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MASTER'S DEGREE THESIS

Internet of Things and Modern Supply Chain Management

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ABSTRACT

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Information flow has a great influence over the flow of materials in the supply chain industry. The behavior by which the materials flow is highly affected by how the information flows throughout the organization in a smooth manner. To develop the supply chain performance and improve the efficiency of information sharing a lot of practices have been developed to achieve that target. However nowadays with the expansion of companies and having complicated structures of communication, ordinary practices cannot suffice any longer. Additionally, a lot of time is not utilized properly wasting a lot of time and lowering the efficiency of the organization.

This research aim is to investigate the development of the internet of things and how when properly utilized it can make a huge impact on modern supply chain management. This research aim is to provide a theoretical basis on how companies can use internet of things to allow easier access for information throughout the organization with minimal effort. The research questions to be addressed in this research are (1), What is the impact of the internet of things on modern supply chain management (2) what are the possible improvements and future work that can be done with regards to the internet of things (3) is it easy to use.

An application of internet of things in the supply chain management is developed based on literature findings. The applications aim is to take place to match between execution flexibility and information abundance. Information sharing aimed should be providing high quality information for the higher ups and management before making crucial and swift decisions.

To improve the flexibility of the operations and improve the pace within the working environment information must be gathered in a swift manner. It was determined that there are several reasons behind the turbulent flow between materials flow and information flow. Numerous plan changes in response to demand changes, varying planning processes which would subsequently cause problems when designing a supply chain model to organize the information flow. Moreover, it was also found that another reason was insufficient data which resulted in the inability of sharing information between various departments.

PREFACE

It is of no doubt that in modern supply chain management practices companies are trying to adopt new approaches to solve their problems. The internet of things aided a lot of companies in that endeavor. Although that the internet of things proved to be quite the tool for a lot of big firms such as Procter & Gamble, it is yet to be adopted by small firms. There seems to be an obstacle preventing firms around the globe from adopting the internet of things.

The thesis aims to understand the issues preventing a lot firms from incorporating the internet of things into their supply chain. To do that many things must be taken into consideration, the internet of things architecture, usability, cost and impact on industries if adopted. Moreover, studying the subject itself is not enough where other things need to be taken into consideration such as; the value it brings to the customers, effect on the mobility and the transportation system. Not to mention whether it helps in tackling existing problems in the supply chain like the bullwhip effect, reducing costs of transportation and effect on communication. The subject itself draws many questions and speculations whether it is the difference needed for improvement.

The thesis will present sufficient information regarding the topic and how it tackles various problems. This will be done through the analysis of the literature while incorporating various case studies that were carried out in different industries. There will be an analysis on each case study showing the findings behind incorporating new approaches. The analysis will show benefits, drawbacks and possible improvements that could be done in the future to smooth the transition from using old practices to adopting the internet of things.

I would first like to thank my thesis advisor Professor Heikki Liimatainen of the faculty of business and built environment at Tampere University of technology. Professor Liimatainen office was always open to new ideas and had a unique perspective to the thesis. The insights provided by the professor helped shape the thesis into the best version it could possibly be, whenever I ran into a troubling spot or had a question about my research or writing he provided simple measures that were effective. He consistently allowed this paper to be my own work, but steered me in the right the direction whenever he thought I needed it. I must also express my very profound gratitude to my father for providing me with unfailing support and continuous encouragement throughout my years of study and through the process of researching and writing this thesis. This accomplishment would not have been possible without him. Thank you.

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Yehia Rashed

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1. Introduction

1.1. Background

Internet of things was firstly defined in 1999 to define primarily recognizable interoperable connected objects. These objects are using radio frequency identification which uses the radio waves to read and gather the information that is saved on a tag that is attached to an object. The first company to use such an approach was Procter and Gamble. Internet of things will have a considerable role to play in the existing industrial systems and will go on to present promising solutions to other systems that are within the supply chain, for example the manufacturing systems and the performance management systems will be enhanced using the internet of things (Ashton,1999)

Internet of things is best described as the time when items and gadgets are linked to the internet more than people are (Evans, 2011), which is estimated to have been reached between 2008 and 2009. Recently the Internet of things has been identified as the growing collection of things being connected to the internet (Rose, et al. 2015). Goods and products made for consumers, industrial, utility components, sensors and daily objects in our lives are getting connected to the internet. Therefore, it possesses powerful data analytic capabilities that ensures the transformation of how we work and live our daily lives (Rose et al, 2015). Five technological advances were identified which enables the internet of things revolution. These five things are ever-present connectivity, widespread adoption of the IP-based networking, cloud computing, miniaturization of computing devices, and advances in data analytics.

It has become self-evident that having refined information is quite necessary for the supply chain managers. Having refined information helps regulating the decisions that are being made which helps in closing the gap between the supply and demand. Minimizing the wasted time and eliminating inefficient management thus increases the profit and the performance within the supply chain (Simchi-Levi et al., 2003; Fisher et al., 1994). Hence, with the availability of refined information, integration has become easier for the supply chain participants.

Companies scope has been directed towards the supply chain management and how to possibly improve the performance within it, this can be illustrated as the coordination between the tactics used across business functions and traditional business functions (Mentzer et al.,2001). To operate and design a manufacturing enterprise decision making at various levels and domains is constantly required. Having a complicated system adds to the variables that must be taken in to account when decisions are being made. Therefore, having a high number of variables makes it difficult to make decisions. The decision making requires real time data collected from machines, processes and business environments. Companies have systems which support the acquisition of data and communication to take decisions. Therefore, the infrastructure of information technology affects the performance of companies and explains the importance for studying the internet of things and its impact on modern manufacturing (Zhuming et al, 2014).

1.2. Influence of information technology

Information technologies have an important role to improve the information sharing and collaboration in the supply chain industry (Simchi-Levi et al., 2003). Nowadays there has been a nonstop pursue in developing the information technology which enables the people within the supply chain to receive and distribute electronic information in an instant. Consequently, that has led to an improvement in the overall information reliability and accuracy. Moreover, by improving the information sharing it helps in providing quicker responses, shorter lead times and lowering the costs for the companies (Xie& Allen, 2013). Information technologies are being implemented nowadays more in the supply chain management. Thus, an improvement in the company's strategic planning, knowledge management and virtual enterprises became apparent in companies (Gunasekaran and Ngai, 2004).

To face the challenges ever rising from the global and changing environments, companies must focus on their core competencies and gradually begin to outsource (Kessler et al., 2012). Organizations nowadays recognize that improving their internal efficiency is not sufficient to improve their supply chain performance, instead more focus must be directed to strengthening their external relationships with key suppliers and customers (Özatağan, 2011). This means that firms need to share the information in a timely accurate manner to improve their supply chain performance (Li et al, 2012), and reap the benefits behind it which includes increased sales, decreased inventory holding and carrying costs. The progress made in the information technology and globalization has given enterprises competitive advantages to take into consideration (Thakkar, Kanda, &Deshmukh, 2008). Moreover, effective management of information is achieved through various supply chain management practices, such as collaboration and information sharing (Li et al., 2005).

Various studies have been made to examine the correlations between information sharing and supply chain performance. There was a discussion whether information sharing has an influence on the bullwhip effect (Ouyang, 2007). The results clarified that inventory variance has an impact on the bullwhip effect. Also, a lot of studies stated that information sharing can a cause an incremental increase in the supply chain performance. The collaboration of both the buyers and the suppliers with each other can give rise to finding new opportunities and the creation of more value for the supply chain members through the sharing of strategic and transactional information (Klein & Rai,2009). Lin (2006) explains that to increase the competitiveness of a company the information should be made available at every end in the structure and be shared with their respective partners. The internet of things has been called many things over the course of time, simply put it can be described as an infrastructure for the information society that is global, it allows advanced services by connecting physical and virtual things based on current and evolving interoperable information and communication technologies (Rose, Eldridge, &Chapin, 2015). Moreover, it has been shown to revolutionize the way of gathering and sharing information to make the operational decisions of the supply chain quite easier reducing the time needed to finish daily operations and increasing the efficiency of the process.

1.3. Focus of the thesis

This research aims to identify the impact of internet of things over different industries, understanding its different applications and how it can be properly utilized for efficient flow of information. This would in turn reduce the expenditure for businesses and wasted capital. The thesis aim is to understand the factors contributing to the success of incorporating the internet of things into a business model. Examining different factors that relate to the success of the application, ease of use for the participants, the industrial applications that it can be used for and how to lay out an infrastructure that guarantees that the work flow runs smoothly. Figure 1 is showing the factors influencing the internet of things.

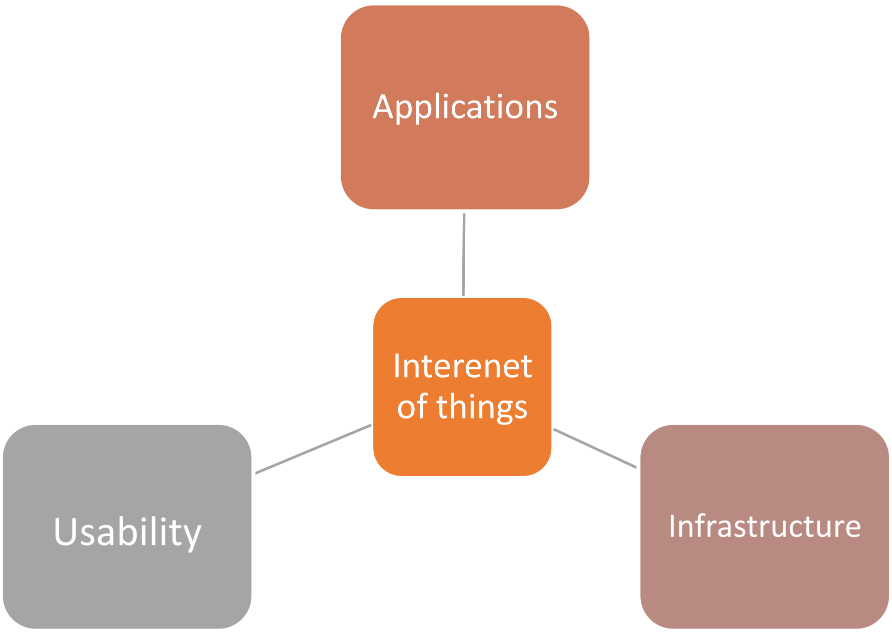


Figure 1. Factors influencing the Internet of things.

This thesis addresses the internet of thing application in different industries and their respective utilization of the system to match their company's needs. The aim is to understand the currently used models and current utilization of the system and how to improve if possible in their respective industries. The flow of information is regarded as highly important in the supply chain management however studies emerge regarding the utilization of the internet of things since its emergence in 1999 and being used by Procter& Gamble. The thesis is being done by using a framework built from the theoretical background, after building the framework some case studies are used to analyze the Internet of Things. Later on, the framework is used on the case studies to help in find possible improvements when using the internet of things and improving the efficiency of information flow within the supply chain management for companies.

1.4. Structure of the thesis

The thesis is structured in a manner that makes it possible to establish a theoretical framework. After establishing the framework different case studies are examined, before finally introducing the framework with personal insights and conclusions built on deduction and deep understanding of the internet of things. Figure 2 explains the structure of the thesis.

Chapter 2 introduces the theoretical background where different supply chain concepts are introduced in that chapter, that would later be used to build a theoretical framework. Chapter 3 then proceeds to explain how the research is designed, the methodology and at the end a theoretical framework is built to be used later.

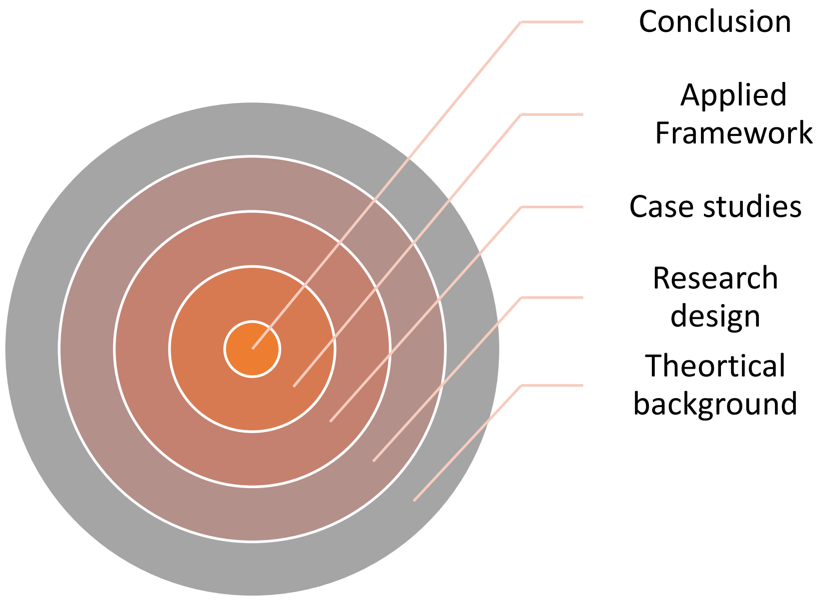


Figure 2. structure of the thesis.

Chapter 4 includes the case studies and various industries who have been using the internet of thing, in that chapter the case studies examine different aspects that affect their business. Chapter 5 uses the framework developed in chapter 3 and the case studies discussed in chapter 4 to analyze the benefits that could be attained by applying the Internet of Things. The usability, feasibility, cost, application, benefits and barriers to execution are examined in this chapter. Chapter 6 is the conclusion where a deduction is made based on the findings throughout the thesis, also the limitations faced and future improvement to the research topic of the thesis is discussed in this chapter.

2. THEORETICAL BACKGROUND

2.1 Supply Chain

The supply chain management can be described as managing and transporting raw materials to the final stage in the production, if possible even reuse the raw material. The supply chain is linked to how firms exploit the process and technology of their suppliers for them to enhance their performance and increase their profits. Supply chain management aim is to increase the activities done by enterprises, by providing the trading partners a target to reach a higher level of optimization and to increase the efficiency of their company operations (Tan et al, 1998). Another perspective for supply chain management as the networks of manufacturing and distribution sites that can get raw materials to manufacture them into semi-finished or finished goods, where they can be delivered to the end customer (Lee and Billington, 1992). Furthermore, the external chain is the transportation of raw materials from the original source through different firms, the firms specialize in getting and processing raw materials to manufacture, assemble and deliver to the ultimate end users (Saunders, 1995). The figure below explains the process.

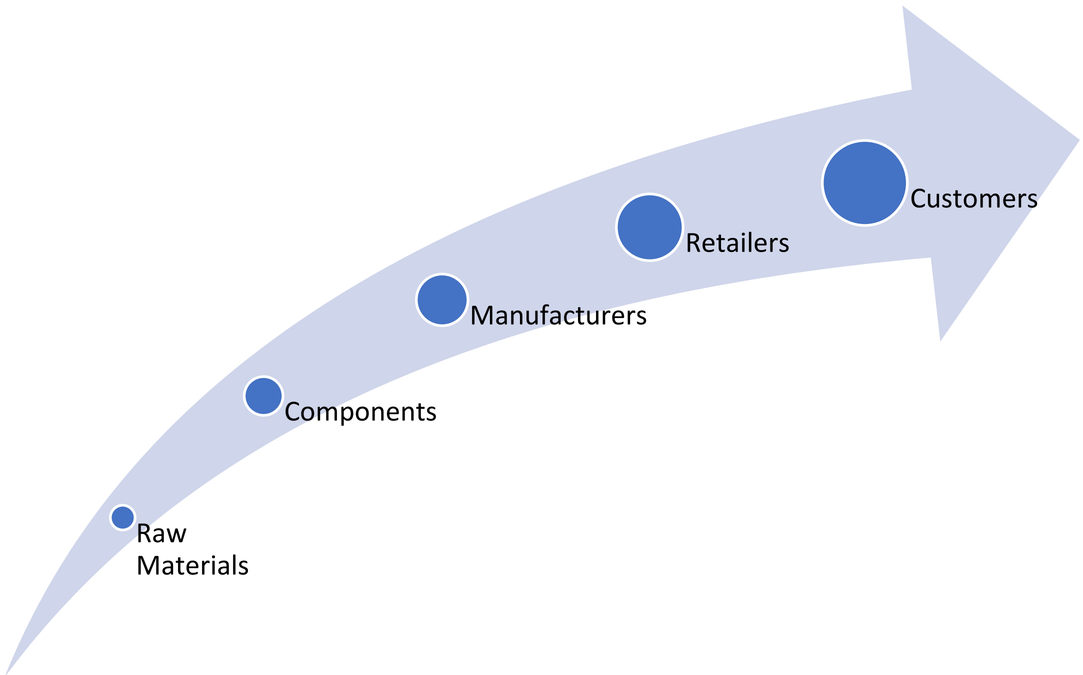


Figure 3. Supply Chain Management.

Moreover, supply chain can be viewed as a group of three or more units of either organizations or individuals that are taking part in the upstream and downstream flow of products, services, and or information from a source to a customer (Mentzer et al., 2001). From the understanding of this definition it has been classified that there are three types of supply chains with different digress of complexities. The three types of supply chains are direct supply chain, extended supply chain and ultimate supply chain. Figure 4 illustrates and explains how supply chains can differ, and how the complexity increases, it will also show how third-part providers cooperation from direct to ultimate supply chains.

Figure 4a. Direct Supply chain management.

Figure 4b. Extended Supply Chain management.

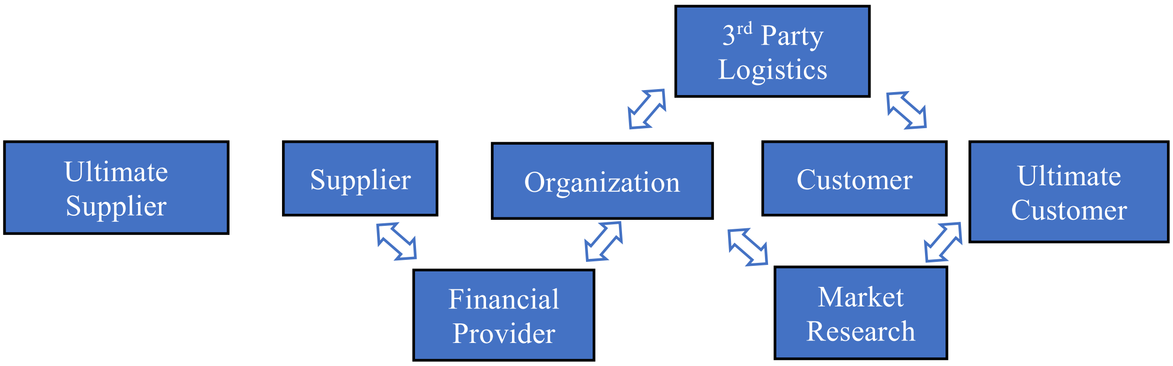


Figure 4c. Ultimate Supply chain management.

Figure 4: Types of channel Relationships (Mentzer et al, 2001, p5).

The direct supply chain is composed of a supplier, an organization and customer, whom all participate in the process of manufacturing or making a product. The extended supply chain is similar to the direct supply chain. Nonetheless, the extended supply chain possesses their own sub-contractors and the finished goods are sold again by the customer. The last type is the ultimate supply chain management. This type is more complicated than the previous two. The network of activities in this type has a central firm which outsources some of the services to a third-party provider. Consequently, this makes the activities carried on in the chain much more complicated, where many providers rely on each other in the process of making a final product.

As explained by Kumar and Nigmatullin (2011) supply chain integration provide firms with lowered lead times which leads to reinforcing relationships. The reinforced relationships lead to lower variability in demands, which in turn cause an improvement in forecasts and reduced inventories. The lowered inventories help in lowering the costs which increase the profits and increase the available capital (Kumar & Nigmatullin, 2011). Moreover, supply chain integration fortifies the relationships and improve the communication considerably between different parties in the supply chain. In doing so the supply chain integration avert from variability in demand and prevent the bullwhip effect. Furthermore, reduced variability contributes to reduced inventory levels and storage costs, which leads to a considerable increase in both profits and available capital. Figure 5 shows the elements in the integrated supply chain management.

Figure 5. Integrated Supply Chain management.

2.2 Forecasting

It is unrealistic to forecast one hundred percent accurately. That is when supply equals demand. However, the main purpose of forecasting is the ability to determine good projections on average over time. Moreover, the focus is to lower the uncertainty and forecasting errors, that in turn will aid in optimizing the information to be used. The forecasts that are in the supply chain and operations are frequently formed from a mixture of simple statistical forecast and judgment (Fildes and Goodwin 2007). An approach that is commonly used is when an initial statistical forecast is changed judgmentally. Proceeding the statistical forecast which is produced, the information could be collected by the forecaster from different areas within the business such as the marketing department and may consequently change the forecast to explain the additional information. These forecasts which have been altered are then used in the supply chain as the final forecast. It is debated that such produced forecasts that are within the functional integration are of high importance in the forecasting process (Moon et al, 2003).

Precise forecasts are pivotal in the performance of any supply chain system. It was quite evident in previous works that it is crucial to have a higher set of information (Fildes and Hastings, 1994). Information sharing, and collaborative forecasts can cause an incremental improvement in the supply chain increasing the profits and reducing the waste or lead time (Lee, So and Tang 2014, Önkal and Aktas, 2011, Yu, Yan and Cheng, 2001). Similarly, negative information may also lead to downward adjustments in the statistical forecast, which would in turn lead to downward adjustments in the forecasts (Fildes et al. 2009).

In another case study done for a manufacturer who produces consumer electronics (Olivia and Watson, 2011) there have been what was called functional silos (Moon et al, 2003), there have been some obstacles from different functions within the business which could not be aligned. With utmost care for the design in the supply chain and operation process, Olivia & Watson (2011) debated that this would lead to effective forecasting. However, there isn’t enough evidence that better integration of information or having statistical features of forecasting processes would improve the forecasting. To gain an insight on the benefits that can attained from getting additional information through the usage of statistical forecast a lot must be taken into consideration. There are a lot of different tricky interactions between using information sources that are different and the metrics related to the forecasting performance that depend upon the organizational processes (Danese and Kalchschmidt, 2011).

It has been found in other studies that the forecaster intentions and hopes about his business is more than likely to be the reason which would affect the selection of certain information sets in the forecasting (Eroglu and Croxton 2010). In specific situations forecasters may follow a variable to be in a forecast, as an example for illustration the desire to reach a higher sales revenue. Such motivation may affect the result which may result in an optimism referred to as being biased or inclined towards a certain goal or achievement, this in turn would affect the predictions to be made (McGregor 1938, Olsen 1997; Windschitl et al. 2010).

2.3 Bullwhip Effect

The bullwhip effect is defined as the amplification of demand variability from a downstream site to an upstream site (Lee et al, 2004). It was also outlined that there are four reasons for the bullwhip effect to occur and several suggestions were made in the managerial practices to diminish the ramifications cause by it. The work was highly inspired by observing the bullwhip effect in several companies such as, Procter and Gamble in their diapers product, Procter and Gamble noticed that there was instability of demand in their factories which was quite immense although the end consumer demand was quite stable (Lee et al, 1997a). Another example would be in Barilla's pasta supply chain and at a factory for soups (Hammond, 1994). In 1989 Sterman suggested that the bullwhip effect appears when subjects are managed as a single product in a simulated supply chain. Moreover, the bullwhip effect has been correlated to the industry's level of unpredictability. There was an indication of the extensive volatility in the machine tool industry to the bullwhip effect (Anderson et al, 2000), also Lee et al (1997a) related their findings regarding the bullwhip effect to the extensive literature in macroeconomics that found that industry level production to be more unpredictable in demand (Blinder and Manccini, 1991).

Lee et al (1997) goes on to describe that the existence of the bullwhip effect may have a negative outcome with respect to the supply chain management, where any change in the demands done by the customer may be the result of variances in the stocking volumes for the suppliers, that happens due to the distortion in the information regarding the demand between the members within the supply chain. Lately the bullwhip effect has had more attention, trying to figure how the supply chain performance may be influenced by it.

Looking at the bullwhip effect it can be considered as an intensification that occasionally can be measured in terms of a change in the orders placed at every supply chain level. This misinterpretation that happens in the demand happens at each echelon. Lee and other researchers identified that there are several reasons behind the bullwhip effect. The reasons are the order batching, price fluctuation, demand in forecast updates and shortage in gaming. This in turn results in affecting the profitability of the supply chain, where the coordination operation of the supply chain cannot be held any further because of the inconsistency from the supply demand information flows between the members in the supply chain.

To address the negatives resulted by the bullwhip effect an alternative method was suggested, the alternative method used was the auto regressive moving average function. Firms were expected to run occasionally into the first order autoregressive demand. If the coefficient was positive, the demand is then positively correlated over time and the production most probably will be more volatile than the sales. When there is a positive demand stimulation it aids the company in replacing the demand stimulation and it would also aid in the increasing of the production with an expectation of future increase in demand (Kahn, 1987). Another suggestion that could also lessen the bullwhip effect would be to delay the demand of information for forecasting (Zhang, 2005)

Moreover, an analysis was carried out by Hosoda and Disney (2006) which was done on three echelon supply chain models. The first order autoregressive end consumer demand was estimated. The analysis showed that the inventory level of the supply chain was not affected, and it did not affect the bullwhip effect; on the contrary the bullwhip effect was affected by other factors. The bullwhip effect is mainly affected by the lead time from the customer and the local replenishment lead time. In the analysis, it was found that the variance error occurring in the forecasting over the lead time was the same as the variance found in the net inventory levels.

Moreover, it was found that the net inventory variance was influenced by the local replenishment lead time. The materials needed to plan the based inventory management approach minimize the order variance as much as possible, where the minimization of the bullwhip effect is directed by means of application of several steps in forecasts which can be attained with the aid of the autoregressive models (Chandra and Grabis, 2005). Another study took into consideration the usage of material balances and the information flow, the transfer functions for each unit in the supply chain can be attained by z-transform. Thus, by joining the transfer functions into a closed loop the entire chain can be modeled. The model then proceeds to prove that it is quite effective in lessening the bullwhip effect, this occurs because of long term tracking of trends for customer demands.

Subsequently a genetic algorithm was proposed to minimize the total cost within the supply chain by looking for the best batch of base stock level at each stage in the supply chain (Chandra and Grabis, 2005). According to the outcome from the above studies and researches done, there are several factors which may lead to the bullwhip effect these are correlation, number of taps used in the moving average prediction of demand and lead time. An observation was made that the bullwhip effect reaches a stationary point when the number of taps increase. The number of taps in the moving average method are used then to predict the demand. Theoretically it has been proved that when increasing the taps in the moving average the bullwhip effect is dampened, however the moving average demand requires a lot of taps and this will slow the reaction to real time demands. Thus, instead of reaping the benefits from increasing the number of taps instead it would increase the costs because of holding and backordering goods.

The puzzling influence still occurs amidst the various values of lead time and correlation coefficient. To dampen the bullwhip effect, the backorder costs and holding costs are taken into consideration, this quite clearly shows that flexibility and massive amount of information is required within the supply chain. This helps in reacting to fluctuating orders within the supply chain, which in turn requires smooth flow of information within the supply chain to dampen the bullwhip effect effectively to optimize the management of the supply chain and the members at all levels require access to the information in a more efficient organized manner.

2.4 Inventory Management

Inventory holding is known that it has a negative impact on the responsiveness in the supply chain. Regarding the matter with the increasing globalization which has a considerable impact over the responsiveness of the supply chain. The increasing in globalization resulted in increasing the supply lead time where using common ways of inventory control eventually leads to greater levels of inventory just to offer the same service levels (Water, 2002)

Lean supply chain thinking is one of the problems in the supply chain, thus it is to be minimized as much as possible (Womack and Jones, 1996). The agile supply chain has inventories passing through in a swift manner which enables the companies to respond as quickly as possible to make use of the changes in the market demand (Christopher and Towill, 2001). Several supply chain classifications that were based on these concepts and most of the stressing and concentration is focused towards reducing the inventories within each of the classifications (Biju Kr. Thapalia et al., 2009). The risks associated with geography for inventory strategies were examined and the effect they had on the supply chain with the aid of a case study that was done by F.T.S Chan and H.K. Chan in 2009.

The approach that was taken for information sharing examined the geographical use to test the efficiency related to the proposed work. Nevertheless, there were some concerns and fear of the true costs of inventory and whether the companies do in fact realize that. As an example, Christopher in 2005 stated that the costs related to things such as storage, things of the past, damage, deterioration, insurance, shrinkage and management costs are traditional cost of capital. Taking an inaccurate assessment over the inventory costs is dangerous for companies, it results in an inaccurate supply chain trade off which would in turn lead to holding too much inventory (Lee and Billington, 1992)

Nowadays it is a given that firms cannot compete effectively without having close interaction with their suppliers and other entities that are within the supply chain. A typical structure of divergent inventory system would be the number of locations which could restock from a central supplier. The uncertainty associated with inventory investments can cause a sudden spike in the inventory investments. Strategies that are commonly used to solve such a predicament include setting up of transshipment links between locations at the same echelon, this would lead to an increase in the flexibility within the supply chain.

Consequently, that would result that the location that are in the same echelon would share the inventory. The monitored movement of the materials between locations at the same echelon does provide a successful process for correcting inconsistencies between the locations viewed demand and their available inventory. Moreover, the transshipments may lead to lower costs and improve the services. This in turn can aid in sustaining the system without any risk of damaging it. An increase in cost efficiency and improved customer service can happen with the aid of lateral transshipments between stocking locations (Mangal& Chandna,2009).

The influence that the transshipments have between the stocking can be seen with the help of two methods. The first method the transshipments should be used after the demand is viewed prior to satisfying the demand. If there is a surplus in the demand at any of the stocking locations some locations will have an excess in the inventory, the lateral transshipments then can be used as a correction mechanism. Furthermore, to get another source of supply to cover the inventory shortages pooling the stocks will aid in that specially that the transshipments are swifter between the stocking locations and their cost is less than the emergency shipments from a central depot backlogging of a surplus in demand. Another way that can be used to analyze the influence that the transshipments have between the stocking locations is to take it as a tool to balance inventory levels of stocking locations during cycles. To keep the customer service level at the same quality in all locations, it is preferred to keep the inventory position at each location in balance relative to one another (Mangal& Chandra,2009).

Human biases could affect the information shared within the supply chain. The examination that was done by Croson and Donohue’s (2006) of the behavioral causes of the bullwhip effect showed that the decision makers underweighting of the supply line not taking into consideration the amount of goods ordered yet to be received were partially responsible for the phenomenon. Therefore, it is not the wrong information shared within the supply chain that ultimately leads to the bullwhip effect; biases in the human decision are part of the reason for the bullwhip effect.

Unfavorable human involvement in making of the operational decisions were seen in other decisions made in MIT Global Scale Network supply chains. As an example, shown by Schweitzer and Cachon (2000) carried through experiments that the human decision makers order semi optimal decision when a onetime purchase decision is being made, such as ordering goods that would fulfill a season’s demand. These altered demands from the optimal quantity are systematic, and may result in potential loss of revenue, specifically more in high margin products (Ho, Lim, & Cui, 2010). Few fundamental human biases, such as having overconfidence were shown to be the main reason of this effect (Ren & Croson, 2013).

Such supply chain issues related to information exchange and human decision-making biases may be cured by using a different information and decision-making ecosystem such as the internet of things. Some of the researches that are being developed on implications of Internet of things for supply chain management propose that the IoT capabilities can aid companies in their quest of improving the efficiency of their supply chain operations and facilitating innovation (Rong, Hu, Lin, Shi, & Guo, 2015). Additionally, Internet of things capabilities can also be used to track goods geographically, providing improved situational awareness, facilitating sensor-driven decision making, automating production processes, optimizing resource use, and allowing real-time sensing of unpredictable conditions (Chui, Löffler, & Roberts, 2010).

2.5 Just in Time

Just in time system needs regular transportation service and specific handling of equipment. Companies that adopt the just in time must be highly flexible and adaptable to account for the tight coordination that is needed in this transportation and distribution network (Harper & Goodner, 1990). The just in time strategy demands a complicated and comprehensive thinking on how to source and the location of the plants and warehouses to be close. Adapting the system to the just in time transportation system would cause or result in several alterations (Chapman, 1992; Gomes & Mentzer, 1991): First by reducing the lead time requirements quicker transportations become a result, second by reducing the size of shipments it would result in occasional dispatches to limit the costs of transportation

The just in time aim to reduce the work load in the work in process inventory by constantly feeding the production line. Costs seem to increase when smaller sized shipments appear which eventually cause an increase in transportation costs, and instead of benefiting from reduced inventory the company suffers from an increase in the transportation costs. The determining factor to whether adopt the system or not is to compare both aspects cost to see if any benefits can be achieved. One of the things that are affected by a systemic just in time approach is the transportation cycle variation. To prevent any disruption in the production having early arrival of the inventory or delayed inventory to the production line may affect the production process negatively. Furthermore, the external factors, such as the weather, congestion and unforeseen mishaps, may result in delaying in the just in time thus resulting in negative consequences on the supply chain.

The just in time manufacturing and inventory management both are growing rapidly. A reduction in the traffic congestion has future potential in having benefits for the supply chain partners by pursuing the just in time system (Rao & Grenoble, 1991b). Moreover, when the orders are smaller and are made at a more frequent pace, lead times are shortened, precision in scheduling is achieved which would impair the clogged streets and highways. The smaller the size and the more frequent the delivery is made the effect on the overall transportation infrastructure is trivial to none (Rao & Grenoble, 1991a, 1991b).

Surprisingly, researches have shown contradicting observations regarding the location from both the buyers and suppliers perspectives. Previous researches have suggested that just in time partners should be in close vicinity to each other to coordinate and communicate faster, other group of researchers disagreed with the proposed argument about the location. It has been indicated that deregulation can make longer distance transportation feasible in the just in time systems, from that perspective the transportation costs can be lower (Anderson & Quin, 1986). The majority of U.S firms do not prioritize the location of the suppliers, on the contrary it is of no importance, only two firms from twenty-two firms believed that the location is quite important and a deciding factor (Ansari, 1986).

Another researcher also discovered that it is not quite necessary to have the supplier closer to the assembly plants. Where, using the just in time does not motivate the suppliers to move closer to their customers (Bartholomew, 1984). Finally, it was pointed out by Harper and Goodner (1990) that the just in time can be utilized in different supply chains challenging the geographical location through having a creative design for their transportation systems. Despite the acceptance of the adoption of the system in the U.S. firm's conventional adoption of it cannot directly benefit the firms (Wood and Murphy,2004). Issues can arise such as on time delivery, fair pricing and quality which were of more importance to the firms (Ansari, 1986). The global end-to end supply chain networks of US firms are geographically spread-out, a significant alteration from the original adoption of the just in time.

Moreover, long distance supply chain systems post challenges for firms to coordinate efficiently which oppose the just in time approach for high frequency of shipping. Thus, partners in the just in time need to overcome the challenges faced such as the transportation costs and long-distance transportation. The transportation costs increase with recurrent long-distance transportation; therefore, an efficient transportation process is required to lower the costs. The long-distance transportation may cause an increase in the lead time and this would result in high lead-time variations which would consequently elevate the inventory costs. Therefore, Persistent long-haul modes must be used to maintain service levels. Lastly, participants adopting the just in time must be prepared for emergencies happening due to unavailability of materials with long-distance supply and distribution line. These disadvantages sustain substantially higher logistics costs in the forms of premium delivery or higher level of safety stock.

2.6 Internet of things

Internet of Things can be defined as a network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment (World Economic Forum, 2015). It is regarded as a key factor towards technological development that will aid in the emergence of the Fourth Industrial Revolution, and is included to be among the nine component technologies in the Industry platform (Rose, Lukic, Milon, & Cappuzzo, 2016). Regardless of its argued revolutionary capability, the indications regarding the internet of things yet remains unclear to many firms (The MPI Group, 2016).

The World Economic Forum (2015) associate this state of vagueness with the state of understanding of the potential applications of the Internet in 1990s; it is expected that the internet of things will radically change the world just as the Internet did. The juxta position of internet of thing’s revolutionary potential and the insufficiency of understanding in its implications is troubling for the firms who are searching for a way to use the technology’s capabilities to find competitive advantages. Since the technology is still new, few cases of success or failures of firms using internet of things have been documented. Hence, it is still unclear whether a firm will need to make strides to improve the performance of its supply chain using the IoT capabilities.

The various definitions of the internet of things have one thing in common: they all project the IoT as a changing point when it comes to the information and communications technology. It is crucial to take into consideration this aspect when viewing the implications of internet of things for supply chains. The imperative role of information in the management of supply chains has been studied in the scholarly and practitioner-focused literature. Lack of information sharing is one of the primary causes of the occurrence of the “Bullwhip effect,” a term which used to describe the phenomenon in which a manufacturer of a product experiences high inconsistency in the orders for that product when compared to the retailer selling it, even when the market demand for the product had no variation (Sterman,1989).

Lee, et al. (1997) states that this effect is due to the distortion of information regarding the market demand as the information travels from the retailer to the manufacturer through the parties involved in the supply chain. As a result, the negative effect of inconsistency on the efficient functioning of a supply chain, the bullwhip effect and the potential solution that could eliminate it have been thoroughly studied. Some of today’s widely-used industry practices, such as sharing point of sales data with the manufacturer, vendor managed inventory (VMI), etc. are intended to lessen the destructive consequences of the bullwhip effect. Different types of information travel across and influence the functioning of supply chains. Lee and Whang (2000) describe five types of information shared in a supply chain: inventory levels, sales, demand forecasts, order status, and production schedule.

The information transfer takes place through different modes such as direct information transfer (e.g., through electronic data interchange), transfer through a third party, or through an information hub. The information shared influences behaviors of the parties using it. Thus, any change in the information can result in unintended disturbances in the supply chain. Lee, et al. (1997) propose the following four potential causes of information distortion that create the bullwhip effect:

- Demand signal processing*:* in which the retailer's orders to the wholesaler who would then order from a distributor or the manufacturer are located on the updated demand forecast, instead of the actual demand.
- Rationing game: in which the retailer orders more than what is needed if there is an anticipation that the wholesaler would distribute less than what was ordered.
- Order batching: in which the retailer orders periodically from the wholesaler and, as a result, the finite demand information is piled into one order.
- Price variation*:* in which retailer orders different order quantities in response to the actual and anticipated changes in price.

The net result of each of these four is that the orders placed by the retailer to the wholesaler exhibit a pattern different from that of the market demand. Human biases also influence the information shared in the supply chain. Croson and Donohue's (2006) examination of the behavioral causes of bullwhip effect showed that the decision makers' underweighting of the supply line, without taking into consideration the amount of goods ordered and yet to be received was partly responsible for the phenomenon. Moreover, their study showed that the tendency to underweight the supply line persisted even when information on inventory levels was shared with the decision makers.

Therefore, it is not just the distortion of information shared in the supply chain that could lead to the bullwhip effect; natural biases present in human decision making are also partly responsible. Negative effects of human involvement in making of operational decisions are also viewed when other decisions are made. A study of the internet of things in logistics (Macaulay, Buckalew, & Chung, 2015), jointly published by the leaders in the domains of IoT (CISCO) and logistics (DHL), explains that internet of things can improve organizations capabilities for measuring, controlling, automatizing, optimizing, learning, and monitoring various activities in the supply chain.

These examples include improvement of operational efficiency in fleet and traffic management, resource and energy monitoring, and connected production floor, improvement of safety and security, equipment and employee monitoring, health monitoring, physical security, improve the customer experience (connected retail, context-aware offers to customers), and create new business models (firms become service providers, usage-based insurance).

2.6.1 RFID and WSN

The wireless sensor networks and the radio frequency identification (RFID) have been highlighted as important features for the usage of the internet of things. Radio frequency identification is best described as a technology which enables the identification of objects through radio waves or wireless communication. This technology can aid in obtaining remarkable improvements as it helps in increasing the efficiency, the efficiency increase can be noticed in warehouse management and in the operations.

Wireless sensor technology is linked to sensors and the capability to collect, monitor and analyze the data from different environmental conditions (Gubbi et al, 2012).

Moreover, it has been illustrated that using this technology enables the user to have real world visibility (Haller et al, 2008). This explains how the user have the potential to track and monitor the products while tracking the performance in real time as well. Aside from data collection the sensors enable the management to have control over previous matters that were uncontrollable through finer granularity. Moreover, the technology aids in improving the accuracy and time management of information that is required by the business to gain competitive advantages regarding process optimization (Haller et al., 2008). Few companies such as Walmart, Procter and Gamble and the US department of defense have utilized the RFID systems in their supply chains. Nevertheless, the capabilities of the RFID go beyond this. Nowadays, RFID has been adopted in various supply chains for tracking, retail stock management, library books tracking, parking access control, marathon races, airline luggage tracking, electronic security keys, toll collection, theft prevention, and healthcare.

Taking into consideration the current tendencies and forecasts regarding this technology, the market is expected to grow faster within the next decade. In 2016 the RFID tags that were sold were approximately 1.02 billion. The total revenue is expected to grow from 500 million to billions in the next decade (Haller et al., 2008). For the RFID system to operate two components are necessarily needed which are the tags and the readers. Each tag has a number to identify it, that is the identification number and it also has a memory that stores data such as the name of the manufacturer, type of the product and some factors that may be of value such as the temperature. To read the data stored on the tags a reader is required which works using wireless transmissions. There are two types of communications between tags and readers.

Communication can either be done through inductive coupling, this method of communication requires antenna structures making an essential feature in both the tags and the readers. The other type is propagation coupling, this works by propagating electromagnetic waves. In an occasional RFID application, tags are attached or embedded in objects that need to be recognized or tracked. When the tags are read a consulting background database is provided. The database enables alignment between IDs and objects, the reader is then able to monitor the existence of the objects.

A sensor network requires a great number of sensor nodes that can be placed in different areas whether it is in vehicles, ground or in the air. Sensor network are adopted in environmental monitoring, surveillance, security and a lot of other applications. Since sensors require a lot of energy for long range communication to reach data sources, multi-hop wireless connectivity is needed to forward the data to remote locations. Wireless sensor networks (WSN) vary from RFID networks where they are usually used to monitor objects in areas of interest or to sense environmental aspects. Nevertheless, RFID systems are usually used to spot the presence and the location of the object from their tags. In usual applications, the relay nodes are released to forward data from the sensor nodes to remote sinks in WSNs. This in turn forms several hop networks where RFID is only single hop and is made of batches of tags and readers. Sensor nodes in terms of intelligence are superior to RFID tags where the sensor nodes firmware can be easily reprogrammed unlike RFID tags where it is not the case (Merino and Mariño, 2012).

RFID readers can be parameterized, however they seldom become user programmed. Therefore, RFID networks and WSNs can be used as two technologies which complement each other, by merging both technologies some advantages can be achieved. The advantages that can be gained from the merger of both technologies are adding ad-hoc capabilities to RFID network, adding sensing capabilities to RFID tags and enabling tracking features for RFID tagged objects that are difficult to tag or detect. The main application of RFID networks is the ability to detect the presence of tagged objects or people. Other important application that can be obtained from RFID systems is the ability to provide the location of the objects. There are different approaches to obtain the location either by detecting the position of the object with a mobile reader, the mobile reader is used to detect the objects at fixed known locations or detecting the position of objects based on the position of fixed readers locations. When using long ranged RFID systems an approximation of the RFID tags can be made by further improvement through using triangulation or signal processing techniques.

Furthermore, the WSN nodes can be used independently or can be attached to objects or people. Customer needs, and requirements are the two main factors responsible for the progress in the international transport. Nowadays logistics require careful planning that is based on the demand. Therefore, the management disciplines are trying to find new ways to enhance the transportation of the available resources. Such optimization can be achieved through ordering of supplies time, cost and information. Production needs to condition the next supplies the place of consumption, and the sequence or order of delivery. Information systems play an essential role in satisfying such requirements and this has been provided through the electronic data interchange (EDI).

Nevertheless, even with the EDI systems that are normalizing the messages content that is required for synchronization between systems, difficulties are still encountered when consolidating information between the suppliers and customers using different software. The intermodal traffic stores information and determine destination to the factories that are tire one in the automotive industry. The system is managed in a way so that the local optima are obtained in each of the processes that are involved in each transport nodes (Moyano, 2009).

The applications achieved by the RFID provide numerous solutions to specific scenarios and in specific industrial sectors, especially the industries that use international standards such as the automotive industry. All the information required can be possibly captured by WSN sensors and made available for SCM. There are five major areas where RFID can increase the efficiency those areas are port cargo terminal: Access controls, Container security, Container identification and Location, Activity Tracking and Regulatory Compliance (Mullen, 2007).

2.6.2 Architecture of IOT systems

The layers that are commonly used by companies are the device layer, connectivity layer and internet of things cloud layer. The internet of things technology stack is pictured in figure 6. The internet of things systems depends on diverse multilayer stacks of technologies Wortman and Flüchter (2015). The layers consist of hardware and software components. Furthermore, companies possess different architecture for the internet of things based on the industry products and the application that it would be used for.The device layer possesses the hardware and software, it may be the RFID tags or the sensors, it would also include the software that is used to manage the components and objects in general. Second layer is the connectivity layer which carries the protocols of the communication process between the item and the cloud. For example, this can be achieved by using the message queue telemetry transport.

The final layer includes the internet of things cloud. The cloud device is mainly used for communication and managing the connected objects, this can be done as the application platform supports the internet of thing application and opens room for development (Wortmann & Flüchter, 2015). Nevertheless, the analytical tools used are essential to overview the collected data and analyze it thoroughly. Finally, the internet of things stacks of technology includes security measurements and identification procedures. This is integrated into the businesses system to protect participants privacy and information secrecy (Wortmann & Flüchter, 2015).

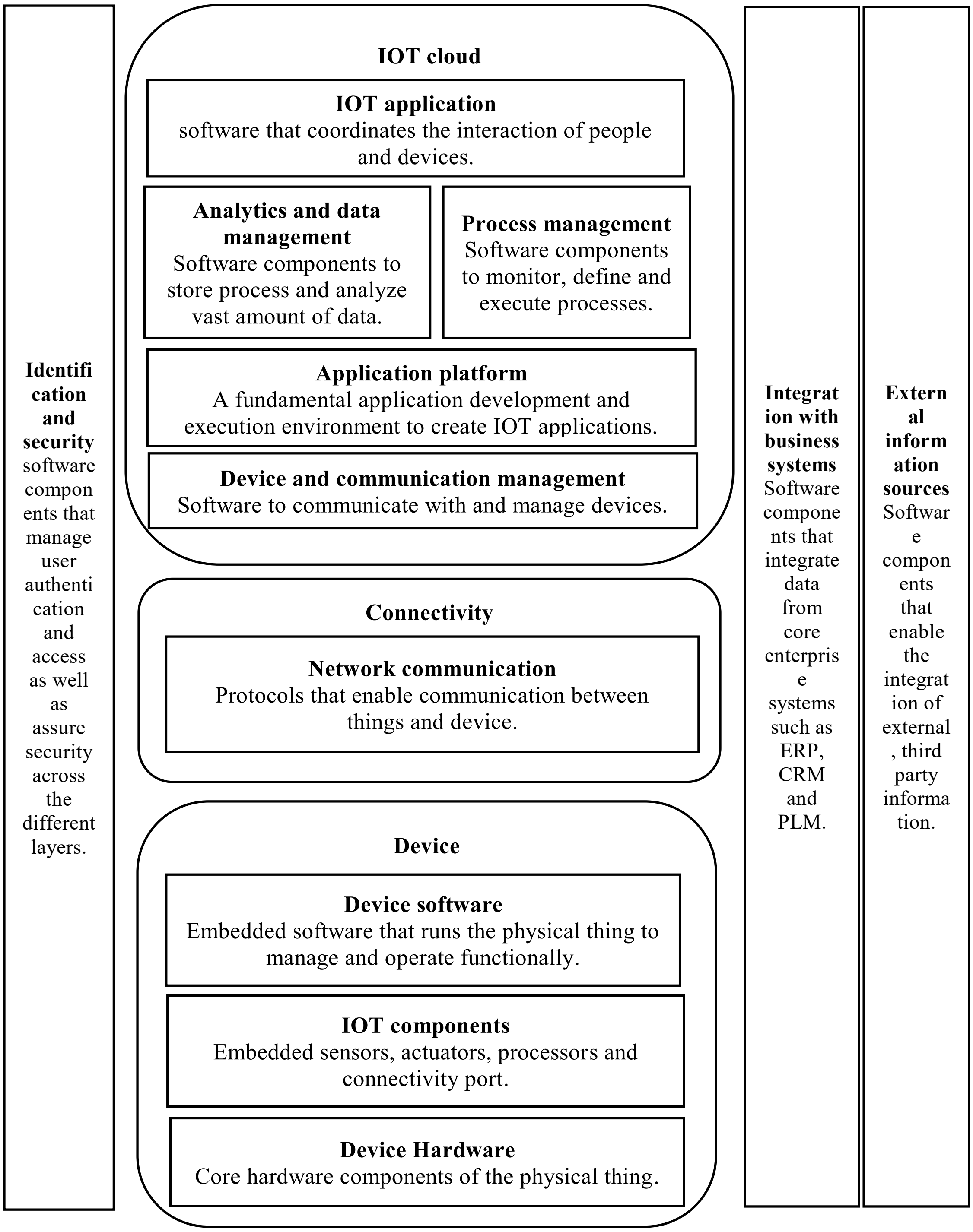


Figure 6. IoT technology stack (Wortmann & Flüchter, 2015, p. 223).

2.6.3 Internet of things applications

The application and utilization of IoT are numerous, and divided across areas of use and industries. Figures 7 and 8 below summarizes some of the applications of the internet of things

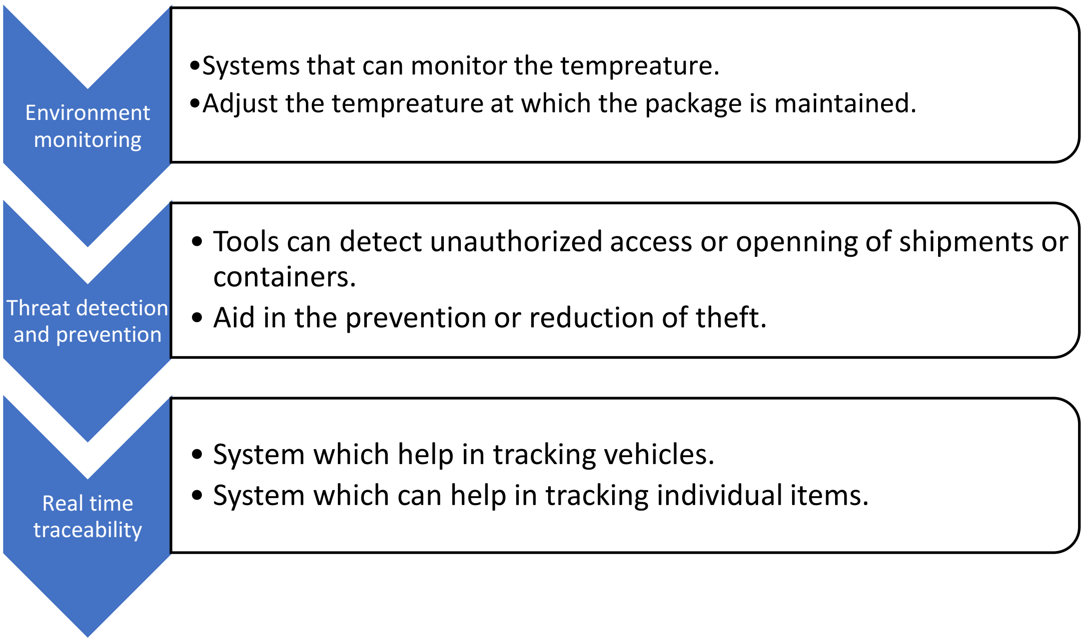
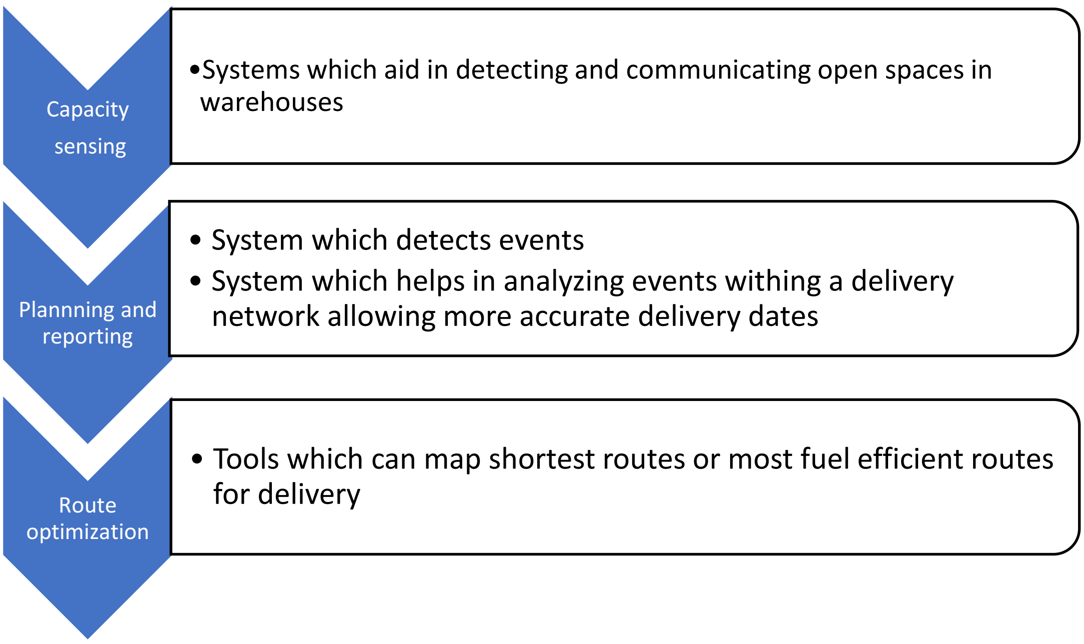


Figure 7. Common applications of IoT for logistics demand (Lacey et al., 2015, p.6).

There is a demand side to the IOT applications and it involves the transportation of goods. The value is then viewed by measuring several variables such as time, traceability, security and the condition of the cargo (Lacey et al., 2015, p. 5). Moreover, IOT can aid in providing high quality through RFID and WSN technology where both of those technologies provide high quality of traceability throughout the supply chain. However, the supply side also includes warehouses, where the goods are stored and forwarded; a transport network and the vehicles that are used to transport the goods from the suppliers to the warehouses and at the end to the customers (Lacey et al., 2015, p. 5). IOT can on the supply side contribute by reducing costs, increase efficiency, reliability and optimizing the transportation routes.



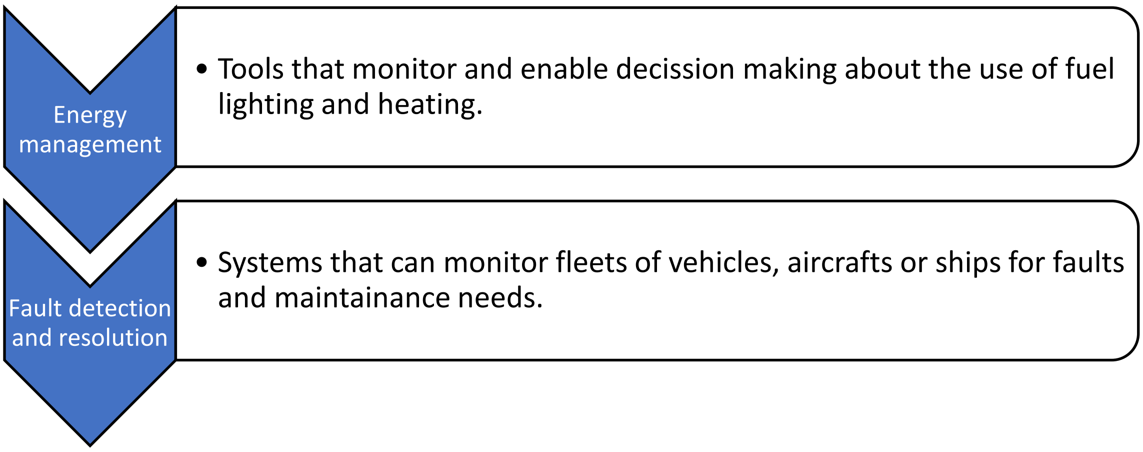


Figure 8. Common applications of IoT for logistics demand (Lacey et al., 2015, p.6).

2.7 Physical Internet

The physical internet is a new method that will ultimately change the field of materials handling, logistics and facilities design. The motivation behind the physical internet happened because of a claim that the way raw materials or materials in general are transported, handled, stored, realized, supplied and used throughout the supply chain worldwide is not sustainable economic wise neither environmentally nor socially. To prove that this claim is correct, Montreuil shows thirteen unsustainability symptoms (2012). These symptoms appear for example in vehicles and facilities that are usually underutilized. Furthermore, trucks became widely used as they became popular for being fast and reliable in multimodal transport.

Nowadays companies have increased the need for transportation as more businesses now have become global, this in turn has led to growth in freight flows. It is expected that by the year 2025 there will be an exponential growth in the freight transport in France, the increase is expected to reach up to 37% which is an enormous growth rate (Dåvøy&Ødegaard, 2016). It is already noticeable that in developed countries the use of freight transport is already playing a vital role in transportation, measuring up to 15%. The freight transport is responsible for greenhouse gas emission such as CO_2 and it is yet increasing although there are targets placed for substantial reduction. Challenging the current issues, the Physical Internet aims to help in global sustainability of physical objects transportation, storage, handling and usage.

Furthermore, to use the physical internet intelligent containers are needed with new logistics protocols and business models, the result is a synergetic and a controlled distribution system. In that sense, goods are placed into containers that have certain dimensions and are being handled as data in the digital world, which is then redirected with the aid of the physical internet identifier towards the aimed destination using efficient storage system means (Dåvøy&Ødegaard, 2016). Constantly improving the standards of the containers and the protocols, the physical internet target is to alter the concept of fragmented hard to optimize organization to an open distribution organization. The change in the paradigm introduced by the physical internet implies that the logistics currently are based on closed operational networks with heterogeneous means. This means that the system needs to be redesigned like the digital internet where networks would be connected through a common operating framework facilitating the breakdown of transport and handling loads.

The physical internet is increasingly allowing the integration that is currently dedicated to the logistics networks into a universally connected system. For the logistics service provider, shipments handling of standard containers which do not follow the same route allows locally focused, highly utilized resources. The usage of the physical internet will ultimately lead to reorganization of the transportation and logistics networks and resources (Dåvøy&Ødegaard, 2016). It will also have a substantial impact on how the goods are valued by people around the world, how it will be designed, produced and distributed to cities and households.

The physical internet can be viewed as an approach which has the capability of bringing researchers from various disciplines together under the supply chain management. For physical internet research to have positive outcomes, it is important to create a shared understanding of the physical internet domain by making a theoretical foundation, which will lead to specific theories. A crucial perquisite for such theory building initiative is to summarize and classify the existing literature to find expanding formations, questions, statements, propositions, hypotheses, constructs, paradigms and concepts and frameworks which constitute the products of theorizing (Hassan 2014).

To date, the physical internet literature is largely disjointed for three main reasons. First, the physical internet is a concept that is yet to mature enough to reach a major influence in top supply chain management journals. Second, a great number of papers has been published in outlets that are of more value to the industry rather than academically, including white papers, project deliverables and reports. Therefore, it is normal that most of papers lack theory; those that have theory (Pan et al. 2014; Cimon 2014; Xu et al. 2013) usually borrow it from unrelated areas with only minor modifications. Third, most of the publications on physical internet are theoretical and involve quantitative modeling and simulations. Theory-building and literature review are rare, which further contributes to the lack of balanced research approach to studying the PI. However, the large number of conference papers and the steadily growing number of papers being published in high quality journals are indeed strong indicators that the relevance of the PI is rapidly growing.

The physical internet as a term was first used in a 2006 headline of the British journal ‘The Economist’ containing a survey of logistics and a variety of mainstream supply chain articles (Markillie 2006). It inspired a team of researchers to investigate whether it is possible to organize the flow of physical goods like the data flow in the digital

Internet (Montreuil 2011). This metaphor sparked interest within not only the academic community but also quickly also gained significant attention from the industry.

Defining the physical internet Montreuil (2011) described 13 issues. (i.e., (1) low space utilization for road, rail, sea and air transport; (2) inefficiency for container returns; (3) shortage of truck drivers; (4) long working hours for truck drivers; (5) poor efficiency in distribution of products; (6) insignificant use of production and storage facilities; (7) mediocre coordination within distribution networks; (8) high inefficiencies in multi-modal transportation; (9) dysfunctional city logistics; (10) inefficient cross-docking operations; (11) low network security and robustness; (12) difficulty to justify use of IT in supply chains; and (13) limited innovation opportunities) that make current logistics practices unsustainable.

Furthermore, he also outlined 13 principles (i.e., (1) instrumentality; (2) responsibility; (3) met systematization; (4) openness; (5) universality; (6) interconnectivity; (7) uniformity; (8) accessibility; (9) uniqueness; (10) encapsulation; (11) identification; (12) contracting; and (13) certification) of the PI vision that he sees to tackle the 'global logistics sustainability grand challenge'. Accordingly, the physical internet has been defined as 'an open global logistics system founded on physical, digital and operational interconnectivity through encapsulation, interfaces and protocols. It is a perpetually evolving system driven by technological, infrastructural and business innovation' (Montreuil et al. 2013). It has also been defined as 'a global logistics system based on the interconnection of logistics networks by a standardized set of collaboration protocols, modular containers and smart interfaces for increased efficiency and sustainability' (Ballot et al. 2014).

Accordingly, the purpose of the PI movement is to transform 'the way physical objects are handled, moved, stored, realized, supplied and used, aiming towards global logistics efficiency and sustainability' (Montreuil 2012). Concisely, the physical internet aims to organize the transport of goods like the way data packages flow in the digital Internet. Through sharing of resources such as vehicles and data as well as designing transit centers, which enable seamless interoperability, the transport of goods will be optimized about costs, speed, efficiency and sustainability. To achieve this, a set of common and universally agreed-upon standards and protocols are needed to facilitate horizontal and vertical cooperation between companies. It is crucial to distinguish the physical internet clearly from its related concepts.

The physical internet is an application of the internet of things (Gubbi et al. 2013), which describes a network of physical objects embedded with technology to collect and exchange data, in the domain of SCM. Similarly, it drives the creation of innovative delivery channels for services, be it in data exchange or logistics, which is commonly subsumed under the term Internet of Services (Schroth, Janner 2007).

Additionally, the physical internet is an application of Cloud Computing (Armbrust et al. 2010) in the context of supply chain management, it is about using a network of remote servers hosted on the Internet to store, manage and process data, rather than a local server or a personal computer. The key way the physical internet achieves its goals is by applying metaphors and concepts of the digital Internet to real-world shipping processes, with physical containers being treated like Internet packets of information (Montreuil 2012).

Following this metaphor, the physical internet does not physically manipulate goods directly; the idea instead is to manipulate and manage shipping containers that encapsulate goods, just like digital Internet packets encapsulate embedded data (Montreuil 2011). To reach a full-fledged physical internet many factors need to be considered simultaneously, including physical objects such as containers or transit centers as well as more abstract concepts such as legislation and business models.

2.7.1 Efficiency of physical internet

The Physical Internet (PI) is a novel concept aiming at optimizing logistical processes to create more efficient and effective supply chains. The PI is defined as ‘a global logistics system based on the interconnection of logistics networks by a standardized set of collaboration protocols, modular containers and smart interfaces for increased efficiency and sustainability’ (Ballot et al. 2014) p.23. It is a holistic SCM concept that merges many relevant areas of current SCM research, including sustainability, effectiveness and efficiency of global value chains, information flows, as well as horizontal and vertical collaboration, which is likely to revolutionize the field.

The European Technology Platform ALICE (Alliance for Logistics Innovation through Collaboration in Europe) has decided to declare the PI as the ultimate logistics goal for the year 2015 (ALICE 2015). Frequently this leads to the misconception that this is a binary state in which the PI either exists or not. Previous research projects and simulations, which focused on a small number of actors in dedicated industries, have shown that considerable gains can be achieved through the application of the PI. Sarraj et al. (2014) used data representing flow of goods from the fast-moving consumer goods (FMCG) industry in France to test various transportation protocols and scenarios. They conclude that the ‘PI is very efficient within the FMCG supply networks of two large retailers and report positive effects on greenhouse gas emissions, cost, lead time and travel delivery time. Similarly, Ballot et al. (2014) report the findings from an exploration project in Canada in which simulations revealed various positive effects of the PI, such as increases in the fill rates, energy savings, decrease in transportation costs and reductions in the total costs of logistics.

A multitude of additional ideas exist on how to successfully apply the PI (or principles thereof) ranging from topics as diverse as humanitarian logistics (Abdoulkadre et al. 2014) to enabling smoothly operating systems of libraries (Roodbergen et al. 2014). Rougès and Montreuil (2014) applied the PI concept (i.e., mobility web) to solving the limitations of crowdsourced delivery (i.e., point-to-point deliveries and processing of parcels by individuals). Zhong et al. (2015) provided a demonstrative system that contemplates the PI application in improving the manufacturing shop floor logistics. Hakimi et al. (2012) ran a simulation to study and quantify the impact in terms of economic, environmental and social efficiency and performance of evolving from the current system of freight transportation toward 4 an open logistics web in France. Finally, pan et al. (2015) ran a simulation for an interconnected city logistics scenario in which taxi fleets collect e-commerce reverse flows in Chin

2.7.2 Interfaces

To achieve a universal interconnectivity, the interfaces are of utmost importance. The physical internet has different types of interfaces:

- π-fixtures
- π-devices
- π-nodes
- π-platforms

To possess an even flow of physical object throughout the physical internet, it is crucial to take into consideration the modularity and fixture of the π-containers. Since the π-containers are modular, the containers possess some features which allows one to connect them with one another. The thing is about π-containers, π-carriers, π-conveyors is that they have these standard features that makes transportation and logistics processes easier to carry out. Furthermore, π-devices refers to IoT and the communication and information of π-containers. This can be achieved by using the traceability systems and smart tags such as RFID, GPS and WSN. The π-devices aid in ensuring the identification, integrity monitoring, traceability π-containers and security of each π-container. It also makes sure that the handling, storage and routing is being automated (Montreuil et al., 2012, p. 5).

Moreover, the π-nodes are decisive factors when it comes to the operation of the physical internet. For instance, to have an organized entry of π-containers into the physical internet and to organize their exit can only be achieved with the aid of the π-gateways (Montreuil et al., 2012, p. 5). Finally, it is also the π-plat forms responsible for information and communication exchange. Digital middleware platforms are pivotal interfaces in enabling the open market for logistics services in the Physical Internet as well as the smooth systemic operation of the interacting π- constituents and routing of π-containers from source to destination through the Physical Internet” (Montreuil et al., 2012, p. 5). Figure 9 below shows the elements of the PI.

π-container	π- nodes	π- movers
Illustrative	π-site	**π-Vehicle**
Modular	π-facilites	π-boat
Dimensions	π-system	π-locomotive
	π-transit	π-plane
0.12 m	π-switch	π-robot
0.24 m	π-sorter	π-truck
0.48 m	π-bridge	
0.6 m	π-composer	**π-carrier**
1.2 m	π-gateaway	π-trailer
2.4 m	π-hub	π-tug
3.6 m	π-distributor	π-wagon
4.8 m	π-frequency	
6 m		**π-handler**
12 m		

Figure 9: Elements of the Physical Internet (Lounès & Montreuil, 2011).

2.7.3 Innovation

Innovation is a determining key factor to develop and improve the physical internet in the future. The practices used currently in the supply chain industry are not feasible as argued by Montreuil (2011). Moreover, to improve the physical internet, the stakeholders must continuously pursue improvement in the logistics solutions and business models. Although improved technology is pursued and encouraged by the stakeholders, there is already technology that if properly utilized can improve the physical internet vision. The technologies meant are the RFID, WSN and GPS.

These kinds of technologies allow the use of smart tags on π- containers, and aids in tracing and monitoring the physical items that are being transported. The technologies empower the users to do that even during the transportation process. Moreover, Montreuil et al. (2012) illustrated that there are researches currently being conducted to discover new solutions and develop new technologies that can rival the RFID, WSN, and GPS.

Moreover, various businesses are expected to use the physical internet simultaneously, businesses such as retailers, manufacturers and distributers. The businesses are to operate as service providers or solution providers. The aim of the businesses is to develop a business model which would help them ultimately in their endeavor to operate the physical internet efficiently. Moreover, this will aid the businesses in delivering better services to their customers and offer more services than before (Montreuil et al., 2012). Thus, it is of utmost importance the companies and government worldwide cooperate, to develop and encourage the innovation and technology to incorporate the physical internet as a standard in the supply chains for companies on a global scale.

The physical internet is currently a paradigm within logistics. The inspiration behind the vision of packets of information is distributed in the digital internet. However, the mindset need to be translated into the real world. The physical internet is a challenge, and the aim is to come up with new solutions that are sustainable environmentally, socially and economically. Furthermore, the physical internet is defined by its modular π-containers. The container eases the application to achieve various methods of transportation. Finally, the physical internet is based on having open supply chains, which encourages flexibility in the supply chain, offering different solution through large transportation networks.

3. METHODOLOGY

This chapter describes the research questions, the focus of the thesis and how the research was conducted. At the beginning of the chapter there is a presentation of the research questions. Following the research questions an explanation is presented about the research design, followed by an explanation of the papers used for studying the influence of the internet of things, then the use of Internet of things is then briefly discussed. Finally, at the end of the chapter a theoretical framework is provided explaining how the physical internet will influence the supply chain practices in the future.

3.1 Research Questions

Supply chain utilizing the internet of things efficiently is chosen as the focus of the thesis. Four questions are formulated based on recently studied topics in the literature. The first topic is related to the impact of internet of things in improving supply chain management. It is of no doubt that the internet has developed in numerous industries and is developing in an incremental way, thus it has caused a radical disruption of structures and processes currently in use. As an illustration of such change in industries is the musical industry where the record labels changed the business from record producers to service providers. Another example would be the automotive industry, the original equipment manufacturers have exploited the internet in their upstream supply chain processes.

Recently studies have explored the effect of the IoT in certain industries. A thesis that was done by researchers at the Malaysian institute for Supply Chain Innovation studied the effect of the internet of things on the chemical industry (Phadnis, 2015; Ravi & Wu, 2015). The researchers showed the current flows of goods and information at a construction chemical business, they documented what the Internet of things capabilities are and then came out with different ways in which the internet of thing capabilities could be used to improve the supply chain throughout different activities such as process control and production planning. The researchers pointed out several potential benefits from the application of the internet of things such as lower variability in shipped quantities, higher revenue with the same or lower finished goods and lower work in progress.

Moreover, another study was made to explore the impact and the applications of the internet of things in high tech industries (Biswas, Ramamurthy, Edward, & Dixit, 2015). The study explains how the internet of things can improve the operations for four types of firms in high tech industry. These firms are semiconductor firms, contract manufacturers, distributors, and original equipment manufacturers (OEMs). The possible improvements in the supply chain operations resulting from the application of internet of things are an increase in the yield of semiconductor fabrication facilities, improvement of asset utilization, predictive maintenance, improvement of the quality of products through effective collaboration between the OEM and the supplier and many other advantages. The case studies that are emerging recently and thesis topics about the internet of things led to the first question in the thesis if the internet of things benefits are outstanding and would cause a clear advantage over competitors then why is it not being widely adopted by all the firms. **What are the barriers preventing use of internet of things?**

The second topic highlights the **feasibility of the internet of things and whether the internet of things is easy to use or not**. The internet of things is not only used for devices. Establishing a connection between things and the social media and integration of social media data such as calendar functions, blogs and Facebook with internet of things functions (Albrecht, 2013) permits the integration of information from various platforms (Atzori et al., 2010).

The internet of things opens prospect for new services (Miorandi et al., 2012) and opportunities to extend the supply chain by using the data to create more visibility of the consumers lives, planned and actual use of resources in combination, with and for people. Having things nowadays equipped with sensors and provided with IP addresses, more data is provided at hand which open room for more analysis; the interactions between things and their use in context can be understood (Nikander et al., 2013). This has led to the third question **What are the benefits of the internet of things?**

However, due to the rapid development of the internet of things challenges showed up concerning privacy, data analysis, GIS based visualization and cloud computing apart from the standard WSN challenges including architecture, energy efficiency, security, protocols, and Quality of Service. The literature and researches done shows that there is more room for development of the Internet of things which would further change the supply chain as currently known. They need to be able operate in both wired and wireless network environments and deal with constraints such as access devices or data sources with limited power and unreliable connectivity. This has led to the fourth question **what are the possible improvements in the future when using internet of things?** Below is figure 10 which explains the research aim and questions

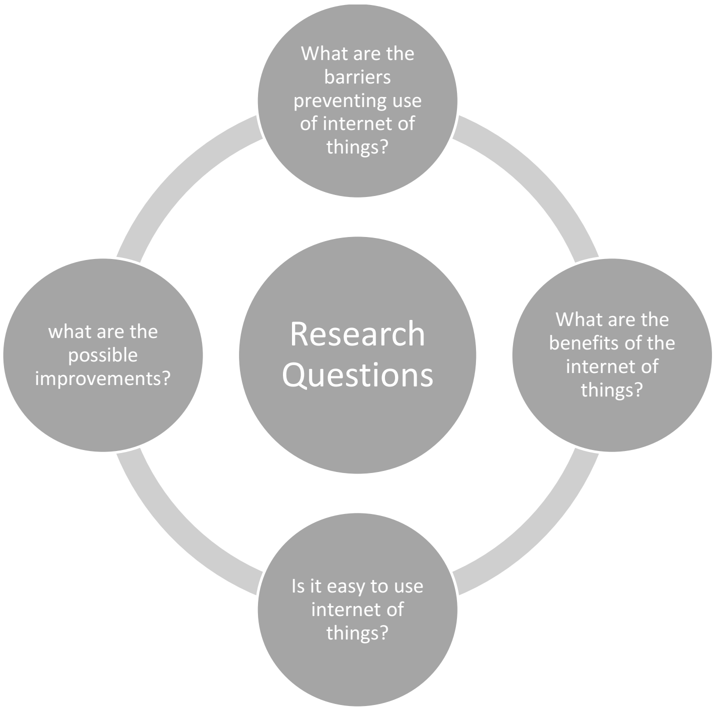


Figure 10. Research aim.

3.2 Research Design

The research onion was constructed by Sanders et al. (2007) to explain the stages that a researcher must go through to design a methodology for his research. In the first step definition is required, this is where the starting point lies, after establishing the starting point a research approach is adopted in the second step. Third step involves the strategy adopted in the research. In the fourth stage lies the time horizon and finally the fifth stage is where the method of data collection is determined.

In figure 11, the research process is explained, in the first level constructionism is the social phenomena where one cannot assume that the interpretation is the same for all people (Ã–stlundet al., 2011). Following is the second level where an approach is followed using deductive analysis based on a hypothesis developed or hypothesis which is based on existing theory (Silverman, 2013). Case study is where an object of interest is examined where based on the key features generalizations are drawn (Bryman, 2012). The Time Horizon is the time framework within which the project is intended for completion (Saunders et al., 2007). Secondary data is where the data is gathered from, the data has already been processed and used by another (Newman, 1998).

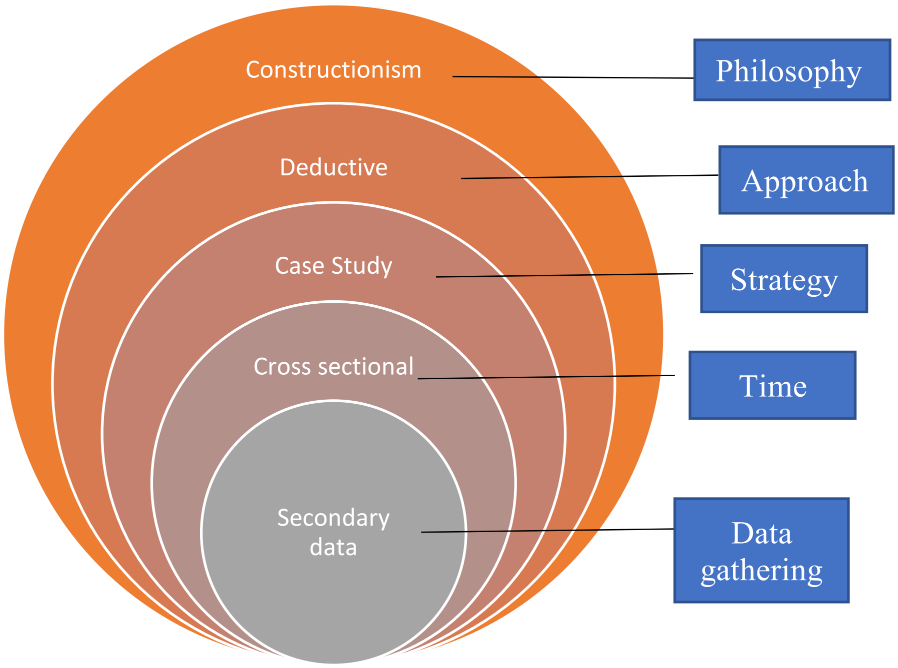


Figure 11. Research design.

Figure 12 below explains the process carried throughout the thesis to get the final conclusions to the questions in the thesis. The theoretical background is essential to gather the needed literature needed to build the framework. The cases take into consideration different aspects such as the infrastructure, practices followed and flexibility in transportation in the supply chain management. The cases were found after searching journals, theses and articles looking for specific information. The cases were carefully selected after it was clear they addressed the questions in the thesis. The main key words used were what is the impact of the internet of things, benefits of using the internet of things, infrastructure of the internet of things in the industry, obstacles to apply the internet of things in the industry and impact on communication after using the internet of things.

After building the framework the research process resumes to find the appropriate cases. Throughout the research process three case studies were found related to fresh fruits and vegetables, fish and a mobility scenario ran by in France. The cases were found using jurn.org search engine. The cases found were related to the benefits of the internet of things, applications of the internet of things, infrastructure of the internet of things, barriers of the internet of things and possible improvements to the internet of things. The results for the above topics were the three case studies presented in the thesis. Although all cases were shown in the results, when searching barriers and infrastructure of the internet of things only the second case study presenting the FI space showed up.

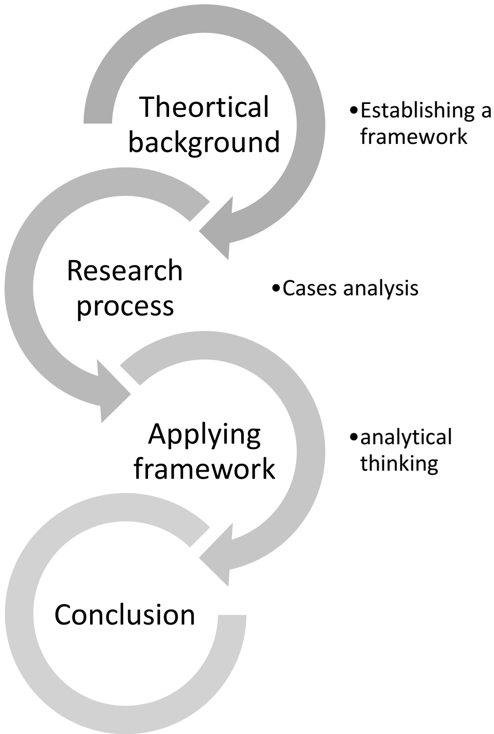


Figure 12. Thesis analysis.

Unsatisfied with finding only one case study related to infrastructure and barriers to the internet of things other search engines were used like google scholar and tut library, however no other case studies were found. After finding the case studies the framework is applied on each case individually to view the benefits and shortcomings of the internet of things. After thorough examination of the cases, analytical thinking process is done to determine the findings combined from the literature and the cases found. This enables establishing conclusive findings in the internet of things. Finally, after gathering the findings future improvement in the research and limitations are discussed.

3.3 Proposed Framework

With the introduction of the physical internet firms are forced to innovate where π-Enabler firms give the necessary physical and material infrastructure. This new infrastructure will provide larger set of services. The new standardization for the Physical Internet will make it more efficient changing the current providers. Car manufacturers for example will use standardized containers for both inbound supply purposes and outbound distribution purposes, this will lead to a change in the business model, which is highly dependent on trucking (Montreuil et al,2012). This could lead to using or coming up with radically different logical solutions or trying to make new products with different market services that goes beyond car manufacturing. By the same token, infrastructure providers will be affected strongly by this new infrastructure. Figure 13 below explains the framework presented in this thesis.

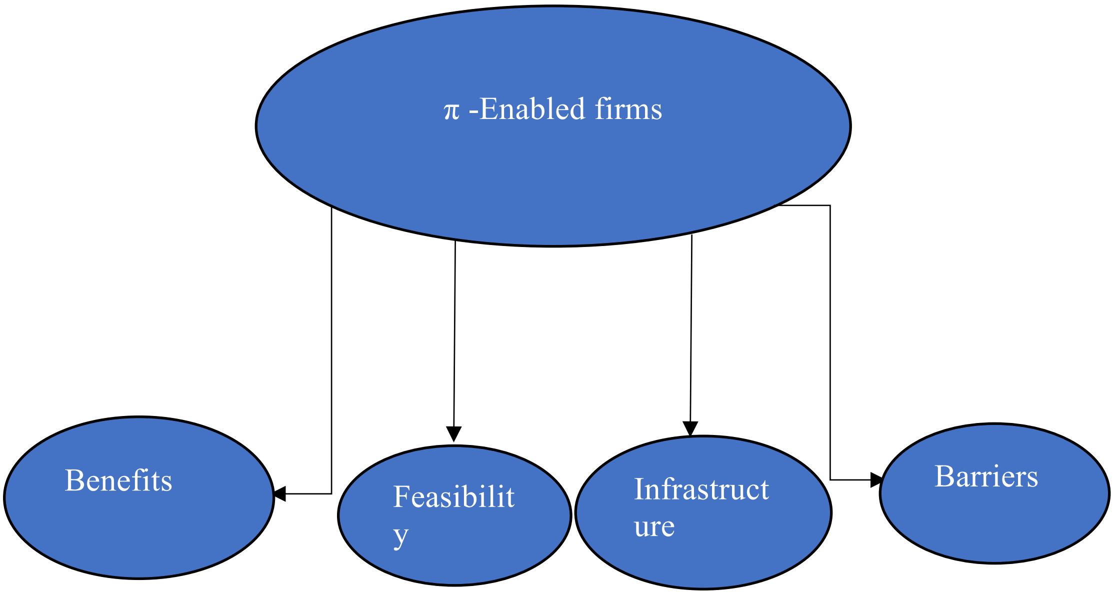


Figure 13. Business model innovation strategies for π-Enabled firms.

The nodes that will become flexible include transit centers, hubs, distribution centers and warehouses, these nodes will become detailed flexible network that will change how cargo, storage and routing is done. Operations in the last mile will become better customized for rural and urban deliveries which will prove to be less dependent on traffic patterns and population density. This could be done through the mixture of public and private means whether they are proprietary or not. Furthermore, the custom agents, insurers and information system developers will be affected where new services are to become more profitable despite the change in intermediation relationships that will provide for real time optimization.

Business models in the realization category can change in one aspect by having an ongoing drive towards increased efficiency and achieving excellence in operation. Having business models scope focused on renewal will make firms go beyond the constraints forced on them through the value chains. The manufacturing process will have reduced costs of supply, storage, and shipping to minimize the time spent in delivery and to improve the reactivity. Retailers will have improved efficiency of their logistics flows, notably increasing stock rotation frequency and in-store product availability, these are determinant factors of success as small customized batcher are at the core of the retailer's competitive advantage (Montreuil et al,2012). Figure 14 below explains the benefits for the π -Enabled firms.

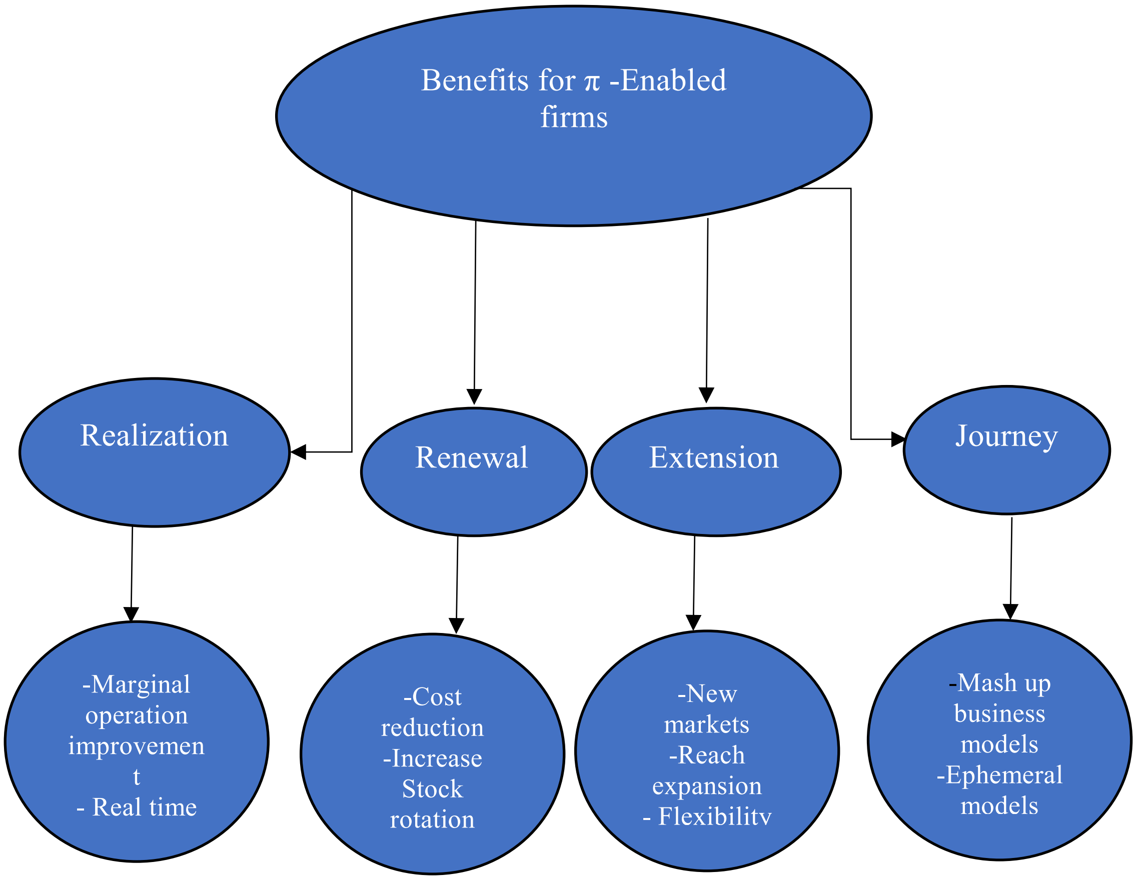


Figure 14. Benefits for π-Enabled firms (Montreuil et al,2012).

Recently, numerous business models coexist. The Physical Internet increases the number of opportunities for tailored models simultaneously to enrich the customer's experience and provide a high value creation for businesses to thrive on. Through efficient, seamless, open, decentralized and distributed mobility, distribution, production, and supply in tune with point-of-sale mobility and flexibility, the Physical Internet allows the introduction of several opportunities to improve the existing business models and the designing of novel business models (Montreuil et al,2012). It can change business models which seemed to be unprofitable or unreachable markets and it can also change ideas into lucrative business opportunities. Moreover, the Physical Internet will introduce a change of several orders of magnitude as the current infrastructure and business models continue to have an impact on one another. However, there are other aspects we should consider before introducing the internet of things. These aspects are displayed below in figure 15.

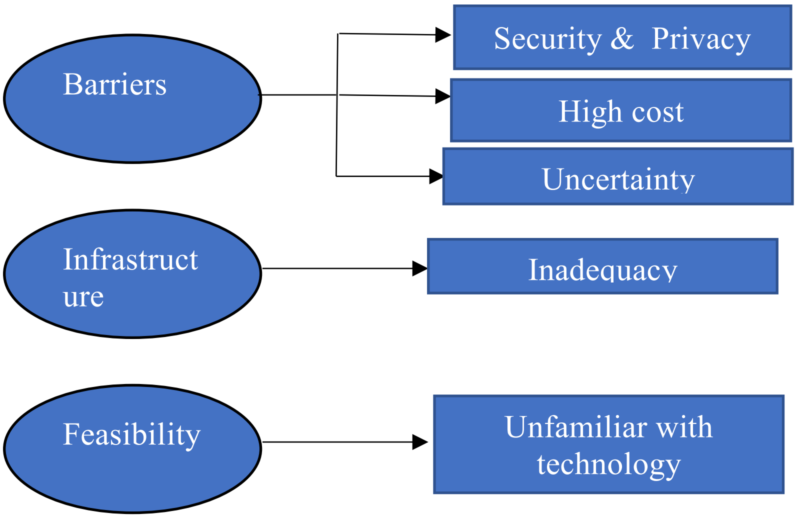


Figure 15. Aspects to consider before introducing Internet of things.

Even when having benefits, one must consider the concern of the participants, for the participants they are venturing into the unknown. There are barriers to consider such as the security of the system, cost of implementation and the uncertainty. The firms also must establish a suitable infrastructure that is adequate to their firm. Moreover, when introducing new tech into the business environment usage is usually a problem, it may require some training, familiarity and getting used to. If all of the above concerns are thoroughly studied and solutions are found, then there would be nothing stopping the firms from using the Internet of things.

4. CASES ANALYSIS

This chapter aim is to study the analysis of different case studies carried throughout different industries. After taking into consideration the conclusion and analysis carried out by different researchers, it will be possible to use the theoretical framework to answer the questions of the thesis efficiently.

The chapter examines three case studies, those case studies were found after searching for the thesis questions. The first case study done by Jedermann et al. (2014) examined the applications of the internet of things in the food industry and the usability of the technology. The second case study done by Verdouw et al (2016) addressed the infrastructure of the internet of things, usability and obstacles to build the infrastructure. The third case study done by Hakimi et al. in 2012 examined the impacts of using the internet of things, benefits, usability and the communication changes to be witnessed.

In the first case study conducted by Jedermann et al. in 2014, the research examined the impact of the internet of things on transporting food. It examined how it would improve the industry and reflect on its surroundings environmentally, socially and economically. The biggest concern of the case is how the supply chain loses a lot of products in the transportation process, knowing that the products are fruits and vegetables and that the world is facing an increase in population. The world cannot afford wasting valuable resources and the internet of things was considered as an option to resolve the problems. Thus, the case examined what can the internet of things do to reduce waste in transportation, improve the quality, improve the communication in the supply chain and even employ new strategies with the new capabilities at hand such as just in time.

The second case study done by Verdouw et al. in 2016 examined the infrastructure of the internet of things. While other researches were concerned about the applications that could be used, this case study examined the foundation of the internet of things and building a proper framework to use. The case study was conducted on fish transportation in Nordic seas, where visualization was made and everything was done through the internet selling, bidding, cancelling shipments and demanding. The case examined how infrastructure could impact the communication and feasibility when used in industries taking into consideration participants and complexity in building the desired framework.

The final case study done by Hakimi et al. in 2012 was concerned about the mobility in the transportation routes. Thus, scenarios were made based on simulations illustrating how the transportation routes could get complicated without proper communication and organizing. Then two scenarios are placed against each other comparing the use of the internet of things and going through the supply chain using old context.

4.1 Reducing Food Losses by Intelligent Food Logistics

An estimated figure of the fresh fruits and vegetables lost due to quality drop is about one third of the global fresh fruit and vegetables. Facing an increase in the population around the globe this is an urgent matter that should be addressed swiftly. A high percentage of these losses is correlated to inefficient handling in the supply chain processes. To resolve this matter, we must overview the shelf life which is a common term used to overview the number of days that a food product has left to be of acceptable quality for consumption. The shelf life takes into consideration several aspects such as the temperature and transportation conditions.

Facing the increasing problem of wasted food, a practice was adopted as a solution to the predicament faced in the transportation of fresh fruits and vegetables. The name of the adopted practice is first-expired-first-out. The basic idea for that method is to do a stock rotation in a way that the remaining shelf life of each item is best matched to the remaining transport duration options, this helps in the reduction of the product waste that results due to transportation. Determining the food quality and the remaining shelf life an automatic reading from the environment is required such as the temperature.

Moreover, after determining several variations in the inventory the warehouse management software matches the data received to inventory rotation, routing and special handling. Unfortunately, due to the lack of automation in the data captured and shelf life calculation first-expired-first-out found very little practical application (Jedermann et al., 2014). Determining the quality of packed food is of utmost difficulty as it is not visible from the outside what happens to the inside texture of the food. To face this problem predications are generally made based on the biological models calculating the effect of accumulated temperature and other influences.

It is quite difficult applying a methodology in which the supervision of the food is done in an automated manner, this task requires a unique approach to achieve acceptable results (Jedermann et al., 2014). Professionals working in the field of sensor systems and communication science, predictive biology and food technology are required to work closely with others in the supply chain to accomplish the task properly. To solve the difficulties faced in accomplishing these tasks, projects such as intelligent containers have been initiated to reach optimal results and solve the problems faced in closely supervising the products in the supply chain. In this paper experts from different disciplines implement a prototype system to determine correct temperature and manage it. Product packaging is usually not used efficiently with regards to airflow and thus affects efficient cooling of the product Furthermore, it should be verified whether the shelf life of the product could be extended by adequate post-harvest treatments.

4.1.1 Transportation before Introducing the IOT

Products in the food industry can be damaged even before reaching the predicament of the shelf life time, this problem happens due to the difficulty faced in managing the temperature. These losses can happen in the following stages of supply chain

- After harvesting the farmers are supposed to pre-cool the food. This is crucial for many commodities, unfortunately it is not being monitored efficiently.
- When transporting the products, the transportation containers lacks proper means to control the environment temperature and meet certain specific values for the products.
- Negligence done by customers when dealing the products leaving them without proper handling. This can happen because the fridge is set to low power consumption trying to save money when storing the food ignoring the required storage temperatures.

Several precautions were taken to address the first problem, in the UK they confronted the issues by applying the waste reduction action plan. This plan assisted the consumer's discernment of 'use-by' and 'best-before' labels, this helped in reducing the waste. Another measure was adopted to face this issue, this measure revolved basically on improving the information exchange that is going between the retailers and the suppliers to be able to come up with accurate forecasting. To improve the information exchange vertical information exchange was used, it was examined thoroughly by Kaipen *et al.* (2013) in three case studies in Nordic countries. The case studies clearly showed that the losses suffered by the retailers could be substantially reduced by applying a demand that is based on an automated demand forecast which can be achieved through better information flow.

However, the second issue related to accelerated shelf life loss did not receive proper attention to address that problem. It was declared by Parfitt et al. (2010) that the cold chain is going to become essential in future endeavors due to two main reasons, the first one is that the income of people will grow and as the income grows their diets will be diversified and it will gradually change to dry starch products like rice and other alternatives such as chicken which requires cold chain transportation. The second reason would be that food is usually sold in the same day in local areas or rural areas. However, due to the increase in urbanization a more complex model in supply chain is required to adapt to the new transportation distances that are going to be longer, specifically when it is winter as the food gets transported from other areas in the world located in an opposite hemisphere.

The cold chain occasionally starts right after the harvesting is done in farms or when the slaughter house is finished, then it proceeds to the retail cabinet of the local supermarket. Cold chain ruptures have severe effect on the quality of food and waste. It was illustrated by Huelsmann & Brenner (2011) that more than 100 reports were due to storage inefficiency in managing the temperature and transport on the ground, by ship which is difficult to manage temperature in as the reefer container needs two weeks to reach the temperature desired, finally transportation by air is quite difficult as temperature varies during flight operations.

However, determining an exact estimation of the average losses in the cold chain is quite a difficult task to do, Gustavsson *et al*. (2011) categorized losses into five losses during distribution vary between 4% and 15% for fresh fruits and vegetables, meat and fish depending on the region and product group. However, they did not list cool chain losses as a separate category. Part of the category called ‘post-harvest handling and storage’ with losses of between 0.5% and 10% should be added to the distribution losses to obtain a raw estimation of the total cool chain losses.

4.1.2 Intelligent Transportation Results

There are several uses right now for the RFID tags that makes it beneficial such as tracing items in the retail industry. RFID tags has been a topic of interest for a while now when it comes to tracing and identifying items in the retail industry, also when it comes to being used in food chain supervision. A program was launched and funded recently with a purpose of developing smart sensor tags that include several parameters such as temperature, PH and humidity, the program was called the Pasteur program. In the program, the RFID tag was prioritized in models for food quality predication which were then translated into algorithms that could be used on RFID chips.

The Pasteur program was not the only program that was launched recently, there was another program called CHIL-ON which was funded from 2006 to 2010, the aim of the program was to identify and predict if any of the food was in hazardous area specially when it came to fish and poultry supply chains. To attain the goal of the project several enhancements were made on the chilling technologies, microbial detection techniques and remote temperature monitoring systems. An assessment of shelf life and food safety risks was conducted by decision support tools based on mathematical models to calculate the growth of relevant food pathogens and by combining a TTI label with an RFID interface for automated, wireless readout.

However, there were earlier attempts in integration of all required electronics and the decision systems made by the university of Bremen in 2004 to improve the containers used in transportation and develop an intelligent container. The tests for the container however began in 2008. The project was funded by the Ministry of Education and Research in Germany, with an extended consortium of six researches and 22 industrial partners, it was initiated in 2010 and completed in June 2013 with a purpose to provide a full-scale prototype and carrying out field tests for different food products.

The overall system of the ‘intelligent container’ consisted of:

- A network of wireless sensors, installed inside the food pallets to monitor deviations of temperature and other parameters.
- A freight supervision unit, installed inside the container to evaluate the measured data and to calculate the shelf life.
- A telematics unit for communication by the global system for mobile communication.
- A remote sever for web access and integration into company databases.

The consortium included institutes from the fields of microelectronics, communication science, operational research, agricultural technology and animal science. The industrial partners included transport operators, fruit importers, delicacy retailers and providers of database services, embedded software, wireless sensor systems and communication and telematics systems.

Three case studies were conducted on berries, bananas and meat. The first case study on berries focus was on the analysis of temperature and shelf life variations in a supply chain for blackberries. The study clearly showed the differences in pre-cooling, transport temperature, and the position in truck had massive effect on the quality of the food. An estimated amount of 57% did not have sufficient amount of time for shelf life in long transport routes, this in turn demanded that shorter transportation routes are used to handle the transportation of berries to avoid substantial losses in the transported goods. To do the research shelf life prediction models were being pitted against each other to find the benefits of each model, this was emphasized specially when it came to berries, it is important to take into consideration various attributes such as the weight, odor and color, it is important to compare different quality attributes to get accurate results.

Moreover, to increase the accuracy of shelf life predictions based on temperature history for all the products, the sensors need to be placed in different locations inside the shipping pallet. Nevertheless, placing temperature loggers inside the center of the pallet is not easy in commercial supply chain processes for several reasons. The calculation of accurate temperature predication can be done using artificial neural network approach taking the measurements of ambient or surface sensors as inputs.

The second case study tested a prototype of the intelligent containers was examining the transportation of bananas from Central America to Europe. When the second case study was being conducted a characteristic feature was being closely monitored for bananas as they generate a lot of heat due to respiration after harvesting. A balance between the generated respiration heat and the amount of heat being removed with cooling was calculated based on a mathematical model for individual pallets equipped with wireless sensors. A prediction of which pallets were at risk of turning into a hazardous spot, from which the generated would be impossible to remove any more through cooling.

Moreover, the study found that about 10% of the available cooling capacity of the unit arrives at the bananas in the center of the pallet load. The efficiency of the cooling process can be enhanced to reach as far as 50% when better loading schemes and packing is executed. Using the temperature history, a green life prediction can be calculated with a margin of error of few days, using this prediction it is possible to prioritize which spots are at risk of being hot spots and which containers should be unloaded first for safety. When risks can't be identified, more processing takes place in the container. The general feasibility of container ripening was verified during three field tests.

The third case study focused on a supply chain for vacuum-packed lamb within Europe. The shelf life of lambs heavily depends on the packing of the product, where having products that are not packed properly or under vacuum packed would lead to bacterial growth which cannot be identified. Therefore, to resume the case study the bacterial growth model had to be excluded. Changes in the quality concerning the product age and storage temperature were examined. Usage a linear model for time and Arrhenius-type temperature dependency resulted in a model with quite a high degree of accuracy. This case study is an example of a networked supply chain, including cross-docking, deconsolidation and consolidation processes by three DCs and a total of four truck transports. Points in which decision needed to take place were identified during the process analysis. Sensors provided solutions for the transportation in which it could be either used online or offline, this depends on infrastructure of the trucks and warehouses. Temperature data and a shelf life prediction can be read out by a handheld device or transferred to a decision support tool on a remote server depending on the network availability.

The findings of the researches done on the case studies showed a lot of benefits when adopting the RFID technologies and the internet of things platform. However, when viewing the market, it is not popular nor widely adopted by the firms and that is mainly because of the cost of adopting the internet of things measures. The best solution will have extended functionalities, such as on-tag algorithm processing or multiple environmental sensors for a reduced cost, and instead of a single prevailing technology, a combination of passive, semi-passive and active RFID will be needed based on the requirements of each application.

4.1.3 Implications on the Thesis

This case study helped in understanding that the internet of things benefits take some time to reflect on the business. Some heavy investment is required in the beginning however it's worth the investment in the long run. When marketing the internet of things, the businesses need to understand that. If the companies understand that the benefits are worth the heavy investments, investing in lowering the cost would not be the focus. Illustrating the benefits to the customers and marketing products with new pricing would be the focus of the firms. The following figure illustrates the payback period and explains that it takes time to realize the benefits and collect profit.

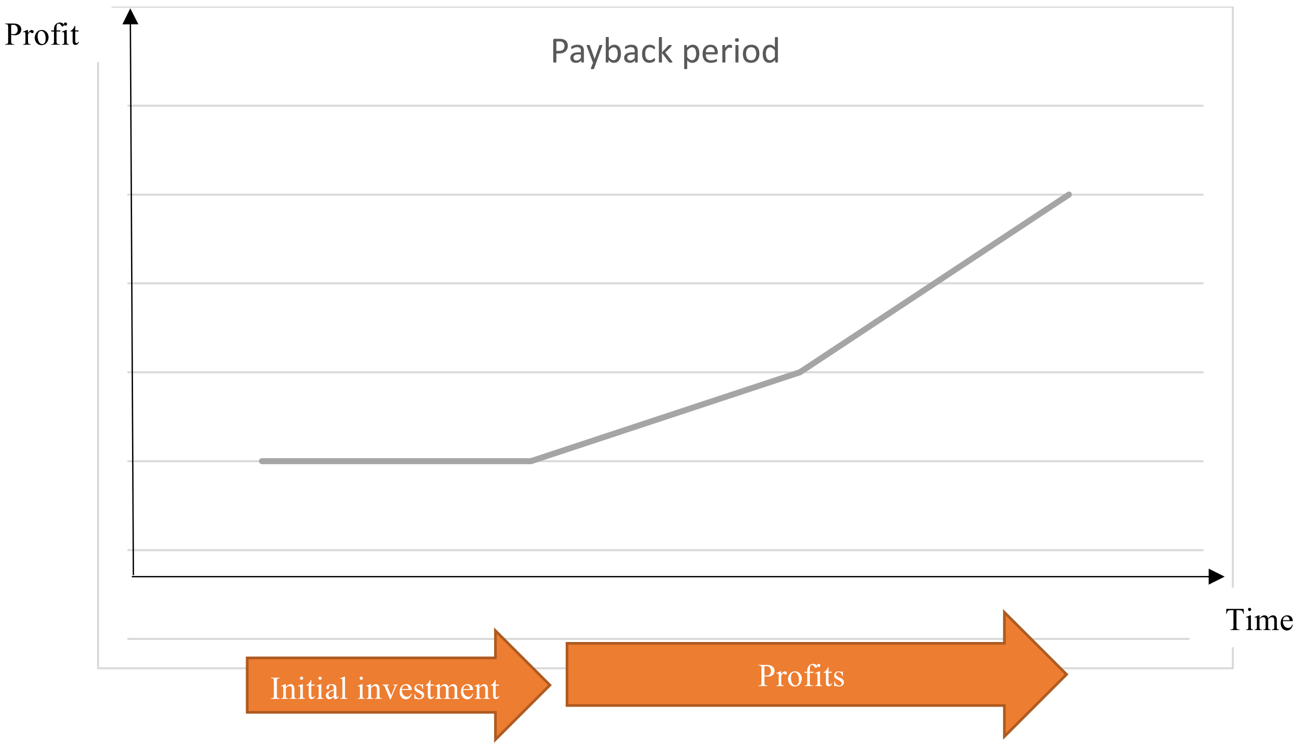


Figure 16. Payback period illustration.

4.2 Food Supply Chain

When building virtual supply chains, it is a necessity to have a traceability system which enables the availability of information for tracking and finding the location of certain items and its history (Thakur et al., 2011; Storøy et al., 2013; Kassahun et al., 2014). To make full use of sensor technologies the objects must be monitored closely over their lifecycle. When monitoring the food as products certain parameters are closely monitored such as the temperature of the food when being stored or transported, also the microbiological information in case of meat, this is extremely beneficial when the food quality is required to reach customers at certain standards (Abad et al., 2009; Heising et al., 2013; Jedermann et al., 2014). This enables companies to have access to different kind of data that allows them to reach new capabilities that goes beyond merely tracking, it allows the companies to have closer supervision over the food quality optimizing different functionalities (Verdouw et al., 2015).

Visualization adds to the intelligence of managing a supply chain, it enables the firm to detect incidents early, this in turn helps in rescheduling in case something happened in storage and it also enables simulation based on ambient conditions. This kind of virtualization happens in early stages of the supply chain, there are a lot of companies that would benefit from such visualization applications such as firms that deal with fresh fish that needs to be sold after being caught in open sea in a virtual auction, this in turn enables the elimination of wasted time and helps keeping the food in an acceptable state for customers to enjoy the freshness of products (Dåvoy & Odegaard , 2016).

There are a lot of applications for virtualization, despite all the applications given to virtualization there is much more that can be done specially when it comes to the food industry. In the future, it is expected to have much more applications which will revolutionize the supply chain in the food industry operating it efficiently and improving the flow of information between the retailers and the suppliers. The focus so far has been on traceability and tracking objects using RFID tags and sensors. However, there is much more that can be done using the generated information controlling the supply chain at different levels.

Moreover, the Food Engineering technologies need to embed in the food chain and have it aligned with the business processes, this is important as it is not addressed in research. The effect of applying virtualization on food supply chain management need to be clearer (Dåvoy & Odegaard , 2016). This case study analyzes how virtualization can affect the food supply chain management and suggests an architecture for information system that enables the implementation of virtualization while reaping different various benefits. This paper proposes the information system architecture that is designed to implement this concept and describes how the architecture is applied to and validated in a case study of fish supply chain. The paper will also discuss briefly the limitations faced and future improvements that can be done to attain better results and more benefits for the suppliers.

4.2.1 Architecture for Supply Chain Virtualization

For virtual supply chain to exist traceability systems must be there, the systems are essential in providing information regarding the objects location and tracing them. There are different types of traceability systems linear, distributed and centralized (Kassahun et al., 2014). When using a centralized approach, the data is gathered in a shared database, for example how the national bovine animal registration system works in Europe. In the linear approach, the data is passed from one point to the next point where at each point records of the supplier and customer products are made. The linear approach can also be called one step forward and one step back principle, it has been referred to as such by the European General Food Law (Beulens et al., 2005). Finally, the last approach which is the distributed approach, all people within the supply chain share and connect their traceability systems to trade traceability data. Recently in food supply chains the Electronic Product Code Information Services (EPCIS) standard is increasingly used to realize distributed traceability systems (Shanahan et al., 2009; Thakur et al., 2011; Ringsberg and Mirzabeiki, 2013; Kassahun et al., 2014).

The traceability systems that are dependent on EPCIS collect data about the food in the supply chain network as it passes through the participants, it is then stored on several repositories and allow queries regarding these events using suitable security mechanisms (GS1, 2014). The events stored on the EPCIS contain information about the products within the supply chain, what is the product, date and time, the product came to pass through, where it is, reasons of delay and many other information related to the product is stored. This is mainly achieved using AutoID technologies, using this technology is possible using bar codes which is then scanned, it is also possible using RFID technology, biometrics, magnetic stripes, Optical Character Recognition, voice recognition, and smart cards (Sundmaeker et al., 2010).

The architecture of the work shown in this case study is possible by using a distributed approach, this approach is feasible due to its feasibility for dispersed objects in virtualization, where that is also the case in the Internet of Things. When a comparison is made between traceability systems and virtualization, it is shown that virtualization doesn't only need to trace the location of objects, it also records and senses information about the state of the objects passing through the supply chain.

Nevertheless, virtualization should allow for controlling objects with the aid of actuators and is also used in showing a projection of the future state of objects to support, plan and optimize (Verdouw et al., 2015). As a result, there are four elements that are required to virtualize food supply chains are (i) identification, sensing and actuation, (ii) data exchange, (iii) information integration and (iv) application services (based on Atzori et al., 2010; Ma, 2011; GS1, 2012; Verdouw et al., 2013). To start the virtualization actuating a physical object is required, what that means is to virtualize real life objects such as boxes and pallets. The physical objects must be automatically identified. The technologies that AutoID is heavily dependent on are RFID transponders and barcodes (Ruiz-Garcia and Lunadei, 2011; Costa et al., 2013; Trienekens et al., 2012). Taking into consideration the expenses and the cost it is beneficial to focus the usage of RFID on containers and pallets, where items on the other hand are identified using barcodes instead (Bottani and Rizzi, 2008).

The architecture designed makes it feasible to use various Auto ID technologies for many applications at different levels of high precision by using standardized GS1 unique identifiers, in the Serial Global Trade Item Numbers (SGTIN), Serial Shipping

Container Codes (SSCC), the Global Returnable Asset Identifier (GRAI) and the Global Location Numbers (GLN) (GS1, 2012). Moreover, the sensors and the devices used in the supply chain are used to measure different parameters of the things such as temperature, ethylene and humidity, microbiological information and other food quality parameters (Heising et al., 2013; Jedermann et al., 2014). The sensors used to measure the ambient conditions can be assimilated with RFID tags (Abad et al., 2009).

The usage of smartphones and mobile devices is also feasible when it comes to object sensing, this aid personnel in the supply chain to perform additional tasks like visual quality inspections. Furthermore, the devices can be fitted with internet-connected actuators that can operate objects from a distance such as coolers, lights and food processing machines. The following action is to communicate the information in the supply chain in an efficient and secure channel. The data are sent to intermediary platforms such cloud proxy machines. With the usage of technologies such as RFID, and technologies that use wireless networks such as GPRS, Wi-Fi and Bluetooth.

For the devices to be connected local computers act as platforms existing at close range of the location for the connection to go through. The rest of the communication in the supply chain is going through electronic message using something like EDI, this is done most of the time in a service oriented approach. The next level in the architecture is information integration. The layer begins with object abstraction creating virtual representations of the heterogenous set of underlying physical objects.

With the exchanged object data being the center, virtual objects are generated and then updated in the internet. Unnecessary information is removed from virtual objects, dependent on the needs or aim of usage. Authorized personal are the only ones able to see each view as the reliability must be indisputable. The information integration layer includes basic data management capabilities such as cloud storage and security. Virtual objects must be constantly updated, this in turn dictates strict needs on the timeliness of object sensing and data exchange.

Finally, the last layer is where the application services provide special functions for different users within the supply chain based on the information gathered from the virtual object. The services that are to be provided are decided based on the intelligence of the virtual objects, this is different from basic virtualization that is only capable of locating objects and tracking them whereas smart virtual objects can possibly take actions. As a result, application services can be seen and classified in different categories such as information handling, problem notification and decision-making services (Meyer et al., 2009). Information handling is concerned with basic operations with object data such as collecting and storing data.

The Fi space architecture contains several modules. A module called ‘System and Data Integration’ enables the integration of legacy systems and services and includes facilities for data mediation. This module generates and updates the virtual objects by integrating data from real-world physical objects through AutoID devices, sensors and other sources, based on the requirements from the application service layer. An 'App Store' module provides a tool supported infrastructure for publishing, finding, and purchasing Apps, which provide re-usable IT-solutions, supporting business collaboration scenarios and which can be used and combined for the individual needs of users. The Apps are accessed through a User Front-End that constitutes of a configurable graphical user interface so that Apps can be located at different points (smartphone, machine terminal, bar code reader, etc.).

The B2B Collaboration core module acts as an intermediary between the services and data application to make sure that the information gathered about the objects and the updates are given to each App in an efficient manner in real time. This will help in providing customized collaborative workflows in guard stage milestone (GSM) models (Richard Hull et al., 2011). To build this model a centric approach is used in which entities have a central role in organizing and managing business processes. For entities like this the most important factor for the objects is the lifecycle scheme and the data scheme that changes as the business process progresses in the future. For the connection with Fispace platform as well as the data from objects that are virtualized in, the applications are organized and processed through the Security, Privacy and Trust module. The figure below displays how the Fispace works.

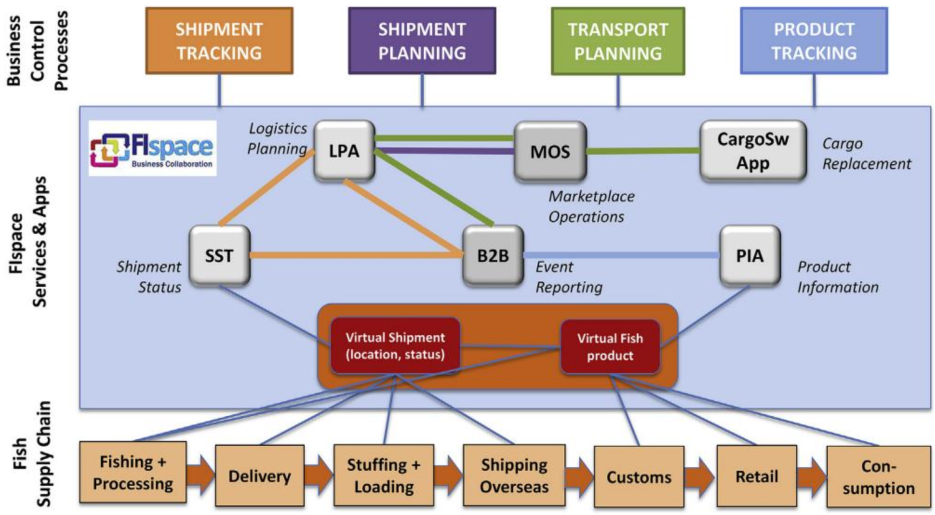


Figure 17. Fispace (Verdouw et.al,2016).

The advantages that we can get from this framework would be providing a secure, reliable access whenever needed, the participants in the supply chain can enjoy exchanging information using secure authentication and authorization methods. The modules can interact efficiently by the operation environment. The operation environment ensures that the communication of Fispace components and applications are consistent throughout the module (Dåvoy & Odegaard , 2016). There is also a software incorporated inside called the development toolkit which support the application developers during the implementation of applications, it aids the developers by providing the required tools and libraries that hide the more complex aspects of the platform.

The products in this case fish loaded in boxes is virtualized through an application called the product information that can provide the consumers with the information they need. After virtualizing the unit in the supply chain which is in this case a sea container, the shipment status application is connected to back end systems. The consumers can keep track of the services offered during the shipment through the business-to-business core services. This enables participants to respond swiftly in case of late cancellations and to keep track of the shipment status (Dåvoy & Odegaard , 2016). The information is then fed to an application called the logistics planning. The application purpose is to provide the shippers the assistance required in the logistics operation planning. The transportation plan and the execution is carried out by it. Subsequently, the logistics planning application determines the best possible routes and services that can be provided based on information that is gathered by the market place operation service application.

Finally, in late stages the cargo search application is then used by the carrier to help with the late cancellations, this can be done after the information on transport demand is available in the market operation application (Dåvoy & Odegaard , 2016). This is crucial and of utmost importance to increase the vessel capacity utilization, because the inherent uncertainty of fish supply. The Cargo search application also aids in the negotiation process regarding the receiving and sending of the bids carried out between the carrier and the user.

The information system architecture as developed in the case study was validated in a user acceptance test and a solution evaluation. The user acceptance test has verified the following test scenarios: (i) Booking and cancellation of shipment, (ii) Search for cargo to increase vessel capacity utilization, (iii) Early anticipation of cancellation, (iv) Transport planning, (v) Automatic booking of transport, and (vi) Early anticipation cancellation alternatives.

Fifteen tests were conducted to confirm that all the tasks in the scenario are approved, to increase the accuracy further five more tests were conducted by the users in the case. The case confirmed that it is quite beneficial applying the scenario to deal with mishaps such as late cancelation. The participants confirmed that it improves the transportation system increasing its efficiency and improving the services offered, based on real time data and the availability of information that is shared between all participants.

The outcomes were substantially beneficial as the performance of tasks considerably improved when it came to book for shipments, reducing the operational costs and efficient utilization of the vessels used in transportation. Moreover, the company in the case study found itself saving up to 30% of time when handling operations like changing plans, cancelling and performing booking for shipments. Nevertheless, the benefits were considerable when market shipments are concerned. Not to mention some obstacles were faced in realizing a successful implementation of the system such as: (i) lack of cooperation when it came to information sharing, (ii) participants feared data security, (iii) difficulty in changing pricing of current dealings, (iv) lack of critical mass, and (v) skepticism about the possible outcomes for current practices

4.2.2 Conclusion of the Case

This paper has shown how virtualization can be a determining factor in facing future challenges in the food supply chains, this in turn will help face unpredictability in the supply chain, high perishability, unpredictable and stringent food safety and sustainability requirements. The concept of virtual food supply chains is derived from a perspective of virtual things in which four dimensions are addressed they are the following:

- Object
- Network
- Process
- Control

Virtualization can be a superior alternative to current practices when facing the challenges in the food chain industry as it allows the decision makers in the supply chain a variety of information through advanced monitoring, control, planning and optimizing the business processes all which can be done now remotely and real time using the internet based on virtual objects (Dåvoy & Odegaard , 2016). However, for the companies and businesses to adopt the virtualization in the food supply chain a major investment is required in the infrastructure is required to support the food companies, this includes the SMEs, to easily connect to the virtual objects safely and reliably, while managing the integrity between different parties. For that reason, the design of the Fispace platform was done in a coherent business environment in which smart Apps and services aid each other to control virtual object.

4.2.3 Implications on the Thesis

The benefits found to the internet of things are substantial however the barriers to the internet of things found in this case study were also numerous which helped in understanding why the internet of things is not popular in the market the barriers found are the following:

- Difficulty in adjusting pricing for products: the customers need to understand the quality of the service they are receiving and the management need to adjust the pricing carefully to reflect the benefits.
- Fear regarding the data Security: the participants fear sharing all their information in one place, thus further investments and clarifications regarding the security of the internet of things is required.
- Skepticism to benefits someone needs to lead and prove the benefits thus some leadership and first movers are required to adopt the internet of things.
- Lack of cooperation and trust between participants, the internet of things requires full cooperation between participants thus withholding information may backfire and cause more harm than good.

4.3 Mass Distribution France

The paper revolves around studying the mobility in France when transporting goods related to fast consumer goods. The study is carried out by running a simulator which simulates the impact on mobility on a large scale in France after adopting the interne of things. The simulator is expected to provide the study with a situation which shows the daily shipments of orders on a large scale over hundreds of sites including plants, warehouses, distribution centers, unimodal and multimodal hubs and transits (Ballot, et al., 2010). The contrasting way of shipping products through current logistic system are shown taking into consideration various variants and different levels of implementation of open mobility webs that are enabled using the Physical Internet.

The simulation of products currently includes the operation of the manufacturers and how they operate with multiple plants and warehouses. The simulation would also include the response to retailer specific orders. The products are often packed on pallets where the shipments are moved to trucks that cover the travelling distance between sites entirely from the suppliers to the receiving customers. The simulation of open mobility web involves handing these to same demand scenarios that is carried out daily by businesses in the current system

Moreover, the simulation includes other variables than players and sites, it must include sets of π-hubs and π-routes. The products are no longer going to be packed in pallets instead they will be packed in π-containers of modular sizes. The π-containers are the only unit loads allowed to be shipped on the simulated open mobility webs. When heading to their destination the π-containers can transit through π-hub where it is possible to move them between transportation means and/or modes. The simulator should thus support the potential modes (truck-based road travel, train travel, etc.) and different types of unimodal and multimodal π-hubs.

It is also possible transporting the π-containers of different actors. Direct travels are not the norm when it comes to open mobility webs, routing agents play an important role to decide which set of route segments and which transportation means are essential to get to the designated locations. The road-based route segments can be then limited to only a few hours, this in turn enables the drivers to get back to their homes within the same day.

4.3.1 Proposed Model Illustration

The suggested model includes three main agents that will be a determining factor when making the decision within virtually simulated logistics web. The three agents will be the supply chain managers, routing agents and the transportation agents. When a task is performed by an agent each task will take many behavioral variants into consideration. The different variants taken into consideration will enrich the simulation providing various solutions, supporting different levels of openness and achieving different objectives. It will be possible to change the agent behaviors to target certain factors such as economic objectives, environmental or social objectives or any level of tradeoff by company retailer, manufacturer transporter and other parties involved. There will be various ways of building, routing and transporting shipments and the π-containers can be modeled to evaluate the impact on the transportation cost, gas emission, number of used transportation means, travel distances and durations, etc.

Supply chain managers

In the old supply chain management where the π-enabled context is not used, the supply chain management agent organizes daily orders by delivering the shipments to the allocated destination without breaching the maximum allowed weight or volume. Transportation carried out through the road and do not meet the weight of a truck load can be consolidated into master bill of lading (MBOLs) to increase the truck loadings to its maximum load. Shipments occasionally surpass the weight or volume allowed for a truck, to solve the issue the agent divides the order to fit in several MBOLs that do not exceed the weight constraint. When the MBOL is ready to be released, the agent in the supply chain delivers a note to the transportation agents who are then responsible to assign a truck to the MBOL.

However, in a π-context the agents can manipulate the order lines to the π- containers instead of consolidating the orders into shipments and MBOLs. Moreover, the supply chain management agent should possess the skills required to determine the group of lines of orders that are meant to reach the same destination, when that happens it enables the orders to reach in common containers which saves space and time for other shipments. If a container is ready to be shipped, the agent notifies the routing agent. The reason the routing agent is notified and not the transportation agent is that the direct deliveries and vehicle dedication are not a must in the π-context. The agent can verify that the transshipment of the π-containers satisfies the regulations. After receiving the delivered shipments that were ordered, the supply chain management agent verify that the goods have been received and adds them to the inventory records.

Transportation agents

The transportation agents are responsible of managing the transportation means that belong to the business. In the old context where the π-enabled is not being used, the transportation agent gets notified of the available MBOL from the supply chain agent. The transportation agent then proceeds to find a truck to handle the shipping process at the desired time. When the time arrives the agent then determines the pallet loading for the MBOL into the truck, when the truck reaches its designated destination the agent monitors the vehicles on the road. When the truck reaches the location of the delivery, the agent begins the unloading operation and notifies the supply chain management agent in the receiving site. Finally, the agent in the receiving end confirms that the products have been received and he updates the inventory records (Hakimi et al, 2012).

However, in the new π-context, the loads of π-vehicles and π-carriers are decided by the routing agents unlike the old context where the supply chain management agents did that. Thus, routing agents are the ones responsible for notifying if any available π-containers could be used for the transportation. The truck drivers can return home daily thanks to the distributed road based transport, where they travel on a segment for a couple of hours. The drivers must go over several segments before finally reaching the designated location. However, the trailers are pulled by a truck along each segment allowing the trucks to change at π-hubs and π-transits across the mobility web.

Transportation agents are also responsible for the loading of the π- containers for it to be transported and unloaded at the π-hubs across the mobility web. When vehicles leave from the location, the transportation agent should alert the routing agents if there was any alteration to the timetable. Moreover, when the vehicle arrives its destination, the agent should notify the supply chain management agents that the delivery has been made. Furthermore, the transportation agent duties include organizing the travel schedules of the trucks and to distribute the schedules to the corresponding routing agents. The routing agents can then use them when establishing travel paths of π-containers. The transportation agent can use different strategies to attract π-containers and maximize the loading of the transportation means (Hakimi et al, 2012).

The travel schedules can be scheduled using several methods, one of them is to use the information related to the density of segment flows, determining which of the served hubs is more important to attend to, running an assessment of possible business opportunities. Moreover, there can be transportations scheduled at a fixed pace at certain days. The size of the π- containers can be a determining factor whether a shipment is ready or not, the agent can then choose whether to let the transporter leave or delay it until more π-containers accumulate. The agent can also choose to cancel the trip and use the set of π-containers for a different transporter-time combination. When regular services are unattainable, the transportation agent can customize trips if requested by the routing agent.

Routing Agent

Routing agents need to be activated in the π-enabled scenarios. The routing agent's tasks include finding proper path segments, π-hubs, and based on the scenario at hand, proper transportation means are determined, the containers then will contract to iteratively reach the final destinations (Hakimi et al, 2012). A routing agent meticulously go through the request for routing π-containers that are delivered by the supply chain management agents. For each request, the agent determines, segment-by-segment, the entire travel of a π-container. Different π-container routing methods can be tested.

Different methods exist; however, it is essentially either dynamic methods or static methods and different hybrids. The static group is simply a two-step method, where in the first step a fixed cost is assigned to each segment between nodes of the web. The cost determined for each segment can be based upon the distance, the expected transportation time or simply an estimation of the transportation process. The second step implements an algorithm to determine the shortest path from one point to another in the transportation process. This is done over a graph whose vertices are nodes of the mobility web and the edges are the inter-node segments. Illustrating the dynamic group, a method searches to assign the π-container to a set of transportation means associated to a set of route segments that will ensure the entire travel between the source and the destination.

This method enables the user to find the optimal routes that would allow the transportation to reach its destination within a short time. It will be displayed on a graph with vertices labeled as mobility web node at a certain time and the edges that correspond.

- Time-phased inter-node segments (e.g. departing from π-hub A at 9:00 and arriving at π-hub X at (11:00) and (2))
- Sojourn times at node (e.g. flowing through π-hub A from 8:30 to 9:00).

The costs corresponding to each node edge and each intra-node edge is put to minimize the shortest path algorithm. This can be illustrated for example to display the total cost caused by greenhouse gas emission, or cost of time consumed to transport to a certain destination (Hakimi et al, 2012).

The routing agent produces a set of possible inter-node edges, this can be achieved by using the travel schedules that are shared by the transportation agents. It makes a set of possible intra-node edges by approximating the handling capacity of the hubs within the allowed time window. However, when the algorithm is unable to find an appropriate time-phased path from starting point to destination, the routing agent can ask for a customized travel from the transportation agent. This allows the algorithm to search again in a different scenario a feasible route in an appropriate time frame. The routing agent then monitors the arrival of new travel availabilities that will iteratively lead the π-container to its destination. When the algorithm fails to find an appropriate path, the agent retries using newly published travels.

4.3.2 Impact of using the Physical Internet

The analysis of both scenarios when the old supply chain management practices were being used versus the new practice using the Physical Internet is being shown in the below figures. It is illustrated in the below figures how using old practices results in a complicated web of travelling. This in turn results in more travelling, more carbon dioxide emissions and complicated channels of communication which makes it difficult for the businesses to control the transportation process smoothly. Moreover, with such a complicated web and a lot of travelling included the cost of transportation will add to the business expenses which in turn affects the business negatively. This is illustrated in figure 18.

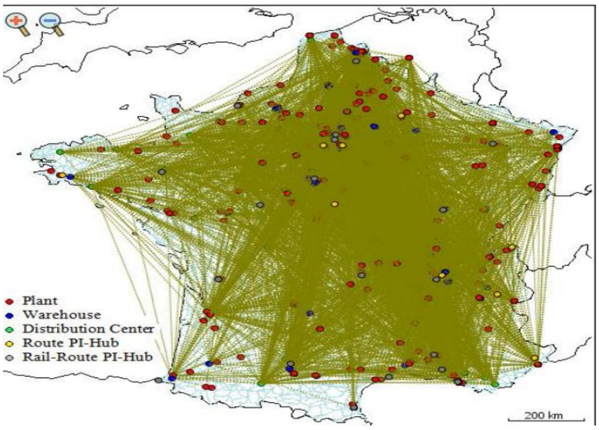


Figure 18. Flow of goods in current mobility web (Hakimi et al., 2012).

When analyzing the new method of handling the transportation using π enabled mobility web, the use of Physical Internet shows a lot of benefits to the businesses. First the complexity of the supply chain no longer exists as the communication along the chain becomes easier. Second the transportation takes less travelling as it becomes more efficient and enable parties to eliminate empty travelling, repeated orders and an overall control over the transportation. Finally, because of having less travelling the gas emission, fuel consumption and greenhouse effect becomes substantially lower. The simulated scenario can be viewed in the figure below showing clearly how the mobility web had a drastic change.

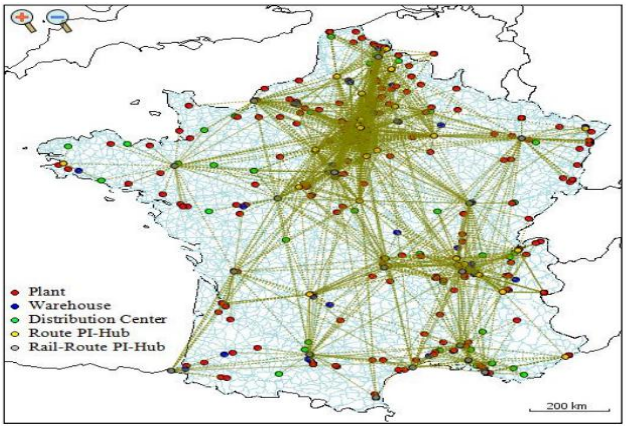


Figure 19. Flow of goods in π enabled mobility webs (Hakimi et al., 2012).

The figure below displays some numbers to compare between the mobility with the physical internet vs the mobility web without using the Physical Internet.

	Route and Rail-Route Physical Internet hubs	Orders	Order lines	Physical Internet containers	Transport Mean travels	Total Travel Distance (Km)
Number of instances in a nonphysical Internet scenario	………..	211 167	282 381	…………	124 618	54 725 706
Number of instances in a Physical Internet scenario	38	211 167	868 093	677 551	270 623	43 735 190

Figure 20. Comparison between PI and normal transportation (Hakimi et al., 2012).

4.3.3 Implications on the Thesis

The number of trips using the Physical Internet is much higher in comparison to employing old transportation means. However, although the number of trips is much higher the distance covered is much lower than the old transportation means. Indeed, the Physical Internet does increase the efficiency, reducing the fuel consumption, gas emissions and reducing the costs. However, the results indicate that numerous trips are required to reach destination which verifies and highlights the utmost importance of the communication between the participants in the transportation routes and personnel in the supply chain.

The results from the case study open discussions and enables us to explore further on what barriers could be faced when having many small trips in a long transportation route. Is there a possibility for the message to get altered as it reaches its final recipient? What possible obstacles could be faced in a system that heavily depends on communication?

5. FRAMEWORK

To face all the negativities found in the market due to globalization, complex operations and increased number of customers around the globe. Thus, measures need to be taken to face these obstacles faced by the firms in modern times. The internet of things is an efficient tool in minimizing the problems associated with the supply chain, where designing a supply chain model in many cases can no longer resolve the issues faced by the management. This section will examine each case study and illustrate how the internet of things resolved a lot of the problems faced in modern day supply chain management. The following challenges in the supply chain management the bullwhip effect, inventory management and just in time in the literature review explicitly show how inefficient communication, low responsiveness and low flexibility are the root cause of problems.

Lee and other researchers (1997b) identified that there are several reasons behind the bullwhip effect. The reasons are the order batching, price fluctuation, demand in forecast updates and shortage in gaming. This in turn results in affecting the profitability of the supply chain, where the coordination operation of the supply chain cannot be held any further because of the inconsistency from the supply demand information flows between the members in the supply chain.

Holding inventory has a lot of disadvantages that has been empathized a lot recently, the impact which adversely affect the supply chain responsiveness. Regarding the matter with the increasing globalization which has a considerable impact over the responsiveness of the supply chain. The increasing in globalization resulted in increasing the supply lead time where using common ways of inventory control eventually leads to greater levels of inventory just to offer the same service levels (Water, 2002).

Just in time system needs regular transportation service and specific handling of equipment. Companies that adopt the just in time must be highly flexible and adaptable to account for the tight coordination that is needed in this transportation and distribution network (Harper & Goodner, 1990). The just in time strategy demands a complicated and comprehensive thinking on how to source and the location of the plants and warehouses to be close. Adapting the system to the just in time transportation system would cause or result in several alterations (Chapman, 1992; Gomes & Mentzer, 1991): First by reducing the lead time requirements quicker transportations become a result, second by reducing the size of shipments it would result in occasional dispatches to limit the costs of transportation

5.1 Fresh Food Supply Chain

With the aid of the internet of things and the Physical Internet it is possible to use virtualization on the crops if they are harvested. With the creation of virtual objects of the Physical Internet it is possible to have virtual auctions on the internet as soon as the food is about to be harvested. This in turn will aid the suppliers in delivering the products at optimal condition as food is valued when it is fresh, not only will the introduction of this new technology help in the selling of the products faster, it will also aid in monitoring the shelf life of the products monitoring the temperature and condition of the food stored.

This can help the suppliers have better communication with the customers and manage the inventory, increasing the rotation and reducing the need on stocking a lot of food products in case they don't have enough products to sell for the customers. Previously customers selling in market and vendors used to stock products of food on shelf and throw products not sold. This resulted in wasted resources, lost profit margin, and in selling low quality products that were not fresh and would not meet the standards preferred by the customers.

There was also a problem before the introduction of close monitoring sensors and virtualization, it was difficult packing the products and monitoring the environment temperature surrounding the products. This made it extremely difficult for transportation over long routes specially when it came to seasonal vegetables and fruits that needed transportation from opposite hemisphere. However, with the introduction of RFID tags and sensors it is now possible to control the condition of the containers transporting the food allowing for the food to reach the customers in optimal condition, this will result in the expansion of the market for suppliers increasing the profit margin and increasing the number of customers.

Moreover, it is now possible for the customers purchasing the food from the suppliers to come up with new strategies for stock rotation. It is possible for the customers to use the Just in time approach without the fear of running out products to sell to the customers, it is also possible to use the Vendor managed inventory where the suppliers can get all the data on their customers products from the shelfs through the internet and sensors installed in place.

This opens new possibilities for the customers to come up with new business models. Each customer can customize a personal business model that fit his business needs as different products require different timing and care. Depending on the products sold by the customers whether they are selling meat products, vegetables or fruits business models would differ. Although some customers would fall in the same category of products like fruits, different fruits possess different life cycle as the case study has shown. Having a greater understanding now of the products in general channel of communication and business models will evolve to fit the business needs. The figure below summarizes the benefits that would be attained from using the interne of things.

Realization	Renewal	Extension	Journey
• Real time reactivity • Marginal operation improvement	• Increase Stock rotation • Cost reduction	• New markets • Reach expansion • Deliver flexibility	• Mash up business models
• The fresh food and vegetables real time reactivity will enable food providers to adapt and react to temperature changes swiftly. • Operational improvement allows supply chain to improve product handling and allows transportation over longer routes.	• Increasing the stock rotation will enable the customers to get fresh fruits and meat which in turn will provide customers with better quality and better services increasing the sales. • Cost reduction regarding wasted products that are lost in the transportation process.	• New markets exporting to other countries seasonal products expanding the business and increasing the sales. • Flexibility in delivery will improve the communication between the suppliers and retailers.	• With flexibility and introduction of new innovative technologies in the supply chain now it is possible to develop new business models tailored for business needs to allow just in time and prevent waste of products.

Figure 21. Benefits for the food industry.

The demand information was often inaccurate due to distortions that happen in the supply chain as we move upstream. This occurred a lot in the old context where the information was unreliable which led to the bullwhip effect occurring a lot. This resulted in obtaining a lot of unnecessary stock believing that customers need more. Moreover, due to the nature of the product and the shelf life a lot of food was not sold and only resulted in increasing the costs of transportation and storage. Figure 22 below illustrates the problem of the bullwhip effect.

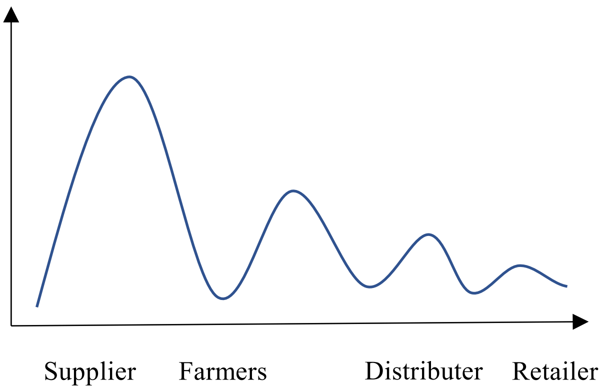


Figure 22. bullwhip effect.

However, when the new π-enabled context was used, and the issue was resolved. The new approach in the supply chain help adopting the just in time approach which in turn helps lowering the transportation and holding costs. It also provides the retailers with fresh products for the customer, improving the quality of the product offered to the consumers. These benefits happened because of the improved communication between the participants, by constantly feeding all participants real time information about the products. The information shared through the internet of things allows participants to react proactively to delays in shipments, damaged products in transportation, cancelation in shipments and allows the suppliers to anticipate any spike in demand.

Barriers

After analyzing the case and realizing that the main issue lies with firms realizing that the benefits are not substantial at the beginning and that it takes time to realize the benefits. It seems that the internet of things is not being marketed properly and the benefits are not reflected on a time line to break it down to the customers. However, If the marketing is done properly and numbers are provided to support the claim that firms can get benefits, then the firms would invest heavily in the internet of things.

Moreover, when addressing the payback period, it would seem wise to also invest in reducing the cost of adopting the internet of things. This can be achieved by investing in extended on tag algorithms which would substantially lower the costs, instead of using several RFID tags to monitor the products which heavily increases the costs when adopting the internet of things.

Future development

It seems that in this case investing in alternative technologies, having alternative to RFID tags employed everywhere is not enough. The pitching of the benefits and the payback period needs improvement, thus to develop the system and convince the firms a research could be done representing costs of investment, payback period, return on investment and profit after a period. The research must be done over a period monitoring also customers behavior after increasing both the quality of products and costs.

5.2 Fish Industry Supply Chain

In this case analysis, the bullwhip effect and the distortion of information along the chain is also important. When transporting the product, due to the nature of the transported product which is fish. The product must be handled in a suitable temperature and transported in a small-time frame. If the product is handled in a long time the fish may lose its freshness which would result in selling low quality products. Figure 23 illustrates the bullwhip effect.

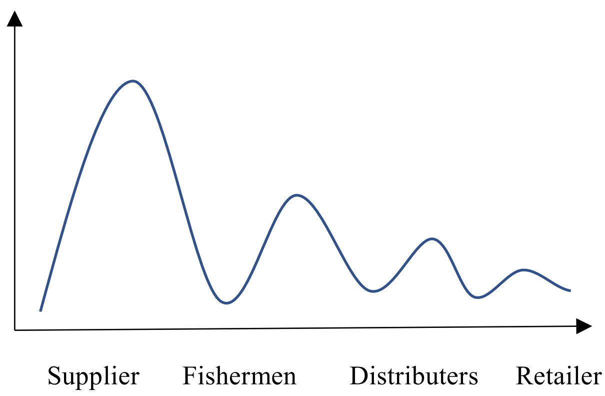


Figure 23. bullwhip effect in the fish industry.

Today the seafood industry is one of Norway´s most important export industries, and reported a total export of 72 billion NOK to 143 countries in 2015 (SSB, 2016A, ssb.no). Approximately 50,1 billion NOK, originated from the aquaculture industry, with sales of salmon accounting for roughly 94,5 percent of the total export. This makes Norway the world´s largest exporter of salmon (Dåvoy & Odegaard, 2016).

Barriers to the internet of things

Trust is a huge problem for firms incorporating the internet of things. However, if the parties adopting the system have been in business for a long period of time and trust was not an issue the communication would run smoothly, and the information shared would not be missing any critical info of the transportation process. This in turn would help determining routes, amount of goods to be transported and expected benefits. Moreover, there are no market leaders willing to invest and prove that the Internet of Things worth and that is due to inefficient marketing and poor pitching of the benefits that could be attained.

Future development

Invest heavily in developing the infrastructure to secure data and improve data security. Advertisements explaining to customers why the increase in cost of products, where the management need to invest some time in the beginning of the financial year to come up with new prices after investing in the internet of things. Same as with the previous case the skepticism in applying the internet of things happens since firms do not realize the benefits on the long run. Failing to realize that the benefits take some time to be realized and that the payback period is worth it is the biggest obstacle and this can be solved with proper pitching and marketing. In the future some research conducted with numbers representing the return on investment, return on income, payback period and profit would be helpful in transitioning the companies onto a new era of technological prowess in the supply chain.

Benefits

Taking Norway as an example if an infrastructure for the internet of things is applied in Norway, it is possible for the country to further increase its exports to countries which are far beyond Europe. Nowadays, retailer's accounts for as much as 60-90 percent of the purchase of imported salmon in many European countries. (Tveterås et al., 2004) (Marine Harvest, 2015). Fresh fish is about 94 percent of the total export. This requires drastic measures to increase the efficiency of the transportation in regards with responsivity, regularity, and flexibility of deliveries, which in turn results in an increased price for the end customer to receive premium products. However, even though the customer pays more for premium products there are substantial cost savings to be taken into consideration that would result from adopting the internet of things and implementing the Physical Internet.

The Physical Internet aim is to provide an open and interconnected logistics web. It helps in rapid developments related to reduced traveling distance, preventing empty travels, reducing storage costs and improving the loading utilization, improved return freight distribution, reduced terminal time and reduced transportation costs. Instead of going back and forth with the fished products from sea, a lot of time can be saved selling the fish in a virtual auction for customers where the fishermen can immediately deliver the products to the customers. The sensors installed in containers allow close monitoring to products, controlling the temperature of the container and provide proper handling of products reducing the number of wasted products.

With the aid of the virtualization of physical objects and having virtual auctions in open sea as fish is being caught. It can alter the industry's dealings and how the transportation of fish is handled. Fishermen can take the role of the transporters and immediately deliver the products to a distributor midway. The distributors will be mediators between the company supplying the fish in Norway and long distanced companies abroad. This in turn will allow the company to capitalize on the time saved and deliver to more customers abroad increasing their profits. Figure 24 summarizes the benefits that can be seen from the framework.

Realization	Renewal	Extension	Journey
• Real time reactivity • Marginal operation improvement	• Increase Stock rotation • Cost reduction	• New markets • Reach expansion • Deliver flexibility	• Mash up business models
• Real time reactivity will enable the suppliers to monitor the fish closely and prevent micro bacterial development and temperature controlling • Operational improvement allows transportation over longer routes. This will be extremely beneficial to countries like Norway.	• Cost reduction regarding wasted products that are lost in the transportation process. Suppliers will maximize on the profits instead of having products lost in the transportation due to poor handling, temperature management, packaging and reduce wasted time.	• New markets exporting to countries that was not feasible exporting to fish before due to distance barriers and difficulty in maintaining freshness and quality of products being exported • Flexibility in delivery will improve the communication.	• With flexibility and introduction of new innovative technologies in the supply chain now it is possible to develop new business models tailored for business needs to allow just in time and prevent empty transports.

Figure 24. Benefits for the fish industry.

5.3 Mass Distribution France

The case clearly shows how the travelling throughout the supply chain is substantially affected after adopting the internet of things. Real time reactivity is not studied thoroughly in this case; however, the transportation efficiency improves allowing operational improvement and travelling over longer routes is now feasible. It is possible also to reduce the cost considerably because of less travelling and less fuel consumption. With such increase in efficiency it is now possible to achieve better flexibility, get access to new customers having more time at hand and market expansion with sights for abroad customers.

Nevertheless, such an increase in efficiency also allows the business to adopt different practices in the supply chain, developing customized business models according to each customer need. This will give a competitive advantage over other businesses as the customers are prioritized and given better services compared to before. The adoption of the internet of things allows also to massively reduce the greenhouse effect lowering the pollution and the emission of $CO2$.

Due to the nature of the research conducted, it was difficult to study the effect of the internet of things on other aspects in the French market. The research conducted highlighted the problems associated with the mobility. However, the research did not take into consideration the products nature, a specific industry and the problems related to the stock level. Thus, it is not possible to analyze the bullwhip effect nor the longevity of the products or their shelf lives. The research however did highlight that the errors related to transportation are minimized and no need for empty running, nor the need to travel to a certain location several times to deliver an order. The figure below summarizes the benefits attained from adopting the internet of things in France and how the mobility is considerably improved.

Realization	Renewal	Extension	Journey
• Real time reactivity • Marginal operation improvement	• Increase Stock rotation • Cost reduction	• New markets • Reach expansion • Deliver flexibility	• Mash up business models
• Real time reactivity was not studied closely in this case study to determine the benefits. • Operational improvement allows transportation over longer routes. This was extremely beneficial in this case study. It was clear when monitoring the transportation, the amount of travelling is less.	• Cost reduction was clear, less empty travels, lower fuel consumption and better utilization of transporting containers.	• New customers can be dealt with, now that the transportation system is more efficient. It is quite easier handling new customer requests • Flexibility in delivery will improve the communication between the suppliers and retailers.	• With flexibility and introduction of new innovative technologies in the supply chain now it is possible to develop new business models tailored for business needs to allowing just in time and preventing empty transports, and increasing the quality of the services offered to the customers.

Figure 25. Benefits in France.

Barriers

The third case study highlighted the heavy duty of communication for the transportation to happen successfully, where the number of trips taken are considerably higher than normal transportation and it takes a highly efficient communication system to support the success of the operation. However, for the communication to happen between participant at this level trust is important, the participants must be open about all their information and allow others to access their information. The firms must possess the spirit of sharing with its partners. If the system does require maintenance during the transportation process, the process might possibly fail as the participants would not be able to access the information midway the operation and the message might be misinterpreted as it moves down the chain by the participants.

Development

It would be highly beneficial to study and develop a backup system to be accessed by the participants if an emergency happens, or the system crashes. A study or research studying the infrastructure of the internet of the things and developing a backup storage of information to be accessed would be highly beneficial, as well as developing and studying the security of the system. The security of the system is also quite important and no studies in this thesis have been conducted to experiment the security of the system provided to the firms and how it prevents outsiders from accessing it.

5.4 Summary

It is of no doubt that the introduction of sensors and tags in the transportation system changes the operation entirely. It eliminates a lot of unknowns and variables in the transportation process. Currently the suppliers will no longer be wandering about the condition of the goods, the customers will no longer speculating or ordering a larger batch of products to anticipate the damaged goods they would receive. The transportation now becomes a controlled environment whatever the variances are whether it is the temperature of the container, the loading if it is done properly, state of the product and even the delays that may occur in traffic. To summarize the outcomes from applying the internet of things, introducing sensors, the Physical Internet and visualization changes the old context thinking of how things can be transported in an efficient manner. The following figure illustrates the key factors when introducing the new technology.

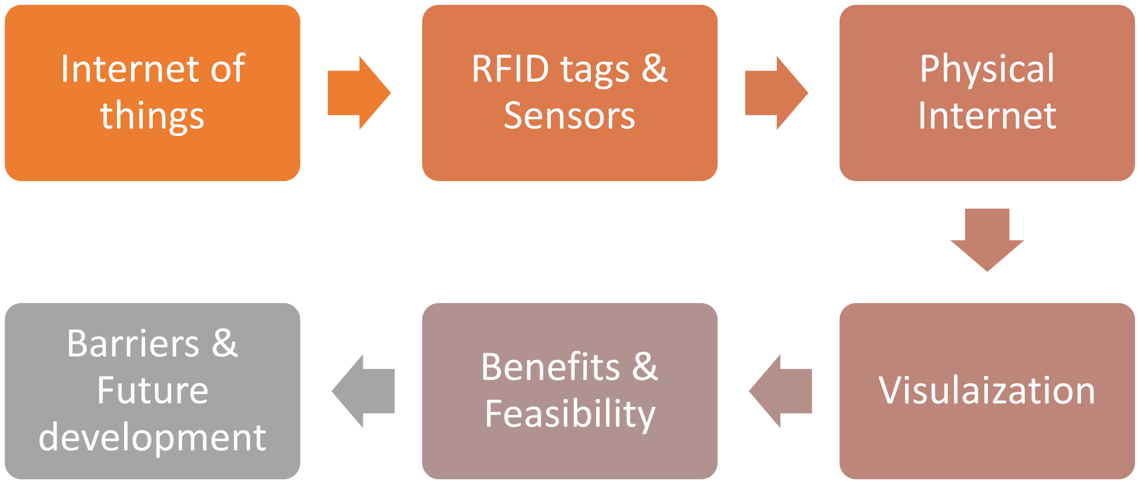


Figure 26. Key factors in applying the Internet of things and benefits.

It is of no doubt that the introduction of sensors and tags in the transportation system changes the operation entirely. It eliminates a lot of unknowns and variables in the transportation process. Currently the suppliers will no longer be wandering about the condition of the goods, the customers will no longer speculate or order a larger batch of products anticipating damaged goods or delays. The transportation now becomes a controlled environment whatever the variances are whether it is the temperature of the container, the loading if it is done properly, state of the product and even the delays that may occur in traffic.

Moreover, the visualization enables a shift in the supply chain model, the role of participants within the chain can change now to run a more efficient process. The manufacturers can handle the transportation of their products, becoming the distributors as they receive offers for their products online as soon as they are manufactured. The suppliers can manage their customers stock as now a communication grid is shared among the participants. The forecasts used to be challenging in the past as managers handling them were the root cause of the problem, due to optimism or being influenced by numbers they need to sustain. Now the managers would no longer order products more than needed eliminating handling costs and wasted storage costs in generals. From the supplier point of view having a shared communication grid with the participants allows less costs also, as the supplier now can avoid lots of mishaps which resulted from fuel consumption, redundant orders, cancelled orders operation costs.

Feasibility

The three case studies showed no signs of difficulty in handling the technology, the technology can be accessed easily using portable devices and can be accessed by using Wireless communication. Moreover, it has been mentioned in all cases that all participants had access to a shared database allowing efficient communication and improved performance in the supply chain.

Barriers& Future development

Nevertheless, after going through all the case studies some barriers have been highlighted and found to be obstacles in adopting the new technology for a lot of firms. The marketing or the pitching of the internet of things seems to be a lacking area where the firms seem to be unaware of the benefits they could have. A proper understanding for the firms can be achieved after conducting a thorough research presenting financial calculations such as return on investment and payback period.

The market is also lacking a leader willing to adopt the technology. However, if a leader does adopt the technology and display to others in the market his success others would follow. Finally, the pricing strategies seems to prevent a lot of firms from pinpointing a suitable price to present to its customers. Introducing the new prices at the beginning of the financial year instead of employing internet of things midway makes it easier to adjust pricing and financial strategies. This could become even easier if the firms provide sufficient information about the quality of the services they would provide for their customers, explaining the sudden rise of the prices of their product.

6. CONCLUSION

6.1 Conclusion

After a thorough review of the literature and establishing a framework. The research process and the case analysis present answers to the questions displayed in the thesis. Regarding the first question what are the barriers for firms when adopting the internet of things. The findings showed that it is quite expensive at the beginning laying out a proper infrastructure as multiple firms need to adopt the method, the customers paying premium price was not an issue and the usability of the system was quite easy. However, the companies are still not convinced about the pricing required for laying out the infrastructure and buying all the required tools. The customers are skeptic and do not trust the benefits due to poor presentation of the internet of things and lack of financial measures that would help in understanding the benefits. The firms also need to be reassured about the security, possible researches done in future concerning the security of the system would be beneficial.

The second question related to the usage of the internet of things, it was shown in the three cases that adopting this new technology was quite easy for the users. The users or the participants within the supply chain had ease of access from mobile devices, using Wi fi connection, access through aps and modern devices was not of issue. In fact, when using the IOT the users could increase their efficiency at work and save time to handle other tasks within their businesses, in fact the participants had more time on their hand to search for potential customers, possible improvements, communication improved considerably which allowed adoption of practices such as just in time. This was particularly useful in businesses handling food products that required delivery in optimal time to deliver the products in the best possible conditions to the customers. It was also beneficial in getting rid of empty running and unnecessary travelling, this helped in reducing the CO_2 emissions and lowering the pollution and greenhouse effect.

The cases displayed a lot of benefits which answered the third question in the thesis what possible benefits could be gained. Overall the distance travelled is much less lowering the fuel consumption and CO_2 gas emissions. This saves a lot of time for the manufacturers selling their products through a virtualized auction, where customers bid for the products. New markets can be reached by manufacturers as a result of the efficient transportation, that in turn helped in increasing the customer database and increasing the profits for the firms. Flexibility in transportation responding to cancellations and sudden orders due to improved communication channels. The Internet of things also allow increased stock rotation which provides customers with high quality products and fresh products which in turn enables the customer to enjoy high quality of service. The service provided would justify the extra prices the customer has to pay for the products offered by the firms.

The fourth question in the thesis was what are the possible improvements in the future, and it was quite clear that mainly the barrier behind adopting this new technology into firms was laying out an infrastructure, and the cost behind getting RFID tags and WSN sensors are the main problem. Possible improvements that would lead to adopting this technology worldwide would be coming up with solutions to tackle the cost problem. This can be done by lowering the production cost of the sensors and adopting extended on tag algorithms. However, the cost is not an issue if the firms are given a suitable presentation of the internet of things, explaining the benefits and payback period. Unfortunately, the case studies lack financial measures such as return on investment to display the benefits of the internet of things.

Moreover, establishing a mutual understanding between the suppliers and the customers which would eventually enable laying out the infrastructure easily where both parties can share the costs and the burden. Participants in the supply chain would share the responsibilities knowing that the customers don’t mind paying premium prices, also the benefits that can be attained in the long run from adopting the IOT by no means can be ignored due to its substantial impact. Nevertheless, poor marketing and pitching did not enable proper introduction of the tech to the firms, so improving the pitching process would increase the chances of adopting the new technology. The marketing will help also in pricing the products and resolving any concerns or uncertainty related to the benefits of the internet of things.

6.2 Limitations and Future Improvements

The main limitation of the thesis is the usage of secondary resources as it was extremely difficult to grasp information from companies. Companies tend to keep information regarding their products and practices private to prevent competitors from gaining information that would damage their profits. The thesis can be considerably improved if access is granted to information in companies. However, the amount of companies adopting the internet of things are few as it is quite costly adopting this technology in small firms. In the future when infrastructure is laid out and small firms can adopt this practice, it is possible to get access to more information that would be enriching to the thesis. The research scope was also limited to studying the food industry and the mobility web in France, it would be interesting to study the effect on other industries.

Specifically, the health care industry, where the well-being of the patients can be affected by the transportation of certain medication. The medical field should be an interesting topic to study the internet of things impact on. The manufacturing of the medicine and the materials needed, how the materials are transported and what variables should be monitored closely. Moreover, organs donated for transplant also need specific temperature regulation, it is supposed to be transported in a certain time frame to ensure the success of operations. The internet of things researches in the future need also to focus on the price, it seems to be the main obstacle for small firms to adopt this technology.

Moreover, an extended research over a period covering financial benefits from adopting the internet of things would be interesting and more convincing to the firms. The studies lack financial measures such as return on investment, payback period, costs vs profits and customer satisfaction to services. If all of this could be displayed as concrete evidence to the benefits of the internet of things it would be helpful when pitching the new technology to firms.

6.3 Contribution to Theory and Practice

The literature in the thesis proved on several occasions that the human biased decisions is the root of problems in the supply chain. However, with the internet of things a lot of the human biased decision is eliminated resulting in higher efficiency and improved transportation. Moreover, the focus of the cases in the thesis and most of the literature is directed towards fast moving consumable goods. The research conducted in this field is somehow limited to this industry. However, the internet of things could prove to be useful in other industries.

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