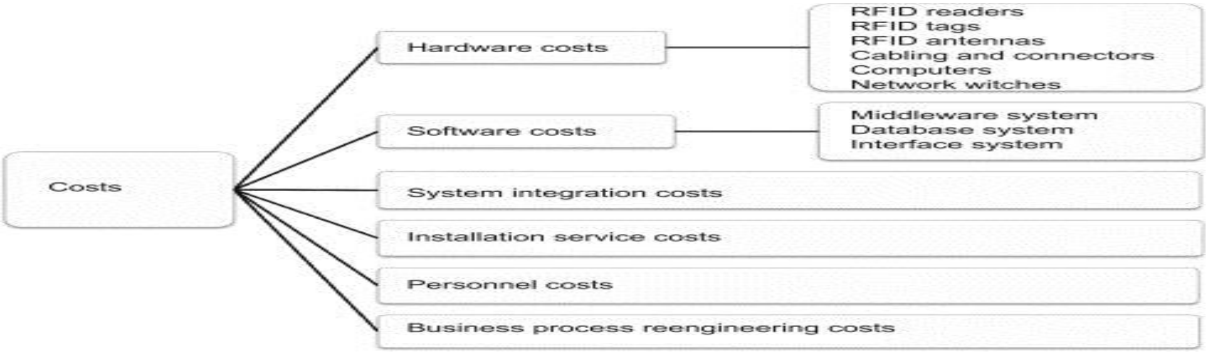


Figure 5: RFID costs tree (Banks, et al. 2007)

In the RFID costs tree in Figure 5, costs are branched into different branches, for our understanding, we can say they are mainly three: Hardware, Software, and other costs. In our case the “other costs” include the system integration, installation, personnel, and business process costs.

(Gaukler and Seifert 2010) mentioned that that RFID tags can cost as low as 0.25 USD up to 10 USD for short ranged passive tags and long ranged active tags respectively. They also suggested a price between 500USD to 5000USD for single RFID reader.

In this research we acquired some costs related to the RFID application from GS1, related costs will be later illustrated.

In accordance with the Smartrack project, it is remarkable to mention that according to TollPost Globe the average IT investment costs of hardware are only 7%-10% of the total costs. (Haugen and Ellefsen 2013), this can be attributed to that there are other costs as software costs and other project and training related costs. Later on the costs of RFID either in case of TollPost Globe or COOP will be presented.

9.3.4 RFID Application in Ports and terminals

In 2009 DP World (one of the largest port operators) started deploying RFID system in three Australian ports that have around 20 Million of inbound and outbound TEU containers. The RFID is supposed to improve security, manage vehicles movement more efficiently; reducing queues and congestion. That way, DP World can manage its containers drop-off effectively, with the advantage of delivering its containers faster to its customers. (Friedlos 2009)

In order to reduce traffic delays (relating to entrance and exit) of trucks, the new Hazira Container Terminal at Adani Port, in Gujarat, India, developed a RFID terminal-operation solution/system. The RFID tags provide the location and movements of the truck; this information is used within the new IT solution that is integrated within the current Terminal Operating System. In conclusion this technology/system has decreased truck waiting time, transaction time and labor costs. This system is forecasted to save more than $100,000 annually in labor costs, not to mentions savings due to reducing delay and transaction time. (Swedberg 2013)

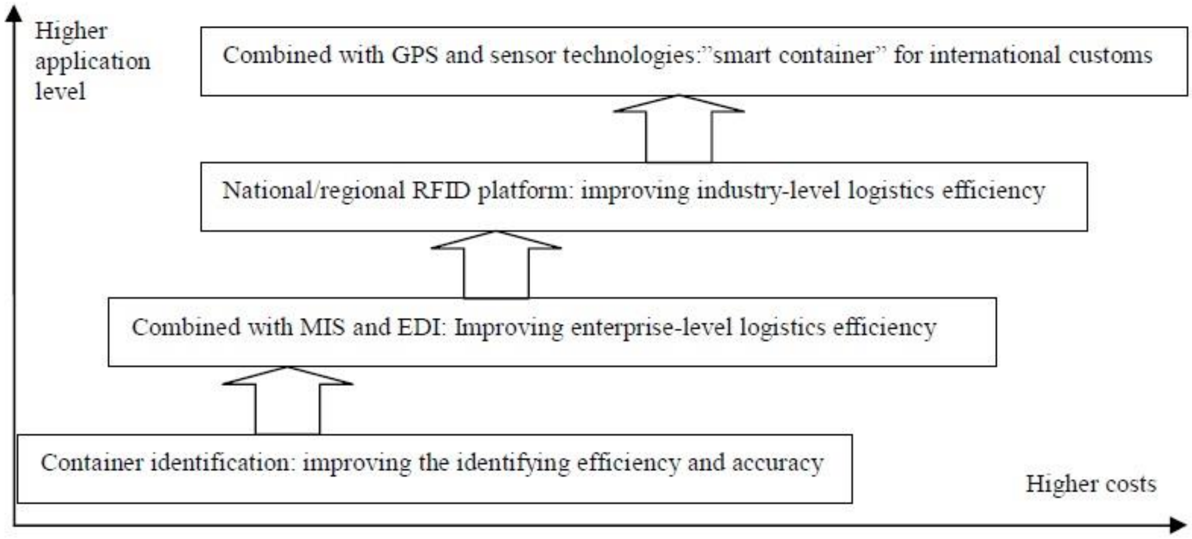


Figure 6 four hierarchies for container RFID adoption (Zhang and Wensheng 2007)

(Zhang and Wensheng 2007) suggested a four level hierarchy depending on the level of usage of the RFID technology, as the application levels up, the costs and difficulties of the application rise up too.

Figure 6 can be summarized as:

Level 1: a basic RFID application (basic wireless identification instead of barcodes). (Zhang and Wensheng 2007 argue that this help improve the Container Freight Station (CFS) and gate operation efficiency.

Level 2: Integrating and combining RFID with Management Information Systems (MIS) and Electronic Data Interchange (EDI). This can help in: container storage blocks allocating, containers locating in the yard, and other storage operations.

Level 3: In this level a multi-user of RFID within the container industry "inter connect" via EDI and MIS of different parties. In this case the overall container intermodal system is expected to significantly improve. Where by the usage of the RFID tag information, authorized users will be able to check their containers information either at their premises or within the control of other parties in this upper mentioned multi-user system.

Level 3: "most advanced application" where RFID is combined by GPS and other electronic equipment to top the security of the container, providing cargo safety monitoring and data recording. This level can also help in better customs' functions performance.

We find that the Smartrack project falls in the third level of the upper mentioned hierarchy. As mentioned before, different authorized users can pull information from the Smartrack database.

9.4 Conclusion

RFID technology has a great positive return on investments based on great benefits: better visibility, less variability, better inventory management to mention a few. Yet there is a gap that is to be closed by more publications either academically or practically, especially in the analysis and calculations area regarding the return on applying RFID particularly on the transportation industry.

10.0 Research Methodology and Data collection

In this chapter we discuss the research methodology, data collection and the model. The Return on Investment (ROI) is a well-known tool that measures the profitability of a certain investment. This investment is the tracking system with RFID that implemented is in the Smartrack project. Our study goes into two main objectives that we focus on: First, the container inventory management at TollPost Globe (namely the Oslo-Trondheim route) and second, the benefits from the end customer perspective i.e. COOP.

10.1 Research Methodology:

A research is defined by Merriam-Webster dictionary as "careful study that is done to find and report new knowledge about something" (Merriam-Webster Dictionary).Thus the methodology of this research –that will help harness the later definition- is a combination of both theoretical studies and collection of empirical data supplied by TollPost Globe and GS1 to exploit and explain the benefits and effects of the RFID solution on both the transport provide (TollPost Globe) and the end user (COOP).

This type of research can be dubbed as an "Explanatory-explanatory Case Study". (Yin 1994) stated that one of the main applications of a case study research is-but not limited- to describe an intervention or to explore situations that an intervention is being evaluated, in our case the intervention is the application of RFID. (Levy 1988) has settled that an exploratory-explanatory case study is best used in the investigation of Information Technology related research. The reason behind the choice of such research type arise from the need to exploit and understand the situation of different actors in the supply chain (both TollPost and COOP being the base of the case studies) before and after the implementation of the RFID solution as part of the Smartrack project, and to explain the cause and effect of such application.

10.2 Data Collection

The first step of our data collection begins by the understanding of Smartrack project, its aims and goals. This has been achieved by an interview to both GS1 and TollPost. The second step comes when we lay down the case studies that we wanted to concentrate on and their specific focuses.

Throughout the data collection phase we have faced some problems regarding the collection of specific numbers related to costs and values of different attributes because the project is still in its implementation phase. It is too early to get performance data on the effects of RFID implementation. Our research's data is gathered from the current and earlier analysis and reports of the Smartrack project. Empirical data on the performance of the transportation chain before RFID was implemented was supplied by TollPost Globe and GS1 (Excel reports collected by "E-mails").

In order to fill the gap of lacking of some data related to the calculation of benefits and costs of the RFID, we made assumptions based on secondary data. Secondary data has been gathered from library books, journals and articles in databases such as Emerald Fulltext, ScienceDirect and CiteSeerX, published magazines in the internet and in paper, and finally from other research that have been doing similar studies.

It is worth mentioning that until the moment of writing these words, the return from the implementation of the RFID solution is not yet realized as the project is still in progress. The outcomes of this thesis can be seen as an estimate of potential outcome of the RFID solution.

10.3 Empirical Model

In this section we explain ROI model that we follow, and we present the mathematical model that we will follow.

10.3.1 Five step Return on Investment (Fush and Gillespie 2012)

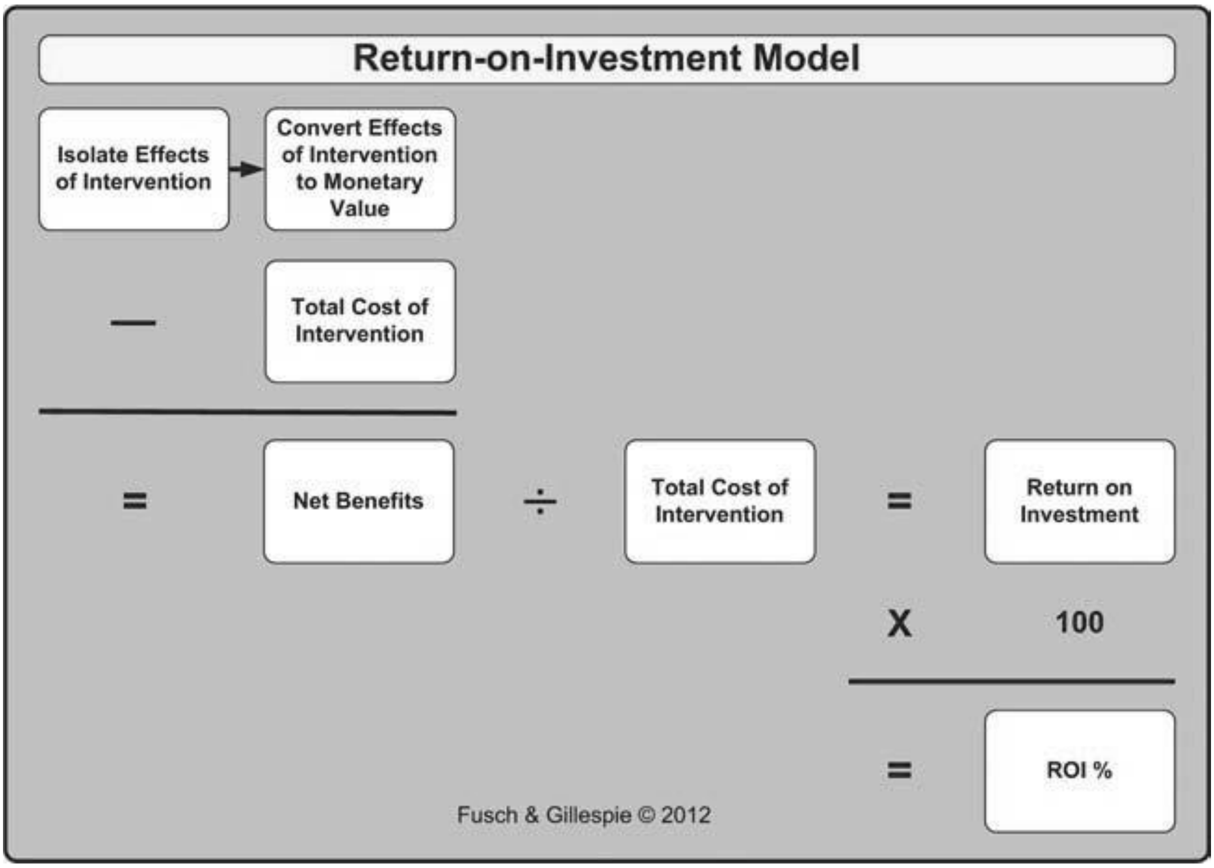


Figure 7 return on investment model (Fush and Gillespie 2012)

The model is explained in details as following:

1. Collect, evaluate and isolate data on the effects of the intervention.

As mentioned in the data collection, our "performance intervention" "is the use of RFID technologies in the transportation chain. We estimate benefits for, one at TollPost Globe and the other at COOP[5].

[5] It should be noted that the authors of this research paper do not have any data related to the effects of the upper mentioned intervention (RFID solution) and thus these are an estimated effects and benefits

We calculate the return on investment for case separately. The performance areas studied in the case of TollPost:

i. Reduction in safety stock
ii. Reduction in the number of containers
iii. Reduction in the returning of empty containers

While in the case of COOP, the performance:

i. Reduction in lost sales
ii. Reduction in waste (hiring extra staff)
iii. Reduction in shrinkage

2. Convert the effects of intervention to monetary values.
3. Calculate the total cost of the intervention.

   In our research the total costs are restricted only to investment costs, which are the costs related to the application of the RFID solution, these costs can be hardware or software or other mentioned costs.
4. Calculate the net benefit of the intervention[6]
5. Calculate the ROI[7]

   Net Benefits= $Monetary\ value\ of\ the\ intervention - costs\ of\ intervention$

   ROI= $\frac{Net\ benifits}{costs\ of\ intervention} \times 100$

[6] These are an estimate of the net benefits.
[7] Based on the upper-mentioned estimations, the ROI will be also an estimate.

11.0 TollPost Globe case

11.1 Container movement data analysis

The data that we received was from the beginning of January until the end of April 2013. The data was collected before RFID was implemented. The data set contains all of TollPost Globe container's movements. We chose the Oslo-Trondheim route as it is this route that has implemented the RFID solution

The data given shows the frequency of the container movement, the frequency being number of container moved against time intervals called "bins". The two statistical measurers; the average and standard deviation are used to analyze the container handling operations (container movements)

11.1.1 Description of the data set

Enhet	Åpnet	Full	Fra	Til	Tomretur	Cont.type
04012	24.01.2013 22:22	25.01.2013 04:12	OSLO	TRONDHEIM		C2
04062	22.01.2013 03:05	22.01.2013 10:51	OSLO	TRONDHEIM		C2
04062	25.01.2013 13:57	25.01.2013 14:59	OSLO	TRONDHEIM		C2
04082	07.01.2013 17:46	07.01.2013 21:31	OSLO	TRONDHEIM		C2

Figure 8 TollPost Globe data description

Figure 8 shows an illustration of the data collected (Excel report). The "Enhet" field shows the container name. The "Åpnet" field shows when the loading operations of the container started, while the "Full" shows when the container loading operations has ended. The "Fra" and "Til" fields shows the shipments whereabouts details (from where it is being shipped and to where). The "Tomretur" field shows if in this container has been shipped empty (filled with "Ja") or was loaded with cargo (no entry in the field). Finally the "cont.type" shows the type of container.

11.1.1.1 Inaccuracies regarding the data

We want to point out some of the inaccuracies in the data set; these inaccuracies can be called "Dirty data"[8]. These dirty data can be attributed to that the data is manually inputted.

We have observed the following different variations dirty data:

Enhet	Åpnet	Full	Fra	Til	Tomretu	Cont.type
03503	24.01.2013 18:30	24.01.2013 14:47	OSLO	TRONDHEIM		Cd

Figure 9 data collection error timing error

In this example the "Åpnet" and "Full" inputs is wrong, as the loading and stuffing of the container started at 18:30 and ended at 14:30 which is four hours earlier.

01633	02.01.2013 21:54		OSLO	BERGEN		C1

Figure 10 Data collection error "Full"

In this container movement from Oslo to Bergen, the input for "Full" is not available.

04548	29.01.2013 09:46	29.01.2013 09:46	OSLO	TRONDHEIM		C2

Figure 11 data collection timing error2

In this movement, "Åpnet" and "Full" times are the same, which is unreasonable.

In the following sections we analyze the set of data regarding the "Oslo-Trondheim" route by running statistical tests to check if the data set follows a common statistical distribution. First we analyze the original data set. Then we omit fragments of the data set, later we will present the logic and reason behind such data omitting.

[8] Dirty data can be defined as: "… data that are incomplete, invalid or inaccurate." (Chu 2004)

11.1.2 First data testing: Original data set

At the first glance after simple Frequency calculations (using MS Excel), Normality tests (through SPSS[9]) and presenting the values on a graph we get the following figure and results:

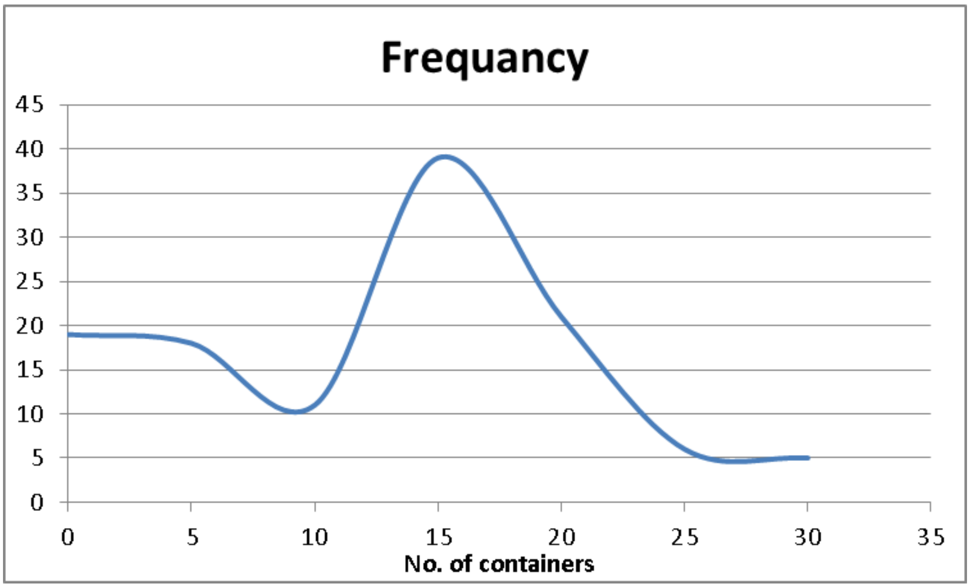


Figure 12 A graphically represented frequency distribution

From Figure 12 above we can see that the data may graphically resemble a Normal distribution, yet there is a deformity in the tails. The reason behind such deformity can be attributed to issues in the lower range. The data has been actually tested for normality by the "Tests of Normality" in SPSS represented in the following table (table 3):

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
# containers	.156	119	.000	.929	119	.000

a. Lilliefors Significance Correction

Table 3 Test of Normality (Original data)

In this test, the significance value of "0.000" means that the hypothesis of the data being normally distributed is rejected. In other words, when testing Normality, a traditional

---

[9] IBM SPSS Statistics is an integrated family of products that addresses the entire analytical process, from planning to data collection to analysis, reporting and deployment. (IBM)

significance of >0.05[10] means that the data is normal. If the probability <0.05 then the data is not normal.

The Average, Standard deviation and variance are presented in the following table 4:

Average	11
Standard deviation	8
Variance	62

Table 4 Average, Standard deviation and Variance.

11.1.3 Second data testing: Omitting zero values

After looking at the data for a second time, we realized that there was 19 days with zero movements, we then detected that those exact days were Saturdays. So we omitted these 19 days from our Frequency and other calculations and we recalculated them again, obtaining the following results:

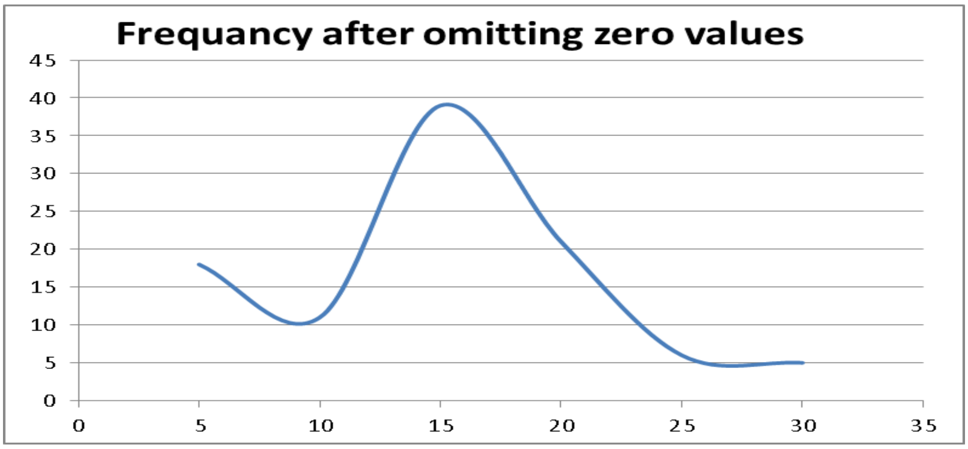


Figure 13 Graphical representation of container movement frequency after omitting zero values

As we can observe here, the zero values from the first graph is now absent due to omitting them from the data array used in calculating the frequency. The measurement of the "tail" leaning to one side of the mean is termed as "Skewness", in the first testing and frequency, Skewness was measured by SPSS to be equal 0.95 (a positive skew means the tail is leaning towards the right side of the mean), and while after omitting the zero values it became 0.003. So that actually means that the data now is migrating more towards being a normal distribution.

[10] The choice of the significance level that reject or accept a certain hypothesis can be described as arbitrary (P Values Calculated Probability and Hypothesis Testing). A moderate significane can fall between 0.01<P<0.05 (Pvalue)

From the SPSS Normality testing we get the following table:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Containers	.112	100	.003	.955	100	.002

a. Lilliefors Significance Correction

Table 5 Test of Normality after omitting zero values

As seen here the significance has a value of 0.002 which emphasis the fact that the data if selected properly it can be normal. Hence the stated sentence at the beginning, that data can be tricky and biased.

Values of the Average, standard deviation and variance are represented in Table 6:

Average	13
Standard deviation	7
Variance	47

Table 6 Average, Standard devation and Varaiance after omitting zero values

As observed here, there is a difference between both cases; here standard deviation has dropped from 7.9 to 6.8. Meaning that the data is now spread in an area less than the first testing, and the distance of data points now are closer to the mean. While variance has changed from 62.6 to 47.4

11.1.4 Third data testing: Performance of normal working days

In this section we only consider the normal working days. So, based on the previous section, we omitted Sundays from the data. Sundays data can be considered as dirty data as it invalid and inaccurate to include it in the irregular working days within regular ones calculations, as a matter of fact by observing the number of containers being shipped in these days we found that they are as low as 1 container shipment per day and a maximum of 3 which actually tails down the data and makes it more skewed and not totally compatible with a normal distribution.

On the other hand, the following results will show that this step actually deemed useful:

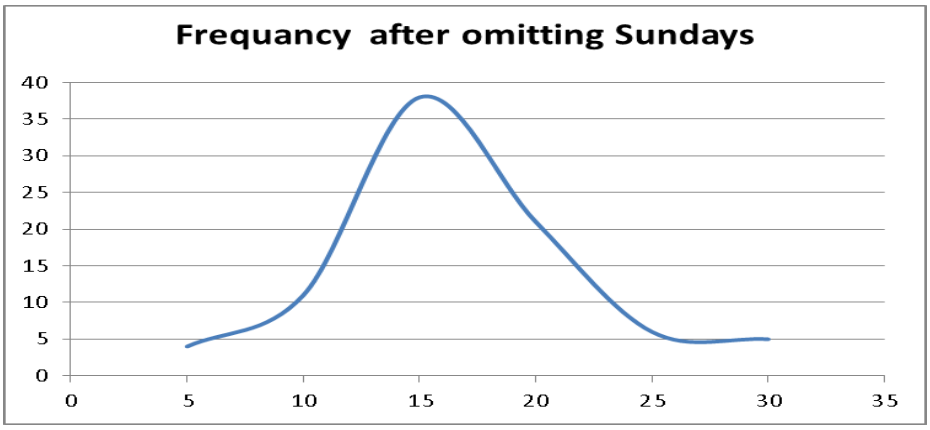


Figure 14 Graphical representation of container movement frequency after omitting Sundays

As seen in the graph, data set is now more leaning towards a normal distribution than in the last two tests. While the following tests of Normality refute that the data is a normal (P>0.05 needed)[11] yet it is apparent now that the data have a potential to be normal if normal workdays are only considered.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Containers	.110	85	.012	.964	85	.019

a. Lilliefors Significance Correction

Table 7Test of Normality after omitting Sundays

[11] The data set here can be considered normal if a we used a low probability of significance as mentioned before. For instance, if a 0.01 probability is used then the data is considered normal.

The following table represents the average, standard deviation and variance of this data set:

Average	15
Standard deviation	6
Variance	32

Table 8 Average, Standard deviation and Variance after omitting Sundays

A small test was done on the frequency of shipping containers on Sundays (data cut from the previous test). The test shows actually shows that for Sundays the data is normally distributed with a high significance also:

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
containers	.343	3	.	.842	3	.220

a. Lilliefors Significance Correction

Table 9 Test of Normality of Sundays only

11.1.5 Performance enhancement by reduction in variability: a simulation of a case with RFID

Based on the literature review in the section of “RFID benefits” which laid down the fact the RFID solution provides better visibility, lower variability and better inventory accuracy and management (Bottani and Rizzi 2007), (Lapide 2004), (Atali , Lee and Özer 2009) and (Lee and Ozer 2007). We used the “Performance of normal working days” section to introduce and test the effects of applying an RFID solution and compare it to the previous sections.

To simulate the effects of RFID-based on the benefits-We tried to better manage the container movement (data set) by merging and consolidating shipments, that is; shipments are grouped or combined together, for instance if there is a shipment of 2 containers and another -which is one or two days maximum before or after the original shipping date- with 4 containers, then we include it as a 6 container shipment, and so on and so forth.

Needless to mention that the we were conservative during this step, in other words we did not pick container shipments at the beginning of a given month and just put it in another total month just to satisfy one purpose or the other. One important logical reason behind this step is that –and as the outcomes will show-we were aiming generally at enhancing the container shipping performance, and more specifically at reducing variability through better visibility of the container movement.

Another reason behind the possibility of doing so is that by consolidation we don’t not send shipments, shipments are just collected together and not the demand. In other words, demand is the same, yet we increase the number of containers being shipped per day.

These merging or consolidation of shipments can be backed up by the fact that container shipments depend on the type of goods being shipped. In regard to COOP as a customer of TollPost Globe, promotional goods are temporarily stored and collected then shipped on weekly basis, while other supplementary products have more fixed intervals for order and delivery. (GS1 Norway, Stima)

As from here on, consolidation can be presumed to be the product of RFID solution. One of the advantages of consolidation of shipments that we came by is that the inventory costs in general are lowered, especially the safety stock as demand in such case can be seen more normal and easier to predict, this is explained more in details in the data analysis “TollPost container management” section.

In the following table we compare between the Normality tests of the “Normal working days” and the RFID case:

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Normal working day	0.110	85	0.012	0.964	85	0.019
RFID	0.103	68	0.71	0.975	68	0.187

Table 10 Comparison of Normality tests of Normal working days and RFID

	RFID	Normal working days
Average	19	15
Standard deviation	5	6
Variance	22	32

Table 11 comparison between the average, standard deviation and variance of normal working days and RFID

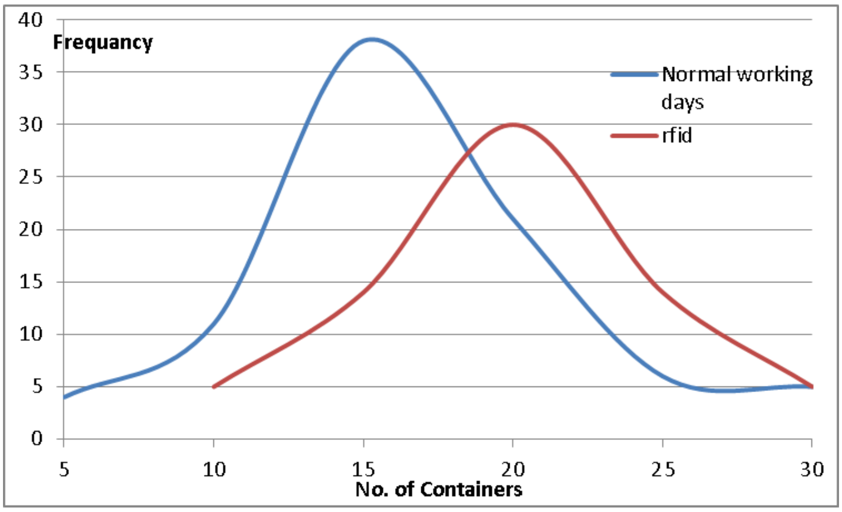


Figure 15 A comparison of frequencies between Normal working days and RFID

Figure 15 actually shows the difference between the distributions of the normal working days and when the RFID technology was deployed.

11.1.6 Empty containers

During this period (4 months) a total of 1298 container trips were made from Oslo to Trondheim using 905 unique containers (there were 3 empty container trips out of the total number of trips). While there was 1603 container trips were made from Trondheim to Oslo using 1105 unique containers (there was 1079 empty container trips done from Trondheim to Oslo).

	# of trips	Empty containers
Oslo – Trondheim	1298	3
Trondheim – Oslo	1603	1079

Table 12 Container trips and Empty containers

11.2 Conclusion

As observed the omitting of dirty data from the data set plays a crucial role on identifying the shape of the data distribution and affects the standard deviation and variance.

	Original	Normal working days	RFID
Average	11	15	19
Standard deviation	8	6	5
Variance	62	32	22

Table 13 Comparing Average Standard deviation and variance

By observing Table 13 we see that the removal of dirty data caused the average containers sent per day has changed from 11 per day to 15 containers per day, and 19 containers per day in case of RFID. While most importantly as illustrated in Table 13, the variance and standard deviation have been reduced. Moreover by looking at Figure 16 we observe that, this reduction means that the data is optimized and is spread in a much less area, in other words the variability regarding the performance of container shipment has been reduced.

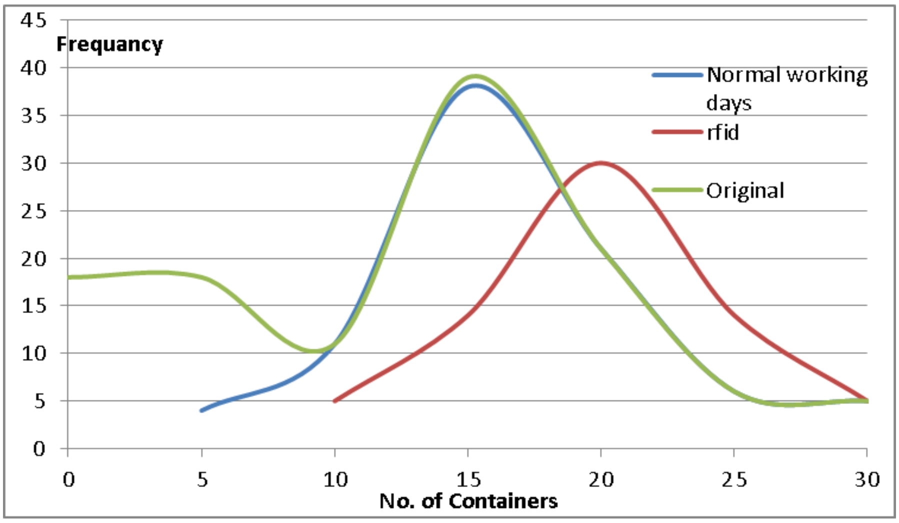


Figure 16comparison of distributions of Normal working days, RFID and Original data set

Also, as we observed this data set is subject to human error, and an RFID solution will introduce better visibility which will remove such variability and inaccuracies, as the data and information will be automatically "caught" and sent to the system without the interference of humans which is in accordance with the literature review regarding this area (SATO 2010), (Varila, Seppänen and Suomala 2005) and (Sabbaghi and Vaidyanathan 2008).

11.2.1 RFID and Six Sigma

In relation with the standard deviation and reduction of variability, it is possible to see the effects upper mentioned of RFID from the perspective of the six sigma's DMAIC methodology:

1. Define: The main goal is to enhance performance through the reduction of variability.
2. Measure: The original set of data can be set as a base line for improvement.
3. Analyze: Low visibility and human error can be seen as a reason and cause for variability.
4. Improve: As a solution for improvement, an RFID technology should be employed, as the literature review and our simulation on the "performance enhancement by reduction of variability" has showed a RFID provides great improvements.
5. Control: Keep monitoring and tracking improvements using the RFID technology to insure a sustained improvements.

As a more unrestricted testing on the improvement phase of the RFID regarding the reduction of variability we simulated another test where the consolidation process regarding the container movement was more aggressive and with less regulation, these were the results:

Mean	25
Standard deviation	2
Variance	2

Table 14 Mean, standard deviation and variance of an unrestricted container consolidation

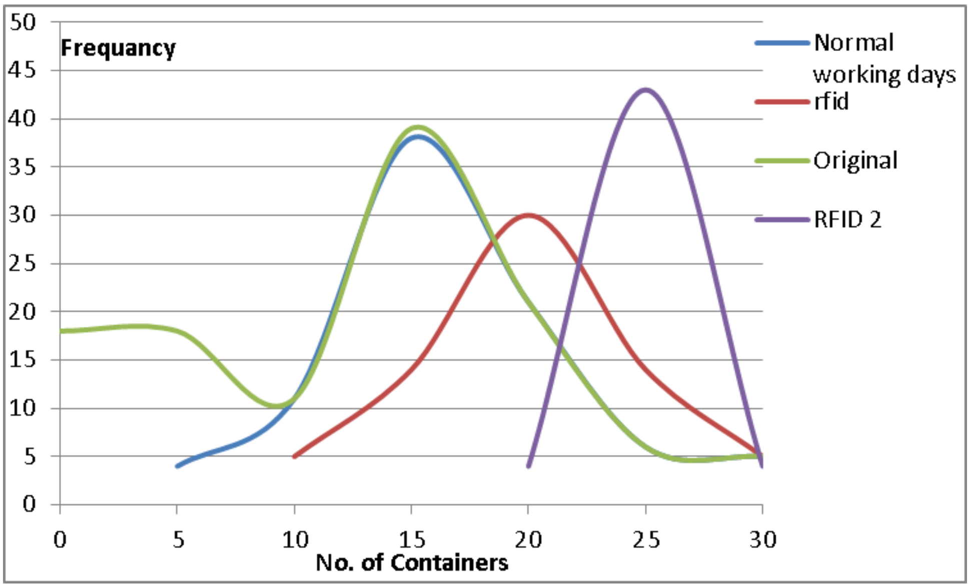


Figure 17 Comparison between different changes in the data set

As we can see from table 14 and figure 17, that the less the variance the less the variability we have in the data set and also the spread of the data is more optimized.

Finally, from the data set we have noticed that there is more than one thousand empty containers were sent from Trondheim to Oslo, and 3 empty containers sent from Oslo to Trondheim, which can mean high costs.

12.0 TollPost Globe Case: container movement description:

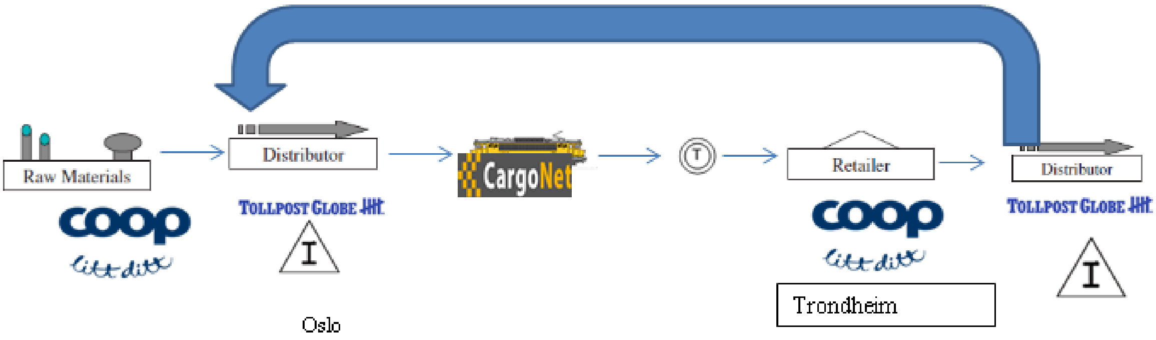


Figure 18 Oslo-Trondheim container movement

In this case we only focus on the route of Oslo to Trondheim (also that is the route that TollPost Globe implemented an RFID solution), where operations are described as following: First, Coop (the customer) loads the goads into a container owned by TollPost Globe (transport service provider) then it is delivered to TollPost Globe where it forward this container to CargoNet to be loaded onto train wagons and off to Trondheim terminal, where the container is unloaded to trucks and then delivered by TollPost Globe to Coop in Trondheim (the end user). Containers are then either sent back empty or wait until they are being used to ship goods back to Oslo (in this case containers are full and used when they are being sent back), and then reused to be sent somewhere else.

Generally speaking this movement situation happens all across Norway, where TollPost Globe operates. It is worth mentioning that, although Oslo is the main center of operation, yet there are containers that are being sent from and to other places, for instance there are containers that are being sent from Bergen to Trondheim, while the amount of these containers is not as much as those of being sent from Bergen to Trondheim yet it shows that containers can travel all across Norway to finally make sure there is enough containers in Oslo.

The following figure shows the ins and outs from and to the four major cities in Norway i.e. Oslo, Bergen, Stavanger and Trondheim respectively.

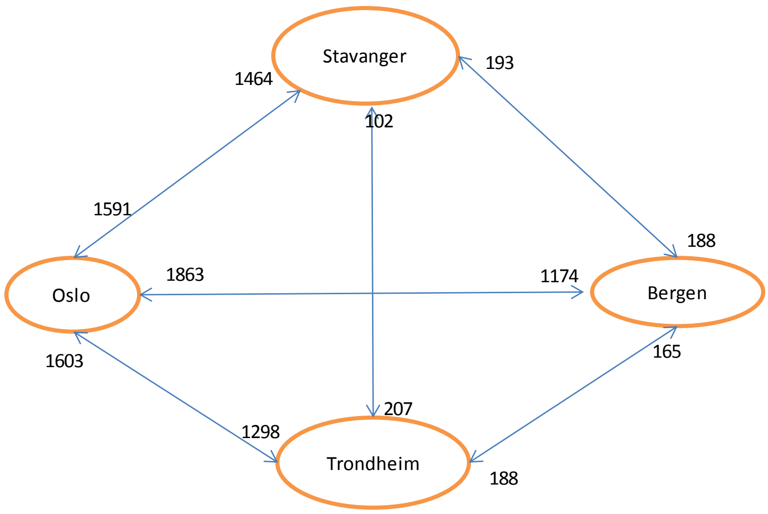


Figure 19TolPost Globe's container movement from and to Norwegian major cities

	In	Out
Oslo	3936	8057
Stavanger	1986	1759
Bergen	2244	1527
Trondheim	4870	1693

Table 15 Summary of TollPost Globe's container movement

Figure 19 shows TollPost Globe's container movement from and to major Norwegian cities: Oslo, Stavanger, Bergen and Trondheim. Table 15 summarizes the container movements (ins and outs) by city. It can be observed that there can be container flow imbalance, i.e. the number of incoming containers is different than the number of outgoing containers, yet it is important to mention that the total ins and outs of these four cities is in balance and equal to exactly 13036 containers. Also it is remarkable to mention that these are not the only cities being served, and there is a larger flow of incoming and outgoing containers involving these cities and other different cities, which in general is supposed as in this case balance the whole container flow.

12.1 Container Inventory case-problem

In the upper mentioned case generally, and specifically speaking on the Oslo-Trondheim route inventory costs (Holding costs, Stock out cost and Safety stock costs) can be seen as optimal in reference to the current container management and conditions of operations, yet, if more detailed information regarding the container movements are made available for instance through a new tracking technologies (RFID in this case), these inventory costs will be affected. The question here is: To what extent the costs and profits are affected (reduced)?

12.2 Data, assumptions and other related information for TollPost case

In the period from 01/01/2013 to 30/04/2013:
A total of 50701 containers trip where generally operated by TollPost Globe across Norway. A 1298 container trips were made from Oslo to Trondheim. A statistical analysis of this data and the frequency of the number of containers being shipped in a giving day are given in the "TollPost Globe container movement data analysis" section.

(World Shipping Council 2011) (Shipping Container Pros 2013) a twenty feet container costs 18000NOK. Later on when we use the unit value "V" (or Unit cost in some cases) we took in consideration that a container life span ranges from 10 to 15 years (Rodrigue 2013) (Sulbaran, et al. 2012). Table 16 summarizes the related container costs.

	Buying cost	Price per day	Price in 4 months	Container life
Cost (V)	18000NOK	5NOK	600NOK	10 years

Table 16 Container unit cost (V)

On the other hand, from TollPost Globe we know that the net profit per container per day is 200 NOK (this can also be used a gain from renting 1 container)-in Maritime shipping we can find a profit per TEU around 305NOK (MDS Transmodal 2013). While we can calculate the revenue (selling price P) as a multiplication of the cost per km of rail transport and the distance; therefore revenue P (or income in other cases) can be estimated to be 3210NOK (6NOK/KM * 535 KM).
Also, since actually a stock out cost is a cost of lost sales i.e. lost profit we can use the same number while also assigning an extra 500 NOK stock out penalty, summing up the stock out cost to 700 NOK/Container/day, stock out costs are referred to as "B" in the News Vendor problem.

In the calculations of container salvage value, we also used a 10 years life time. A salvage value is defined as "The estimated value that an asset will realize upon its sale at the end of its useful life." (Investopedia). Later on, when calculating, the salvage value "g" of a container is estimated to be 7678NOK on average (either sold as a metal scrap, by which a ton of metal scrap costs around 2136NOK/ton or just a used container). By using the same 10 years life span of a container used before, we get 2.10 NOK/container/day (7678NOK/(365days*10years)) or 252.5 NOK/container in 4 months as a salvage value.

Holding (carrying) costs can be defined as "The associated price of storing inventory or assets that remain unsold" (Investopedia). Hamburg port carrying holding costs are 53 Euros on average per container per day (73.6 USD or 432 NOK) (Samskipmultimodal 2011) which is actually the same as the average of terminal MSC-gate at Bremerhaven port (MSC - Mediterranean Shipping Company). Although these are port costs, yet these is the closest we could get. Also, these numbers can be used as a close estimation, as TollPost Globe can substitute them anytime. Thus we will calculate the Holding cost based on these numbers.

An assumption of reducing the returning empty containers by 1%-5% due to better management of containers owing to better visibility is assumed. We would like to note that this percentage is fair as they are very low compared to those mentioned in the literature review section which can be up to 40%.

12.3 RFID related costs in case of TollPost Globe

The following table represents "Total costs of intervention" or in other words the RFID investment costs for TollPost Globe:

Investment				
	Tags			
		RFID Tag price Tollpst	20	NOK
		# of tags	1300	
		QR tag price	5.5	
		# QR tags	2000	
		Total	37000	
	Readers			
		RFID reader	22500	
		# of readers	2	
		Total	45000	
	Software			
		EPCIS database	2500	NOK/Mon
		# months	12	
		Enlight QR software	13500	
		total	43500	
	Project management		500000	
		project period	18	Months
		cost per year	333333	per year
		Total Costs	458833	

Table 17 TollPost Globe related RFID costs

We would like to mention that we did alter the costs, namely the RFID“# of tags” which was 200 tags, to 1300 (based on the original data set) to cover the whole number of container moved from Oslo to Trondheim. The number of readers was originally one, yet we increased it to two. The EPCIS database is supposed to be for all partners, yet we assumed that it as a part of TollPost Globe. The “Project management” costs are supposed to be shared between all partners of the project, yet we assumed that it will be credited only to TollPost Globe as labor related training and other project costs. We assumed that the project period to be 18 months which is the period between the start of the project and until the final report that will take be published in February 2014, and then we calculated the project related costs per year.

12.4 Data Simulation

In this section we will simulate the inventory costs and benefits relate to different data sets. First we will simulate the results based on the original data set, then based on the normal working days, finally for the "Performance enhancement by reduction in variability: a simulation of a case with RFID". At the end of this section we will conclude with our findings regarding this data simulation.

12.4.1 Simulation based on original data set

This is the current Inventory and inventory costs at TollPost Globe based on original data set of the container movement from Oslo. This is section does not include any inventory managing calculations.

# Containers	Demand	Income	Holding H	Stockout S	Units costs C	Π=R-H-S-C	P(Di)	P.Π
30	0	0	12960	0	150	-13110	0.2	-2093
30	5	16050	10800	0	150	5100	0.2	771
30	10	32100	8640	0	150	23310	0.1	2155
30	15	48150	6480	0	150	41520	0.3	13607
30	20	64200	4320	0	150	59730	0.2	10541
30	25	80250	2160	0	150	77940	0.1	3930
30	30	96300	0	0	150	96150	0.0	4040
		337050.0	45360.0				Σ (P.Π)=	32951

Table 18 Basic scenario simulation based on the original data set

Table 18 shows the current status of inventory and estimated profit (P.Π) based on current data. The first column shows the number of containers that should be available on any day, this number is based on that there is no stock outs[12]. The number of containers is thus the maximum number of container demand in one day in the period mentioned before. The Demand column and the "P (Di)" are both taken from the container data analysis section; here we use it to calculate what are the costs and profits related to such demand, where "P (Di)" is an estimate of the probability of this demand happening. "Holding H", "Stock out S" and "Unit Cost C" are: holding, stock out and container value costs respectively.

Holding costs are calculated as the difference between numbers of containers on hand minus the demand of containers multiplies the holding cost of one container. Using the same logic stock out costs is calculated as the difference between the demand and the containers on hand multiply the stock out cost of one container. While unit cost is the multiplication of the container value in on day (mentioned before in the data assumptions section) and the number of containers on hand i.e. 30 containers.

[12] No stock outs have been stated by TollPost Globe.

Income is the selling price "P" as stated before. The "Π=R-H-S-C" is the difference between the income and all mentioned costs.

In this basic current case, TollPost should get an estimated profit of approximately 32591 NOK. There is no costs for stock outs as mentioned before, Holding costs seems to be the most dominant cost of all three.

12.4.1.1 Simulating different number of containers based on original data set

In this part we use the logic behind the previous section to simulate different number of containers and calculate different outcomes for the purpose of finding the highest profit.

# Containers	Demand	Income	Holding H	Stockout S	Units costs C	Π=R-H-S-C	P	P.Π
20	0	0	8640	0	100	-8740	0.2	-1395
20	5	16050	6480	0	100	9470	0.2	1432
20	10	32100	4320	0	100	27680	0.1	2559
20	15	48150	2160	0	100	45890	0.3	15040
20	20	64200	0	0	100	64100	0.2	11312
20	25	64200	0	3500	100	60600	0.1	3055
20	30	64200	0	7000	100	57100	0.0	2399
			21600	10500			Σ (P.Π)=	34402

Table 19 highest profit, Original data set

After simulating different number of containers (5, 10, 15, 20, 25) the highest profit realized is from having 20 containers in hand in any day. In the upper table 19 we can see that there is a stock out costs for the demand more than 20 (i.e. 25 and 30 containers in a day) and logically there is no carrying costs for those demands. While there are stock costs and holding costs, yet the profit yielded in this case is higher than of that having 30 containers this can be attributed to a lower holding cost related to that in this case we hold 5 containers less in each case of demand.

12.4.2 Profit sensitivity to container volume per day

Table 20 compares between different number of containers and profit associated with it. It is observable here that when having 20 and 25 containers, profit seems to be very close (22 NOK difference).

# Containers	Profit
5	7206
10	19981
15	30749
20	34402
25	34223
30	32951

Table 20 simulation comparison of different containers and profits

We also did some tests to see if the number of 20 containers will change or not. First we lowered the income to 1600NOK, which resulted in the same previous answer. When we changed the income to the double (6420), a higher profit then was realized when having 25 containers.

Second we changed unit costs from 5NOK to 10, 15 and 500NOK, also same answer. Third we changed the stock out cost to 1400NOK; profit was slightly higher when having 25 containers than of having 20 containers by approximately 145NOK. The same 20 containers also will yield higher profit if we lowered the stock out costs by the half.

Finally, the highest profit is yielded from having 20 containers when we changed the holding costs up to the double (864NOK).When we lowered the holding costs to the half, having 25 containers yielded a higher profit.

We should mention that if we only considered calculating costs only results may vary in selecting the optimal quantity (basic scenario will not change). Costs are calculated as $\sum(H_i + S_i + C_i) * P(D_i)$ that is the summation of: holding, stock out and unit cost multiplied by the probability of the related demand of happening. The result of the original data is:

# containers	Costs	Income
15	3374	240750
20	4037	288900
25	5670	321000
30	7646	337050

Table 21 comparison between costs and income of different containers

We can see that the lowest cost comes from having 15 containers other than from having 20 containers for the original set, which can be attributed that when having 15 containers the holding cost is rationally less than when having 30 containers.

12.4.3 Simulation based on the Normal working days

Same as the previous two sections, we simulated having different number of containers based the data set of “Normal workings days”.

# Containers	Demand	Income	Holding H	Stockout S	Units costs C	Π=R-H-S-C	P(Di)	P.Π
30	5	16050	10800	0	150	5100	0.05	240
30	10	32100	8640	0	150	23310	0.13	3017
30	15	48150	6480	0	150	41520	0.45	18562
30	20	64200	4320	0	150	59730	0.25	14757
30	25	80250	2160	0	150	77940	0.07	5502
30	30	96300	0	0	150	96150	0.06	5656
		337050	32400				Σ (P.Π)=	47733

Table 22Simulation of basic scenario based on the normal working days data set

From table 22 we get that the estimated profit (P.Π) is 47,733NOK in case of having no stock outs, and having 30 containers in hand to cover any rising demand based on the normal working days data set.

12.4.4 Simulating different number of containers

Based on the same data set of Normal working days, we simulated different number of containers to see which optimal number of containers will yield the highest profit.

# Containers	Demand	Income	Holding H	Stockout S	Units costs C	Π=R-H-S-C	P	P.Π
25	5	16050	8640	0	125	7285	0.05	343
25	10	32100	6480	0	125	25495	0.13	3299
25	15	48150	4320	0	125	43705	0.45	19539
25	20	64200	2160	0	125	61915	0.25	15297
25	25	80250	0	0	125	80125	0.07	5656
25	30	80250	0	3500	125	76625	0.06	4507
			21600	3500				48641

Table 23 highest profit, normal working days

After simulating different number of containers, we found out that highest profit is yielded from having 25 containers. It is also noticeable that the difference of the estimated profit between having 25 containers and having 30 containers is exactly 908NOK.

12.4.5 Simulation in case of RFID

In this section we-the authors- did another simulation of the number of containers but based on the data set section of "Performance enhancement by reduction in variability: a simulation case with RFID" we got the following results:

# Containers	Demand	Income	Holding H	Stockout S	Units costs C	Π=R-H-S-C	P(Di)	P.Π
30	10	32100	8640	0	150	23310	0.07	1714
30	15	48150	6480	0	150	41520	0.21	8548
30	20	64200	4320	0	150	59730	0.44	26351
30	25	80250	2160	0	150	77940	0.21	16046
30	30	96300	0	0	150	96150	0.07	7070
		321000	21600				Σ (P.Π)=	59730

Table 24 Simulation of RFID

As observed in table 24, we get a 59730 NOK in total profit in case of having 30 containers in hand and having no stock outs. In this case the total costs were calculated at 4470 NOK. While the largest expected profit was for having 25 containers, at 60318.7 NOK at total costs of 2701.2 NOK

# Containers	Demand	Income	Holding H	Stockout S	Units costs C	Π=R-H-S-C	P	P.Π
25	10	32100	6480	0	125	25495	0.07	1875
25	15	48150	4320	0	125	43705	0.21	8998
25	20	64200	2160	0	125	61915	0.44	27315
25	25	80250	0	0	125	80125	0.21	16496
25	30	80250	0	3500	125	76625	0.07	5634
			12960	3500				60319

Table 25 Simulation highest profit Normal data

As observed in table 25 we have a stock out of five containers in this case. On the other hand there is a slightly higher profit of 588 NOK in case of having 25 containers.

12.4.6 Conclusion of simulation method

From the following Tables (26, 27, 28), we can see that the highest profit (regardless of the number of containers) is generated from the RFID case. Most notably the profit increased by 20% in case of applying RFID solution when having no stock outs when compared to the normal working days.

Moreover the costs are cut down by around 25% in case of having 30 containers when compared between the Normal working days and the RFID case, while costs were cut by around 33% in case of having 25 containers.

Also the tradeoff in case of the RFID in terms of having an extra 5 containers (difference between 30 containers in hand and highest profit from 25) does not generate a hard decision of choice between paying an extra fee of having an extra five container for not having stock out.

Original data set	No Stockouts	highest profit	Difference
# container	30	20	
Profit	32951	34402	1451
Costs	7647	4038	3609

Table 26 Original data set comparison of profits and costs

Normal working days	No Stockouts	highest profit	Difference
# container	30	25	
Profit	47733	48641	908
Costs	5893	4041	1852

Table 27 Normal working days comparison of profits and costs

RFID case	No Stockouts	highest profit	Difference
# container	30	25	
Profit	59730	60319	589
Costs	4470	2702	1768

Table 28RFID case comparison of profits and costs

As final conclusion, it is very apparent that applying the RFID solution yields benefits based on higher profits and lowered costs.

12.5 Newsvendor model

Another approach to look and get insights at the inventory of TollPost Globe is to use the News-Vendor problem. The Newsvendor problem is a classical model that identifies the optimal quantity to be purchased with associated costs of overage and underage costs (underage costs are the costs related to out of stock, while overage costs are costs related to having extra inventory). With this in mind, this exact optimal quantity is then calculated to get the maximum profit (Silver, Pyke and Peterson 1998). The Newsvendor problem can give business decisions regarding setting safety stock, inventory level, selecting the right capacity for a facility (Hill 2011)

The reason behind using this method is to use a more traditional and conventional method in determining inventory related decisions as safety stock and inventory level, other than using a very simple simulation method. We later on compare between the Newsvendor model results and the previous simulation method results.

In our case the optimal quantity can be interpreted as the number of container that should be available at any day that will yield maximum profit in regard with the aforementioned underage and overage.

12.5.1 Mathematical Formulation

In order to find the optimal value we should first find for discrete distribution:

$$P_x < (Q^*) = \frac{C_u}{C_o + C_u} = \frac{p - V + B}{p - g + B}$$

$$ES = \sum (x_i - x_{chosen}) * P(x_i)$$

$$SS = \sum (x_{chosen} - x_i) * P(x_i)$$

$$E[\Pi(Q)] = (p - g)\hat{x} - (V - g)Q - (p - g + B)ES$$

Where;

Q^*: is the optimal quantity (number of containers that should be available in any given day) also referred to asx_{chosen}

$P(x_i)$: is the probability of a demand x_i to happen

$\hat{x}$: is the mean

$E[\Pi(Q)]$: is the expected profit

C_u: is the underage cost (Probability that the Q will be less than demand, Stock out cost) and can be calculated as: $p - V + B$

C_o: is the overage cost (Probability that the Q will be more than demand, holding left overs) and can be calculated as: $V - g$

p: Selling price

V: value of each unit

B: penalty cost of stock out for each unit

g: salvage value
ES: Estimated stock out ($\forall\ x_i > x_{chosen}$)
SS: Safety stock per given day ($\forall\ x_i < x_{chosen}$)

On the other hand, in case of a normally distributed demand:
First we need to find:

$$P_u \geq (K) = \frac{V - g}{p - g + B}$$

Then, from the normal probability distribution table we get the relevant values of "k" and$G_u(k)$, by which we can apply in the following equations:

$$Q = \hat{X} + K * \delta_x$$

$$ES = \delta_x * \ G_u(k)$$

$$SS = K * \delta_x$$

$$E[\Pi(Q)] = (p - g)\hat{x} - \ (V \ - \ g)Q \ - \ (p - \ g \ + \ B) * \delta_x * \ G_u(k)$$

Same notations are used as before, while $\delta_x$is the standard deviation of demand.
After calculating we compare this ratio with the cumulative probabilities (if the value we get is between to cumulative probabilities we can check which is best by calculating which yields the highest expected profit and choose it.)

In our case we used the "Bin" and "Frequency" that we used before in the "TollPost Globe container movement data analysis" to solve the Newsvendor model. The "Bin" was used as demand while from the frequency of this demand happening we calculated the probability of this demand.

12.5.2 Solution of the News-Vendor problem

We solved the news-vendor problem for three of sets of data. First the original one, second "Normal working days", and finally the "performance enhancement by reduction of variability: a simulation of a case with RFID" in the TollPost Globe data analysis section where the data was a Normal distribution.

Original data set	
P-V+B	3905
P-g+B	3908
P<(Q)=	0.999276
Q*	30
ES	0
P-g*X^	40570
(V-g)Q	85
(P-g+B)ES	0
SS	17
E(Π(Q))	40486

Table 31Solution Newsvendor Original data

normal working days	
P-V+B	3905
P-g+B	3908
P<(Q)=	0.999276
X chosen	30
ES	0
P-g*X^	53591
(V-g)Q	10427
(P-g+B)ES	0
SS	13
E(Π(Q))	43164

Table 29Solution of Newsvendor for Normal working days

RFID Application	
P≥(K)=	0.000723649
K=	3.19
Gu(k)=	0.0001922
Q	29
ES	0
SS	9
E(Π(Q))	59309

Table 30 Solution Newsvendor RFID

In the first case (Table 31) where the original data was used the optimal quantity was the same for the normal working days which is 30 containers. While for the RFID application, the optimal data is 29 containers. These 30 or 29 containers mean that the quantity in hand will satisfy all of the upcoming demand with regard of the probability of this demand happening.

We also run some tests to see the effects of the optimal quantity chosen on the amount of safety stock and the estimated stock outs in case of the original data set. We assumed the optimal quantity Q to be: 25 and 20, the safety stock then is lowered to approximately 13 and 9 containers respectively while the Estimated Stock outs increased from 0.21 to 0.67 respectively. This can be attributed to that the higher the optimal quantity "Q" is the higher amount of demand probabilities it covers leading to a lower estimated stock outs and higher safety stock that will cover any demand that may happen.

On the other hand we can see the difference between both the Normal working days data and the RFID case (Table 29 and Table 30 respectively). As noticed in both cases a better output in case of the normal (RFID) as it have a higher profit and a lower safety stock (at least 9 less containers to be stocked).

12.6 Analysis of the simulation method and the News-Vendor model

As mentioned in (Aberdeen Group 2008) RFID can increase inventory turnover by an average of 5.4%. In (Hanebeck and Lunani 2008) after applying an RFID solution, they have found inventory carrying cost savings and a 30% reduction in containers. Also in (Hardgrave, Miles and Mitchell 2009)mentioned that "inventory accuracy improved by more than 27 percent, under stock decreased by 21 percent, and overstock decreased by 6 percent" under stock meaning stock outs while over stock meaning extra inventory, we- the authors of this research- should mention that these results are related to the different industries and thus these results may vary if applied to another industries.

	Basic simulation	Highest profit Simulation	News-Vendor
Optimal Q	30	20	30
Expected stock out	Zero	0.67	Zero
SS	18	9	18
Expected Profit	32950	34401	40485
Mean $\hat{x}$	11		

Table 32 Comparison of Original data: Basic simulation, highest profit simulation and Newsvendor

	Basic normal working days	Simulation normal working days	N-V normal working days
Optimal Q	30	25	29
Expected stock out	Zero	0.3	Zero
SS	13	9	13
Expected Profit	47733	48641	43164
Mean $\hat{x}$	15		

Table 33comparion of normal working days different methods

	Basic RFID	Simulation (highest profit)	N-V RFID
Optimal Q	30	25	29
Expected stock out	Zero	0.3	Zero
SS	10	6	9
Expected Profit	59730	60318	59309
Mean $\hat{x}$	19		

Table 34 Comparison of RFID case data: Basic, simulation, Newsvendor

It should be noted that when we mention "Basic" we mean when there is no stock outs. We can notice that the safety stock in the original data (table 32) set in the News Vendor problem is 18 while it is a maximum of 10 containers when having RFID (table34)
These reductions in safety stock can be attributed to lowering the variability in the data through the better visibility obtained by the deployment of RFID.

It is observable that using any of the two methods, we see that the application of RFID yields better results in terms of profit than that of before applying (normal working day for instance). It is also observable that both results from the News-Vendor problem have an expected stock out, while the simulation method in both data sets has stock outs.

So as evident it is safe to say that an RFID solution presents the highest profit of all, and by any attribute (stock outs or safety stock) it is still better.

13.0 Calculating the return on investment for TollPost Globe case

To calculate the return on investment we use the aforementioned ROI model represented by (Fush and Gillespie 2012). We will consider the following benefits (monetary value of the effect of intervention):

13.1 Reduction in safety stock:

In the latest report by the Smartrack project (GS1 Norway 2013), it is mentioned that as RFID can provide more visibility to the current condition of the containers (being in use or not) TollPost can actually rent out the unused containers. In this case, since we actually see a reduction of safety stock containers by 8 per day (difference between the simulation original and RFID case) or by 9 per day (difference between Newsvendor original and the RFID case) thus it is possible to rent out these containers for extra gain, which in (GS1 Norway 2013) TollPost Globe pointed that this as a benfeit and gain.

In the "Data, assumptions and other related information" section, we mentioned that container profit per day per container is 200NOK. If we considered a worst case scenario of 8 containers therefore a profit of 192,000NOK in four month can be achieved (200NOK*8 containers*120days) or 576,000NOK in one year (192000*3) if we want to generalize the solution for one year.

13.2 Reduction of number of containers:

In case of the Newsvendor problem that we solved for the RFID case we get that we should have 29 containers in hand in any given day, which means 1 less container to keep in storage (difference between optimal quantity of original data and optimal quantity when having an RFID, check table 32 and 34), so it is also possible to rent out this container too. Thus we will gain a 24,000NOK in four month or 72,000NOK per year.

13.3 Reduction of returning empty containers:

As seen in the "TollPost Globe container movement data analysis" and "data, assumptions and other related information" that there is 1079 empty containers from Trondheim back to Oslo in the period of four months, and as we mentioned that this can be reduced due to better management owing to enhanced visibility gained by the application of RFID by 1% to 5%. Therefore in case of 1% (approximately 11 containers) a total reduction of costs by approximately 104,000NOK (1079containers*0.01*6NOK*535KM*3trimesters). Later in the discussion section we will argue about the possibility of this reduction.

13.4 Labor savings

Savings in labor is one of the most mentioned benefits (due to automation) other than the inventory related savings. So, hypothetically speaking if we to include labor savings to our calculation, we can assume that there is savings regarding only one worker, and if we assumed that the average income of a worker is 400,000NOK (according to Norwegian statics bureau SSB the average total gross income in 2012 was 475,200NOK per year (Statistisk Sentralbyrå 2013)) So we get savings equals to 400,000NOK per year.

13.5 Net benefits

Net benefits are calculated as the difference between the monetary values and costs of intervention:

$$Net\ Benefits = (Reduction\ in\ safety\ stock + reduction\ in\ number\ of\ containers + reduction\ in\ empty\ containers + labor\ savings) - Total\ costs\ of\ intervention$$

As mentioned in the “RFID related costs in case of TollPost Globe” the total costs of intervention was 173119NOK.

$$Net\ Benefits = (576{,}000 + 72{,}000 + 104{,}000 + 400{,}000) - 458{,}833$$

$$Net\ Benefits = 693{,}167 NOK/\text{year}$$

13.6 Result of the Return on investment for TollPost Globe

Return on investment in this case will be:

$$ROI = \frac{Net\ benifits}{costs\ of\ intervention} \times 100$$

Thus;

$$ROI = \frac{693167}{458{,}833} \times 100$$

$$ROI \cong 151\%$$

An explanation and analysis of this return on investment will be later disused in the conclusion chapter.

14.0 Coop's Case: Cost of not having information

It is important in every supply chain to deliver a good product to the end customer. In this case it is Coop Faghandel who wants to receive better customer service from TollPost Globe in order to keep up with other competitors. In this section we will show the importance and the value of having good information for Coop. When deviations occur in the supply chain it will have consequences for Coop and certain costs will arise that could be avoided if better information is available.

First, we are going to shed light on typical costs that Coop must pay because of deviations, and then we will calculate these costs before implementing any tracking systems and present what can be saved after implementing RFID in the supply chain. Last but not least we will try to find if it's worth to implement the RFID by comparing the related costs and outcome benefits of the application of RFID through using a return on investment model (ROI).

Now we will show a scenario of a common problem that can occur when transporting goods from Oslo to Trondheim. In this scenario we have TollPost Globe transporting fifteen containers that are sent from Oslo by train with new campaign merchandise for Coop in Trondheim. The cargo will go from Oslo by rail to a terminal in Trondheim. There it will be loaded on to trucks and transported to the Coop warehouse and sorted out and transported further to the Coop stores. The merchandise must arrive to the warehouse in Trondheim at a reasonable time before the week long campaign starts. The Coop warehouse in Trondheim has hired extra staff to help out with the unloading of the cargo and to store it in the warehouse (Bø 2012). The cargo is planned to arrive so that they will have enough time to unload the cargo and transport it to the various Coop stores in the district, leaving the shelves fully stocked with new products before the campaign starts.

With limited information regarding the situation of the containers being transported, the workers wait, but the containers don't show up. The warehouse manager in Trondheim contacts Oslo to find the reason behind such delay. He is informed that the containers have already been sent and that they should have been there by now. Consequently Oslo contacts Trondheim terminal to check on the status of the containers, but he also is being informed that the containers haven't arrived yet without any information regarding its current location, so actually neither the transport service provide (TollPost Globe) nor the customer (Coop) knows the current whereabouts of the shipment .

Let’s say in this scenario that another phone call is being made and it turns out that there has been a flood that made it impossible to transport the containers the rest of the way to Trondheim by train. Now they have to arrange trucks to transport the containers the rest of the way.

The late availability of this valuable information to the manager in Coop could have been avoided and the related costs could have been saved if the manager had known of the delay earlier. In (Bø 2012) “Undersøkelse av nåsituasjonen” interviews were conducted at Coop, in which they stated that it can take 3 – 24 hours before they get a response back from TollPost Globe. In the same interviews Coop also states that over half the time when goods are unaccounted for, they are the first to notice.

This is a serious problem since 60-70 % of Coops revenue is based on promotional products which are advertised in their own brochures and in newspapers (Bø 2012). If the product is not on the shelves in time of the start of the campaign, they will experience lost sales. Lost sales can be represented as customers will start to complain about the unavailable advertised products and will search for those products elsewhere.

In 2012 Coop Faghandel had a turnover of 4.6 billion NOK (Coop Norge SA 2013). If we take the revenues from promotional products (65% of 4.6 BN) we get: 2,990,000,000 NOK. This is just to see how important these goods are for Coop. If they do not have these products in stores by the start of the campaign they could be in great risk of losing a lot of sales. Customers would also begin to question their trust in Coop campaigns and buy the same products elsewhere (Bø 2012).

14.1 Cost of not having information in the Supply Chain

In the scenario where the shipment is delayed we get some direct costs that occur for hiring the extra help. As the extra workforce receives hourly payment for their work, these extra help stands idle waiting for the shipment. This now unnecessary extra workforce becomes an unnecessary cost for Coop. There is also the unnecessary time and cost for the administration for hiring the help, they make phone calls and use a lot of time to find the extra workforce they need.

The warehouse manager in Trondheim goes through a long process to receive the information because he must call several actors through the supply chain to get that information himself. He is unable to do anything about delays until he receives the information that he needs.

As stated before the common consumer goods provided by Coop can also be found at their competitors, and thus indirect costs arise as a risk of the delivery being a day too late than it was advertised, leaving empty shelves for the customers and lost potential sales for Coop

14.2 Benefits from having information in the Supply Chain

The indirect benefits of having RFID are the results of dynamic effects that happen throughout the supply chain due to the various benefits the RFID provide which are discussed in the literature review chapter. The supply chain consists of many steps with a lot of activities so what happens in activity could have bigger effects on other steps in the supply chain (Young M. Lee, Feng Cheng, Ying Tat Leung 2005). This can be referred to as the Bullwhip effect (Forrester 1961)where one effect amplifies throughout the dynamic behavior of the supply chain. In our scenario for the Coop warehouse in Trondheim not to receive any goods for one day due to delay can result in stock outs and lost sales, and unsatisfied customers who will do their shopping elsewhere.

In the upper mentioned scenario there are neither notification systems nor an alarm system that informs the right actors for delays. The information is handled manually by making phone calls and it takes time to assess the delay. Communication goes through too many actors before it ends up to the right persons in need of the information, this in our case being the warehouse manager at Coop. If there was some system that could give Coop the information directly without having to go through several other actors first, necessary steps could be made much earlier too prevent unnecessary costs.

It should be mentioned that implementing RFID won't keep the trains on schedule all the time. RFID will eliminate the human errors because the supply chain will be more automatic (Sabbaghi and Vaidyanathan 2008), (Varila, Seppänen and Suomala 2005) and (SATO 2010). It will be difficult to take away delays completely, but by getting more accurate information on an early stage it will reduce costs.

With an RFID tracking system linked up to database with EPCIS[13] the information can be available faster and more accurate for every actor in the supply chain. With RFID readers along the route from Oslo to Trondheim you can keep track of the delivery. If the train happens to be late for the next checkpoint along the way, an alarm can go off with information on potential delay of the delivery. This information goes on to the database that can be accessed by every actor including the warehouse manager. He sees the alarm on the

[13] EPCIS: Electronic Product Code Information Services. EPCIS: the "What, Where, When and Why" of the item in question (EPCglobal 2007).

delay and can then begin to take the necessary steps to eliminate any potential waste. In this case the warehouse manager can call off the extra workforce as they will not be needed for the period of delay.

COOP can then find alternative products or replacements instead of the delayed ones, for instance -if it is possible- these goods to be sent from other COOP stores so that the shelves are refurbished with the advertised products.

The handling of workforce will be covered under the reduction of waste further down. Today there is an RFID reader based an hour outside Trondheim CargoNet Terminal. This reader provides information on the delivery and it will send a message stating that it will shortly arrive at the terminal. The Terminal can then get ready to handle the cargo as quick as possible and ship it off to the Coop warehouse. This message will be uploaded to the EPCIS database for everyone to see it. However currently there is no alarm system that goes off and notifies the warehouse if the trains are delayed.

Return on investment for Coop

In the scenario we mentioned some potential challenges that could occur when transporting freight from Oslo to Trondheim. We also mentioned some benefits to why RFID is of great use in a dynamic supply chain. With the benefits we have already mentioned we will now find some costs before implementing RFID and the same time what can be saved with an investment in this tracking system.

By using the model Return-on-Investment (ROI) (Gene E. Fusch, Richard C. Gillespie 2012) we are now going to find a monetary value that states that the value of having RFID is greater than the investment.

14.3 Collect, Evaluate, and Isolate Data on the Effects of Intervention

Using the model we go through five steps where we start with step 1: "Collect, Evaluate, and Isolate Data on the Effects of the Intervention" (Gene E. Fusch, Richard C. Gillespie 2012). The intervention is implementing the RFID and the following effects that will occur, and we are going to collect these data of the effects. If we take all the benefits mentioned above on having RFID in the supply chain and compare them to not having RFID we can find some effects related to handling of cargo and workforce from the Coop perspective. These mentioned effects with use of RFID will not just happen when delays occur, but could also happen on an everyday basis.

Effects of implementing RFID:

- Reduction in lost sales
- Reduction in waste
- Reduction in shrinkage

The benefits and data are found in Ola Bø's interviews at TollPost and Coop, and other various articles and reports.

14.4 Convert *the effects of performance intervention into a monetary value*

14.4.1 Reduction in lost sales due to stock out: Before RFID

Step 2: "Convert the effects of performance intervention into a monetary value". (Fusch and Gillespie 2012) In 2002 a research study was made using the largest findings on the extent, causes and consumer responses to retail out-of-stock situations for the Food Business Forum, Grocery Manufacturer America amongst others (Gruen, Corsten and Bharadwaj 2002). With their findings they state that the stock out rate in Europe is on an average of 8.6 %. The sales loses due to out-of-stock is 3.7 % on average in Europe. If we take the operating results stated in the Coop annual report of 2012 which was 4.6 Billion NOK and multiply them with the sales loses on out-of-stock percentage we can find the numbers of lost sales due to stock out this year is (4,600,000,000 * 0.037) 170,200,000 NOK. We have to take into consideration that stock out cause are several. One fifth of the reasons for stock outs are due to upstream causes according to the mentioned research study which includes common causes to stock out like human errors (incorrectly registered container ID, arrives too late at loading terminal for train, didn't get loaded onto train, loaded onto wrong train) which happens "from time to time" (Bø 2012) and delayed in transport which are the most commonly reason for causes of deviation in door to door transport in the Smartrack-project (Bø 2012). Also we take into consideration that of the stock out rate of 8.6%, around one of fifth of that stock out is due to upstream casus. (Gruen, Corsten and Bharadwaj 2002) Now let's say that an error happens in the upstream either delay of the shipment or human errors, caused by not having a sufficient automatic system leaving the supply chain prone to errors, one fifth (20%) of the 3.7 % of the lost sales due to stock out. That leaves a loss of (170,200,000 * 0.20) 34.040.000 NOK annually in potentially lost sales of the annual revenue of 4.6 BN.

14.4.2 Reduction in lost sales due to stock out: After RFID

(Pisello 2006) states that it is proven to do a 16% reduction in product out-of-stock. Let's say that we can get a reduction of 2% on the lost sales due to stock out after implementing the RFID the first year. When we take this percentage into our calculations on the lost sales due to stock we get (34040000 * 0,02) 680,800 NOK in savings of lost sales during first year with tracking system.

14.4.3 Reduction in waste: Before RFID

As mentioned in the beginning that a delay occurred and the extra labor stood around in idle state. The report from "Undersøkelse av nåsituasjonen" (Bø 2012) said that one of Coop stores estimated the cost to ten hours times 200 NOK per missed container. In the examination of the situation as it is now on the cause of deviations (Bø 2012) it states that delays on route by train happens "often". This is an approximate indication and will vary through the year. Let's say with this information that these delays happens once a month. Let's also roughly assume that one shipment have 10 container on average. Then we have an annual cost of: 40,000 (20 containers) times 12 equal to an annual cost of 480,000 NOK.

14.4.4 Reduction in waste: After RFID

This is a cost that can be prevented by having RFID automatically upload data to the EPCIS database so that the warehouse manager can see the status on the incoming shipment. He can now be observant on potential delays. An alarm system can also be installed that sends a message to the manager telling him that the shipment is going to be delayed, he now doesn't have to keep an eye on the shipment if it passes by the RFID checkpoints or not. When he gets the message that there is a delay he can quickly call off the extra labor that will no longer be necessary or call them in on a different time of the day when the shipment is going to arrive. A more extensive use of RFID will provide better visibility on the container flow (Gruen, Corsten and Bharadwaj 2002). If a delay should occur on the rail, trucks can come and take the cargo the rest of the way. If the database tells the manager that the delivery is going to be delayed and that the products will not arrive in the shelves on time before the start of the campaign, actions can now be taken in good time to get products from other Coop stores in the area. Either way the extra staff will no longer be a wasted cost for Coop.

14.4.5 Reduction in shrinkage: Before RFID

Another problem we discussed was shrinkage. Shrinkage can be defined as loss of products or reduction in inventory between when the goods leave the manufacturer to the point of sale.

The leading cause of shrinkage according to research is internal and external theft (Vaxevanellis 2010) (Chris Konstantinou, Chronis Kokkinos) there has been no mention of theft being an issue along our supply chain for neither TollPost Globe nor CargoNet. Theft could be an issue for Coop Faghandel we don't know, but this is not what the Smartrack project is focusing on right now. The RFID implementation is to help tracking container movements at this moment and not the products at Coop stores. We will in this part focus on shrinkage happening once the goods have left the manufacturer till it arrives at Coop, namely in the transportation part. Reason for shrinkage could be container sent to wrong location, billing errors, damage on products, human errors resulting in wrong container ID leaving some products not arriving at the right location that can lead to wrong inventory compared to record in the IT-system. It is in the transportation part that shrinkage least occurs (Vaxevanellis 2010), but according to the interviews from Coop these situations that we mentioned can happen "now and then" (Bø 2012) so we think it is worth to include it. As we mentioned the supply chain consist of many activities and that improvements in one area can have a positive effect throughout the supply chain. Shrinkage can also result in stock outs since the goods could risk not being at the right customer at the right time. Reducing shrinkage will leave customers more satisfied with greater choice in products which will increase loyalty to Coop. For Coop it will lower cost, have more efficient replenishment and increase sales and profit. (Chris Konstantinou, Chronis Kokkinos).

In (Vaxevanellis 2010) it is mentioned that lost sales due to shrinkage can be between 1% and 2%. It is also mentioned that of this percentage only 5-11% is caused due to logistics, meaning transportations issues from the manufacturer to store. So let's assume we take the mean numbers of the lost sales and use the turnover numbers from Coop we get (4,600,000,000 * 0.015) 69.000.000 NOK. Of this sum we can take a number in between the percentage caused by logistics, let's say 7, and we will get (69,000,000 * 0.07) 4,830,000 NOK. So we now have the loss of profit caused by shrinkage using numbers we have found in other research.

14.4.6 Reduction in shrinkage: After RFID

As mentioned we will focus on shrinkage happening once the goods have left the manufacturer till it arrives at Coop. Misplaced products or products that are uncounted for over time will be considered as lost and will be counted as inventory shrinkage. If RFID is implemented the tracking of containers will be an automated process instead of manually registering the container IDs. This will prevent the deviations to occur and same time should lower the shrinkage.

The deviation that creates shrinkage in our case happens “now and then” according to interviews at Coop (Bø 2012). We have mentioned that RFID will remove the manual registration of containers and therefore we agree that the shrinkage will be reduced significantly. We will therefore choose a random percentage of lowered shrinkage during first year of RFID implemented. Let’s say that the annual shrinkage cost is 4.830.000 NOK like we calculated earlier. If the shrinkage will be lowered 1 % of the first year we get a saving of (4830000 * 0.01) 48300 NOK.

14.5 Calculating total cost of implementing RFID

Step 3: “Calculate the Total Cost of a Performance Intervention” (Gene E. Fusch, Richard C. Gillespie 2012). Now we will calculate the total cost of implementing the RFID. We will be using the cost provided to us by GS1. The RFID is not fully implemented in the supply chain yet and we don’t know which of the actors involved in the Smartrack project that is going to pay for which RFID readers, tags and software etc. So we will be using the cost that is most relevant to Coops case. The costs we have received from GS1 are cost of read points, software, QR tags, EPCIS data base and GUI. The next cost that we will include is staffs training costs for the new system. This will be estimated costs with values gathered from average salary and hours worked during one year in Norway. An average salary in Norway is about 450000 NOK before taxes (Samfunnskunnskap.no) Average working hours during a day is 7.5 with average working days during a year is 230 (Skatteetaten 2013). That gives us 1725 working hours in one year. An hourly salary is then (450,000/1725) 260 NOK on average. The GS1 system promotes simplicity and standardized interfaces that won’t demand many hours training courses to the users (GS1 2012) We take a number of 30 people that will receive a 10 hours course in the Smartrack project and the implementation of RFID and EPCIS database.

We can then calculate a cost for training the staff. We get an estimated cost of (260*10h*30) 78000 NOK. In the table below you will see the total cost of implementing RFID:

1 Read point	22,500 NOK	
Mobile software	13,500 NOK	can read and send events to EPCIS from QR codes
QR tags	11,000 NOK	2000QR*5.5nok/QR tag
EPCIS data base 2500 NOK/month for 1 year	30,000 NOK	Server use.
Profitbase/Tracetracker GUI	100,000 NOK	Widgets as maps and/or graphs,etc
Training staff	78,000 NOK	Smartrack project, usage of EPCIS.
Total Cost	**255,000 NOK**	

Table 35 RFID costs related to COOP

The investors in this project are mainly the transport businesses, TollPost Globe and CargoNet. Their main objective in this project, as mentioned, is to provide good customer service for Coop. Coop will only draw the benefits from implementing the RFID. What we will find is the return of cost for TollPost which is the benefits for Coop. The costs that we will be using are the hardware that is going to be applicable for Coops part of the investment. We have left out the readers and other hardware that will mainly benefit TollPost and will not create any direct benefit for Coop.

14.6 Calculating the Net benefits for implementing RFID

Step 4: "Calculate the Net Benefit of a Performance Intervention" (Gene E. Fusch, Richard C. Gillespie 2012). In this step we will subtract the total cost of implementing RFID for Coops part of the investment with the value of the benefits we found in our calculations and find the net benefit.

Monetary Value of the benefits	680800 + 480000 + 48300 = 1209100 NOK
- Total Cost of Intervention	255000 NOK
= Net benefit	954100 NOK

Table 36 Net benefits for COOP

14.7 Result of the Return on Investment for Coop

As presviously mentioned we will use the ROI model (Gene E. Fusch, Richard C. Gillespie 2012) calculating step 5.

Net benefit / Total cost of intervention	**= Return on investment**
954100 NOK / 255000 NOK	= 3.74156862745098
Return on investment * 100	= **ROI %**
3.74156862745098 * 100	= 374 %

Table 37 Return on Investment for COOP

These results will be explained in details in the next chapter.

15.0 Final conclusion and analysis

This chapter represents the conclusion of the findings; it also answers the research question that was asked at the beginning of the research.

The RFID costs differ from one case to the other, table 17 shows TollPost Globe RFID related costs:

Investment				
	Tags			
		RFID Tag price Tollpst	20	NOK
		# of tags	1300	
		QR tag price	5.5	
		# QR tags	2000	
		Total	37000	
	Readers			
		RFID reader	22500	
		# of readers	2	
		Total	45000	
	Software			
		EPCIS database	2500	NOK/Mon
		# months	12	
		Enlight QR software	13500	
		total	43500	
	Project management		500000	
		project period	18	Months
		cost per year	333333	per year
		Total Costs	458833	

Table 17 RFID costs related to TollPost

While in case of Coop it is represented in table 26:

1 Read point	22,500 NOK	Explanation
Mobile software	13,500 NOK	can read and send events to EPCIS from QR codes
QR tags	11,000 NOK	2000QR*5.5nok/QR tag
EPCIS data base 2500 NOK/month for 1 year	30,000 NOK	
Training staff	78,000NOK	Training staff on Smartrack project, usage of EPCIS and other technical issues
Profitbase/Tracetracker GUI	100,000 NOK	Widgets as maps and/or graphics, etc.
Total Cost	255,000 NOK	

Table 26 RFID costs related to Coop

15.1 Potential benefits for using RFID tracking for TollPost Globe container fleet:

While the reported findings of the potential benefits for using RFID tracking to gain control and visibility on TollPost Globe container fleet are based on better visibility of the container fleet, and thus better and efficient management of the container movement can be done namely as in the Newsvendor problem based on RFID. Those benefits are:

A. Reduction in safety stock,
B. Reduction in the number of containers and finally,
C. Reduction of returning empty containers.
D. Labor savings

15.2 The potential benefits for using RFID tracking to gain control and visibility for Coop?

In Ola Bø's interviews at Coop (Bø 2012) he identified the problems that was causing Coop not having their products arrived at the designated time that would create Coop problems for them. Because of the lack of visibility they had on the supply chain and the same time their shipment they use a lot of resources into tracking down their cargo. If they could see the progression on of the shipment through the supply chain and same time have some sort of alarm system that were triggered at a time were shipments were going to be delayed due to some sort of accident or error they could take early actions and prevent unnecessary costs. Implementation of RFID will turn most of their manually tasks and make them more automatic. This could reduce human errors and it could also reduce the deviations that make the container fleet run much more smoothly and this will benefit the whole supply chain including end customer. The benefits in this case will be:

A. Reduction in lost sales
B. Reduction in waste
C. Reduction in shrinkage

15.3 The return of investment for TollPost Globe and Coop

15.3.1 Return on investment for TollPost Globe

As we mentioned in the potential benefits for TollPost Globe, the benefits that we concluded were: reduction in safety stock, reduction in the number of containers, reduction of the returning empty containers and labor savings. The value of each is:

A. Reduction in safety stock by at least 8 containers which and thus a gain from renting this container will be 576,000NOK for one year,
B. Reduction in the number of containers by one container, which if rented will gain 72,000NOK per year through having the optimal quantity of containers based on RFID and inventory management through the Newsvendor problem.
C. Reduction of returning empty containers by 1% (or 11 containers) which means a gain of 104,000NOK in one year.
D. Labor savings: one worker will be reduced from the total work force saving a 400,000NOK/year

After calculating the ROI, it is showed that there is an approximately 150% return on the RFID investment, which means that there is at least three times gain from such investment. This return on investment can be seen as high or may raise concern regarding our results. We refute any allegations by:

1. (Pisello 2006) recorded a 580% return on investment on investment on a warehouse and distribution case study, (De Souza, et al. 2011) calculated an ROI of 101%
2. In the return of investment calculation, usually the costs of implementation of RFID are fixed costs (and probably a one-time investment), even if they are high, the benefit that is gained from the RFID application as shown in the “RFID Benefits” section in the literature review covers these costs (and probably these benefits are gained on annual bases).
3. Regarding the returning empty containers, as we observed in figure 19 and Table 15, the container movements are already in balance, and more specifically regarding the Oslo-Trondheim route as mentioned the container ins and outs are also in balance, yet, there was more than a 1000 empty container being shipped from Trondheim to Oslo, and it is very logical to assume that there is a 1% decrease in these number which is only 11 containers out of 1000, and these reduction is based on better visibility and reduction and variability which is discussed before.

15.3.2 Return on investment for Coop

We calculated the return of investment from Coop's case to be 374 % in one year. For finding the ROI it will be beneficial to include as many costs as possible related to the investment (D.W. Smith & Associates 2001). In our case we have listed the once that are most important and the costs that will have most impact on the investment. These cost are the once that are directly related to the benefits that Coop receives from the implementation of RFID.

We should mention that we consider the fact that there is a cost-benefit asymmetry regarding the investment costs for both Coop and TollPost Globe. As TollPost Globe has to invest in RFID tags that will be attached to TollPost Globe's containers, these tags are a major and crucial component of the RFID application, and consequently for the whole benefits that are yielded from such application, of which Coop will reap these benefits without paying or investing in it. This asymmetry or imbalance is shown in the high return on investment for Coop and TollPost Globe's modest return on investment.

With an ROI of 374 % we can see that the investment will give Coop a huge profit in a very short time. We should also have in mind that this is a first year calculations were there costs that are only occurring once like staff training, read points and software. The savings can also become greater with time once the operations will run smoother. By using the ROI model we have come across benefits that will provide Coop with better visibility of the supply chain, while TollPost Globe providing Coop with better customer service.

The ROI does not take the risk of implementing RFID into consideration. There are many financial possibilities regarding this kind of project. The strategic structure of the organization has not been taken into consideration. It is important that projects like this follow the organizational structure. Projects can be cancelled to follow other projects that are considered more important at the present time (Brown and Russell 2008)

We can see from other research that implementing RFID will provide better visibility and reduce deviations in the supply chain. It is remarkable to mention that even though we have reduced much of the effects and values regarding the benefits of RFID in our calculations then what is mentioned and used in other studies, we still got has a positive effect of implementing RFID

15.3.3 Total Return on Investment for TollPost Globe and Coop

As we explained, we calculated the ROI for each case separately, On the other hand if we to include both the benefits and costs of both cases the return on investment will be:

$$ROI = \frac{Net\ Benfits\ of\ TollPost\ Globe + Net\ benedits\ from\ Coop}{Total\ costs\ of\ TollPost\ Globe + total\ costs\ of\ Coop} * 100$$

$$ROI = \frac{693{,}167 + 954{,}100}{458{,}883 + 255{,}000} * 100$$

$$ROI \cong 231\%$$

We see that we have presented a fair argument regarding both cases, especially when it comes to the benefits, as we tried to capture these major benefits and values in a rational manner even if there are some estimations and assumption introduced. Thus based on that, we see that these numbers can be used as actual outcome of the RFID solution, which can then be substituted and compared by the actual numbers from the final Smartrack report.

15.4 RFID benefits regarding variability and human error

First we would like to discuss the effect of RFID and its relation to variability and then regarding human error. As we have observed in the “container movement data analysis” section, when we introduced the RFID, better visibility is gained, which had two major benefits in this case:

15.4.1 Reduction in variability

As mentioned in (Bottani and Rizzi 2007) and (Dai and Tseng 2011) and as our figures 15 and 16 shows that when we introduced the RFID situation, the variance has decreased (table 11) decreasing the variability.

As mentioned in the literature (Michael and McCathie 2005) (Atali , Lee and Özer 2009) have discussed that the decrease in variability is met with a decrease in safety stock, from our finding we can approve there argument, as we found that the safety stock has actually decreased from 18 containers to just 9 containers which is 50% decrease, and as we observed this is actually the highest benefit of all the other four benefits the we encountered in the TollPost Globe case.

15.4.2 Reduction in human error

The human error in the data collection should be reduced as information regarding the containers now is automatically processed (Varila, Seppänen and Suomala 2005) (SATO 2010). The following is a screenshot of the Smartrack EPCIS event dashboard.

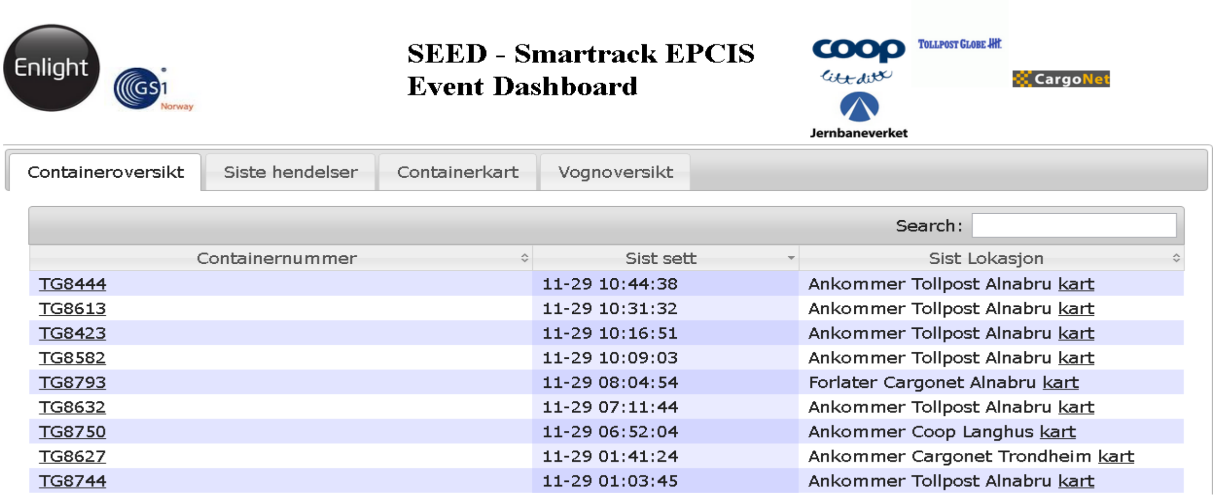


Figure 20 Smartrack EPCIS Event Dashboard

Asset Details

Search:

Tidspunkt	Container	Vogn	Tog	readPoint
11/29/2013 11:44:38 AM	TG8444			Alnabru_portal_1
11/26/2013 5:11:02 AM	TG8444	2427644320728	5707	CargoNet_Trondheim
11/25/2013 7:00:00 PM	TG8444 TG8377 TG8094	2427644320728	5707	tollpost.system
11/25/2013 7:00:00 PM	TG8444 TG8377 TG8094	2427644320728	5707	tollpost.system
11/25/2013 4:52:41 PM	TG8444	2427644320728		Alnabru_portal_1
11/14/2013 4:02:11 AM	TG8444	2427644320728		rail.Hoyseth

Figure 21 Smartrack EPCIS Event Dashboard Asset Details

Enhet	Åpnet	Full	Fra	Til	Tomretur	Cont.type
04012	24.01.2013 22:22	25.01.2013 04:12	OSLO	TRONDHEIM		C2
04062	22.01.2013 03:05	22.01.2013 10:51	OSLO	TRONDHEIM		C2
04062	25.01.2013 13:57	25.01.2013 14:59	OSLO	TRONDHEIM		C2
04082	07.01.2013 17:46	07.01.2013 21:31	OSLO	TRONDHEIM		C2

Figure 22 TollPost data description (Figure 8)

As we can see from the upper screenshots, and the data which we received from TollPost Globe that the RFID has automated the whole data collection process, leaving no room for human error in data collection, nor there is dirty data.

Regarding Coop's case, as observed if the warehouse manager had such information ready before him (Figure 21), he would have been able to take informed decisions regarding delayed shipments and thus reduce the waste of extra labor and stock outs.

Unfortunately this event dashboard is relatively new as it was set up during the end of our research, also we have counted only 131 containers that have been RFID tagged and the container movements was not all from Oslo to Trondheim, some of the container movements were from Coop Langhus where the container are supposed to be stuffed and sent to TollPost Globe container terminal at Alnabru.

15.5 Further research

We have used one of the most conventional models for measurement i.e. Return on Investment, others as Net Present Value, Internal rate of return, only provide preliminary analysis, a further step can be taken by can using uncertainty based models as Real Options Analysis (ROA) Which provide option-based evaluation and show the long term benefits and opportunities when the analytical models are too complex (Ustundag 2013)

Also in case of the Smartrack Project, a Retrun on investment should be measured for other actors in the supply chain as Jernbaneverket and CargoNet AS should be conducted.

15.6 Limitations

The major limitation that we have come across is the availability of data and numbers regarding the application of RFID in the Smartrack project as the project is not yet concluded and finished which led us to assume and estimate numbers based on previous researches and studies.

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