MASTER THESIS REPORT

Reducing costs and GHG emissions across Construction Logistics using principles of Lean SCM and Green SCM to achieve Synergy

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Master Thesis Report

Reducing costs and GHG emissions across Construction Logistics using principles of Lean SCM and Green SCM to achieve Synergy

By

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Acknowledgement

The thesis report is written in fulfillment of the two-year Master's program in Construction Management and Engineering at the Technical University of Delft. During my study, I learnt the importance and impact the construction industry had on a global scale. Construction and development forms a huge part of a countries economy and has massive impact on people and the environment surrounding it. Delving deeper into its impact on the environment it was realized that the industry is lagging in terms of incorporating environmental conscious decisions. This led me to thinking and researching more on the topic before finally stumbling upon the logistics department of the construction industry that has so much potential but is neglected. The logistics department forms a major chunk of the construction project and holds a key role which defines the efficiency of a construction process. This eventually led me to a meeting with Thomas Bart from the procurement Department of PVH Europe where I was doing an internship, who was already working on a similar project and was willing to let me carry out my Master thesis research in optimizing the logistics of a construction process. I was fortunate to have found a mentor in Thomas Baart who would meet with me on a weekly basis along with Mr. Hay Dings from Seacon to analyze the current flaws and come up with strategies to optimize the process.

With the topic in hand, the next step was to form my master thesis committee. I got in touch with Dr.ir. R. Vrijhoef given his expertise and knowledge in the field of construction supply chain and logistics, this led me to a meeting with Prof.dr.ir. J.W.F. Wamelink who was willing to take the time out from his busy schedule to meet with me to be my thesis Chair. Next, Assistant professor Dr. Jafar Rezaei was contacted for his knowledge and experience in the field of supply chain management in the department of Transport and Logistics to complete my thesis committee. This wouldn't have been a possibility without their insight, guidance and patience throughout the entire process.

At this juncture, I would also like to thank Bronwyn McConnell, Laura Kunga, Bogdan Spetcu, Aron Panto, Laura Hovrath, Laurens De Lange, Anna Tadini and Fabienne Van der Iersell from the company for their input and support throughout the project. Last but not the least I would like to thank my parents, my brother and friends for always supporting me through thick & thin and keeping my sanity in check.

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Summary

Introduction

The research study focuses on implementing Lean SCM and Green SCM principles harmoniously to reduce costs and GHG emission across the logistics department of a supply chain, thereby making a supply chain eco-efficient and giving competitive advantage to an organization.
The construction industry over the years has been grappling with costs overruns and low productivity; many paradigms have been implemented to tackle this issue but haven't been successful. The lack of success is attributed to the highly fragmented and uncertain nature of the construction industry. In terms of GHG emissions the construction industry accounts for 50% of global CO2 emissions, a substantial chunk of this emerges from the operational phase and most research focusing on reducing CO2 emission in construction focus on the operational phase and very little research is dedicated to reducing CO2 emissions during the construction phase and in specific logistics.
Hence this thesis aims to develop a framework using principles of Lean SCM and Green SCM to reduce costs and GHG across Construction Logistics.
To develop a comprehensive framework a set of research questions and sub questions were formulated. Four research questions were formulated. The research questions were answered based on existing literature and the case study conducted.

Do Lean SCM and Green SCM principles have synergy when implemented simultaneously to reduce costs and GHG emissions across Logistics?

1. How do Lean SCM practices affect costs and GHG emissions of supply chain?
2. How do Green SCM practices affect costs and GHG emissions of a supply chain?
3. What are the aspects wherein Lean SCM and Green SCM diverge and converge?
4. Does Lean SCM lend itself to Green SCM and vice versa?

Literature review

Supply chain management is a theory that originated in manufacturing business and was later implemented in the construction industry. The construction industry unlike the manufacturing industry is unique; every product is different from the other and is carried out in an environment filled with uncertainties. Hence a construction SC needs to be treated differently from a manufacturing SC.
Even after the implementation of SCM, the construction industry has been projecting deficient performance in terms of costs, time, quality and environmental effects. One of the main reasons for this inefficiency is poor material management. Poor material management in the beginning of the construction process creates delays and cost over runs which is carried forward to the later stages thereby harming the overall performance.
While focusing on GHG emissions in a building, operational phase of a building contributes to maximum GHG emissions, but during the construction process transport and inventory contribute to maximum GHG emissions. When it comes to costs, logistics accounts for 60-70% of total costs and transport in specific account for 30-40% of these costs. Hence to narrow down research and have sufficient impact, the sector that will be focused on will be Logistics of a Supply Chain.
There are multiple paradigms that can be used to optimize Logistics; Sustainable supply chain management, Lean supply chain management, Green supply chain management, Agile supply chain management and Resilient supply chain management. But the ones that tackle costs and GHG emissions specifically are Lean SCM and Green SCM. Sustainable SCM tackle

environment, costs and people which broadens the scope, Agile SCM focuses on making the supply chain responsive to fluctuations in demand and Resilient SCM makes a supply chain flexible and change as per changing conditions. The above-mentioned paradigms tackle issues that are not the focus of the report and hence the aim will be to use Lean SCM and Green SCM harmoniously.

Lean management historically has been implemented in manufacturing industry to increase efficiency thereby reducing costs of production. Toyota first came up with the paradigm and was identified as Lean manufacturing in 1990's. From then on many manufacturing companies have implemented Lean manufacturing principles to achieve similar benefits. Its use in the construction industry is rather scarce though there is a lot of research that imply that it is beneficial. Seven wastes have been identified in Lean manufacturing; Transport, Inventory, Motion, Waiting, Over-production, Over-processing and Defects. Transport and Inventory are directly related to Logistics, but the other five wastes also contribute to non-value adding activities in logistics. In transport, Lean SCM practices are just in time delivery to avoid inventory holding costs and third-party logistics as they tend to be cheaper. In terms of inventory, Lean SCM specifies use of single inventory and vendor managed inventory. Vendor managed inventory, the vendor has direct control over stock as the vendor is aware of the required lead time and demand for the material. To eliminate waste emerging from over production, lean practices a Pull based system wherein products are pulled based on demand to avoid unnecessary production which will require, time, money and labor. Opting for "U" based process and providing safe packaging for products, waste emerging from over-processing and defects can be negated.

Green SCM is rather new to the construction field. It emerged as a need to be more environmentally conscious in managing the supply chain. Green principles identify six distinct green practices; Green Procurement, Green Manufacturing, Green Design, Green Packaging, Green Transport and Reverse Logistics. Each of these green practices influence the GHG emissions of logistics. Green transport practices are to implement intermodal transport, as rail and sea have lower rate of emission compared to truck and Air. Using owned and operated vehicles; vehicle maintenance plays a key role in GHG emissions as ill maintained vehicles tend to emit higher GHG's. Use of electric vehicles for delivery, electric vehicles have considerably lower GHG emission than trucks but this also depends on the type of electricity used to charge the vehicle but at the least it reduces 25% of GHG compared to truck and best case 80%. Consolidate shipments, consolidating shipments will ensure fuller trucks are running to site. The last green transport practice is circuit delivery, planning delivery and pickup to ensure trucks are not travelling empty. Green inventory implies minimum inventory, but stock based on forecast to avoid just in time. Green Procurement is to procure materials that have been sourced and manufactured sustainably. Green Design is to design products for assembly and disassembly which will require less manpower and equipment thereby reducing GHG emissions. Finally, Reverse logistics is material takeback, where suppliers take unused or spare material for it to be recycled.

Theoretical Framework

From the above two paradigms, it is evident that Lean SCM and Green SCM diverge in the aspect of just in time delivery, use of third-party logistics, and inventory storage. But what is similar is that both eliminate waste and there is potential for synergistic implementation. A theoretical framework was developed were in aspects that are diverging, trade-offs solutions were suggested and aspects that are converging, simultaneous implementation strategy was suggested.

Case Study

The developed framework was tested practically to see the benefits of implementing Lean SCM and Green SCM harmoniously.

Before choosing the case and analyzing, the organization and the stakeholder perspective on the above issue was studied. The analysis brought to fore that all stakeholders agree on the need to reduce GHG emissions and costs by optimizing the current working process.
Once the stakeholder views were known a spend analysis was carried out to figure out the supplier who contributes to transport the most. The but obvious answer was Seacon who is the logistics provider of the company. Then total outbound and inbound data from Seacon was gathered for analysis, two individual projects were also chosen for analysis to view the benefit on a project level. A two-supply flow analysis was carried out using the soft system methodology to systematically dissect the problem and review the effect of Lean and Green. This was followed by developing an Interpretive Structural Model(ISM) to study the interdependency between Lean SCM and Green SCM variables to understand the hierarchical links between all the variables to get more clarity on where to start implementation.

Conclusion

Lean SCM practices and Green SCM practices were analyzed against the five key elements of logistics. As per literature and case study, Lean practices reduce costs and GHG emissions in varying degrees. The only aspect wherein Lean SCM practices increase GHG emissions is JIT practice when deliveries are global. Considering costs Lean SCM practices according to theory and case study analysis prove to reduce costs through elimination of non-value adding activities.
Green SCM practices as per theory and case study analysis show that they tend have higher initial costs, but are cheaper in the longer run as they require less electricity and maintenance. Green practices increase inventory costs through the practice of consolidation and intermodal transport, but these costs are negligible considering the savings made on Green transport.
Both Lean SCM and Green SCM practices as per theory emit synergy, articles suggest that implementing one strategy enables the adoption of the other easier. In the case study analysis both practices were analyzed using an ISM methodology in the context of the case company to test how both practices interact with each other in the environment of the company, the ISM methodology showed that both practices enabled one another creating a hierarchical order of strategy implementation.

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Chapter 1- Introduction

This chapter an introduction to the problem statement is given explaining the need for the research in the current scenario. Following which the aim and objective of the study is established, to achieve the mentioned aim and objective certain research questions will be formulated which will be answered by the end of the study. The chapter ends with an explanation of the research approach.

1.1 Problem Statement

With increasing global warming and depletion of natural resources, national and international bodies around the world are taking stringent steps to reduce Greenhouse Gas emissions across various sectors of Business operations, the construction industry is one such sector that has come on the line of fire. The construction industry has come under the radar for its negative impact on the environment specially transport, given that most construction activities are taking place in bustling cities. Globally, construction accounts for 40-50% of the total GHG emissions (Seo, Kim, Hong, & Kim, 2016), a large part of these emissions arise from the material manufacturing, transportation and construction stages (Jeong, Lee, & Huh, 2012).Construction transport alone accounts for almost 10% of these GHG emissions (Ying, Tookey, & Roberti, 2014).The construction industry and in specific the logistics has a major impact on the global environment, yet no major steps have been taken toward reduction of these. The reason for this is many fold but the main reason behind this is the perceived lack of financial return and requirement of specialist knowledge (Zenios & Allen, 2016). Hence a proposal that is attractive to a company is one in which there is significant costs savings along with environmental benefits.

The construction supply chain accounts for a sizeable amount of construction costs and the costs of supply chain has been increasing over the years, but the inefficiencies and wastes innate to the construction supply chain hasn't diminished over these years. Optimizing a supply chain and managing it efficiently can result in 10-17% reduction is total costs (Vrijhoef & Koskela,2016), reinstating the economic importance and potential of optimizing supply chain management in construction. Logistics covers a major part of construction supply chain, it accounts for 60-70% of total costs (Bell & Stukhart, 1986) and has significant impact on GHG emissions. Out of which materials account or 30-50% of the costs and transportation accounts for 39-58% of these costs (Fellows, Langford, Newcombe, & Urry, 2002). Inefficiencies in logistics process is carried forward to the other phases of construction, thereby delaying the entire process. Inefficient logistics management result in idle labor on site, which translates to time and costs over runs (Mossman, 2007). Hence, focusing on logistics will help in reducing maximum costs and GHG emissions. Logistics primarily consist of Transport and Inventory but other aspects of a supply chain like supply base formation has a significant impact on the efficiency of the logistics department (Rezaei, Nispeling, Sarkis, & Tavasszy, 2016).

Though logistics plays a key role in the construction sector, little importance is given to it in terms of research and practice. Most articles that speak about construction GHG emissions refer to emissions arising from operational phase and little research is dedicated to emissions arising from the logistics phase. Hence this report will focus on reducing the greenhouse gas emissions arising from logistics in conjunction with reducing overall costs to make it Eco-Efficient.

There exist multiple paradigms to optimizing the logistics of a supply chain. The construction industry over the years has heavily borrowed from the manufacturing industry to optimize its operations; supply chain management(SCM), Lean SCM, Green SCM, Agile SCM and Resilient SCM are few such paradigm that emerged in the manufacturing industry and then borrowed to the construction industry. Yet, the construction industry hasn't been able to reap the benefits that the manufacturing industry has, the reason for this is multi fold but the main ones being fragmentation and myopic control of a construction process in comparison to manufacturing.

The multiple paradigms mentioned above differ fundamentally on its final aim. Lean SCM tends to reduce costs and increase the final value delivered to customer (Womack, Jones, & Roos, 1991), Agile SCM tends to make a supply chain responsive to constant unpredictable changes in the environment (Agarwal, Shankar, & Tiwari, 2007), Green SCM tends to incorporate environmental friendly practices in managing the supply chain and Resilient SCM tends to make the supply chain robust and

immune to disruptions (Tang, 2006). But as costs and greenhouse gas emissions is the focus, Lean SCM and Green SCM will be studied.
But Lean SCM and Green SCM have different principles and practices that need to be brought together to find one common ground to make supply chain eco-efficient. Lean SCM focuses on reduced costs in terms of eliminating waste across the supply chain. The waste reduction invariably leads to a certain greener supply chain due to unwanted process being removed. But this is not always the case; there are many factors that diverge. Lean SCM focuses on Just in time delivery which is not the best option to choose from when it comes to going Green and Green SCM has a lot of aspects that are not necessarily Lean SCM friendly (Carvalho & Machado, 2011).

With the growing need to be more environmentally conscious, organizations need to embrace eco-efficiency to stand the test of market competition (Millar, 2015). Hence the report will focus on reducing costs and greenhouse gas emissions across the logistics section of a supply chain using synergistic implementation strategy of Lean SCM and Green SCM principles.

1.2 Aim and Objective

To establish the scope and outline of the report an aim and multiple objectives will be defined in this section. The aim is defined based on what is expected by the end of the report, the objectives defined are a set of steps that will help achieve the aim.

1.2.1 Aim

To analyse the principles of Lean SCM and Green SCM in relation to construction Logistics to reduce costs and GHG emissions through synergistic implementation of both paradigms.

1.2.2 Objective

The research has three primary objectives. The first objective is to study the principles of Lean SCM and Green SCM in relation to construction logistics and chalk out the points of divergence and convergence to develop a synergistic framework. This will be done through extensive literature survey; the key elements of logistics will be listed out then Lean SCM and Green SCM principles will be analysed against these key elements to understand the effect on costs and GHG emissions. Based on its effect on costs and GHG emissions a comparison between both paradigm will be made to develop a synergistic implementation framework.

The second objective is to test the above formulated framework. To do this the logistics in the case company PVH will be delineated. Then the existing Lean and Green wastes will be chalked out after which the proposed framework will be implemented in a two-supply flow analysis to bring to fore the effect of Lean SCM and Green SCM practices on the current logistics process, a soft system methodology will be adopted to carry out the afore mentioned.

The third objective is to study the level of interdependency and independency between both the paradigms using an ISM method. The level of interdependency will help to understand the interaction between both paradigms in the context of the case company.

1.4 Research Question

To address the previously mentioned problem statement in a streamlined fashion a set of research questions will be formulated. The research approach will be designed to answer the below formulated research question.

Do Lean SCM and Green SCM principles have synergy when implemented simultaneously to reduce costs and GHG emissions across Logistics?

1. How do Lean SCM practices affect costs and GHG emissions of supply chain?
2. How do Green SCM practices affect costs and GHG emissions of a supply chain?
3. What are the aspects wherein Lean SCM and Green SCM diverge and converge?
4. Does Lean SCM lend itself to Green SCM and vice versa?

1.5 Research Approach

The research was carried out in five phases. Each phase will be regarded as a chapter in the report. The diagram below depicts the chapters and the research carried out in each chapter.

Figure 1 : Methodology

Literature review on supply chain management in general was carried out. Research gate, TU Delft University library, SCOPUS, Google Scholar etc. was used for most of the research papers, articles on supply chain management in manufacturing and construction was reviewed initially. Following this the difference in manufacturing and construction supply chain was established. This brought to light the difference in supply chain of manufacturing, construction and store development. This was followed by elaborating on the importance and significance of logistics in supply chain management. Then the key elements of logistics management were listed and individually its effect on costs and GHG emission was studied.

After setting the initial premise, literature review on concepts and practices of Lean SCM was carried out. The seven Lean wastes and the methodologies to tackle them was researched upon and listed, following which practices implemented to mitigate these wastes was reviewed. The reviewed practices were then analysed against the key elements of Logistics to know how they influence the costs and GHG emissions of the resulting supply chain. Later the position of GHG emissions in Lean SCM was reviewed upon to see to what extent Lean SCM incorporates or has potential to incorporate Green practices.

Following the review of Lean SCM, Green SCM practices were reviewed similarly. The practices of Green SCM were added to the construction phases to bring to light the attributes that green supports. Following this the position of costs in Green SCM practices was analysed. To see were Green SCM lacks in considering costs.

The supply chain configuration with respect to Lean SCM and Green SCM were then combined to see were both paradigms diverge and converge. The aspects where they seemed to diverge a trade of analysis was carried out and the aspects where they converge, harmonious implementation strategy will be suggested. With regard, an analysis was carried to see if Lean SCM lends itself to Green SCM or vice versa.

To test the proposed framework, a case company PVH was chosen. The procedure and practices of the company were observed for two months and then an interview of stakeholders was carried out to gain their perspective on the said topic. A stakeholder map was created, every stakeholder had vested interest in Leaning and Greening the supply chain but all agreed on the need to bring about a change to make the supply chain Eco-Efficient.

After getting clear understanding of the current practices in the company and stakeholder views, it was important to structure all data gathered to reach a result. Result in terms of potential steps to be taken. Soft System Methodology was adopted to analyze the current waste in the company and analyze the cost and GHG emission benefit of implementing the proposed framework, this was done through weekly focus group meetings with the procurement and warehouse team. Once the benefits of the proposed strategies were known the interdependency between the strategies had to be established to gain further insight. An Interpretive Structural Model (ISM) was developed in the context of the company to establish a hierarchical order of interdependency between the various practices.

Chapter 2 – Literature Review

This section focuses on literature review. The first part of this section elaborates upon supply chain management and its evolution in the construction industry following which the difference between construction supply chain and manufacturing supply chain is established.

The next part of this section, the logistics department is broken down into the various sub categories it entails. The decisions made result in the final configuration of construction supply chain. Hence these decisions were analyzed to see how they affect costs and GHG emissions.

Following this Lean SCM and Green SCM paradigms will be reviewed and they will be analyzed to see how the practices of each paradigm fit in the previously listed phases and what effect it has on costs and GHG emissions.

This section partially answers the following research questions

1. How do Lean SCM practices affect costs and GHG emissions of supply chain?
2. How do Green SCM practices affect costs and GHG emissions of a supply chain?

2.1 Introduction to Supply Chain Management

According to the premier association of supply chain management, SCM is defined as the process from initial raw material extraction to the ultimate consumption of the finished product linking across supplier-user companies (APICS Dictionary, 1995). Supply chain management is the involvement of all activities and functions that are part of a value chain which delivers a consumable to a customer. A supply chain can be broken down into multiple value chains and pipelines.
A supply chain consists of multiple firms, each of these firms have a value chain that contributes to the overall supply chain of a product. Hence a value chain is a sub part of a supply chain; it is the function of each firm involved in the supply chain that adds value to final product (Fredendall & Hill, 2016). A product is formed by the assembly of multiple parts; each part has a supply chain of its own and is called a pipeline. Every value chain of a pipeline consists of information flow and money flow which is very important, information exchange is important to ensure smooth operations of the supply chain. Money is an important aspect in every industry and every supplier aims is to maximize output and lower input.
(Stadtler, Kilger, & Meyr, 2015) in their book on supply chain management, define supply chain as two or more legally bound organizations that are connected through material, financial and information flow.

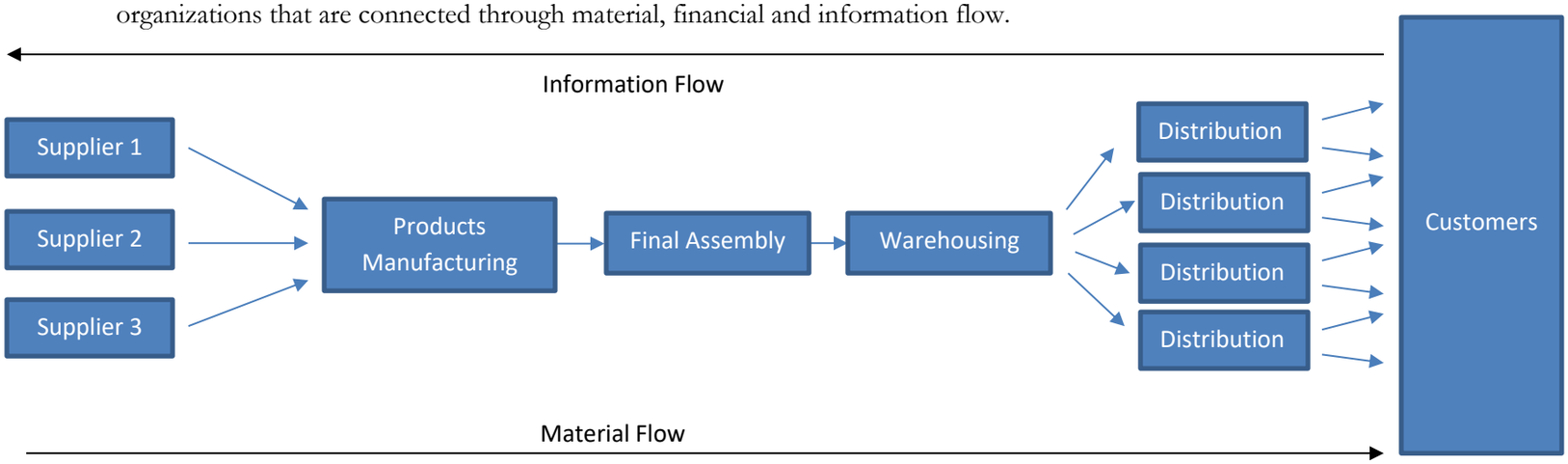

Figure 2: Example of a supply chain (Hartmut Stadtler, 2015)

Further, to better understand a supply chain and make it comprehendible, the supply chain council has developed a supply chain operations reference model (SCOR). The SCOR model splits a supply chain into plan, source, make, deliver and return.
The plan aspect of a supply chain entails balancing of supply and demand by chalking out an action plan which consists of sourcing, production and delivery.
The source aspect deals with purchasing and procuring suppliers and other services such as transport and inventory. This stage focuses on supplier relation, contracts and performance assessment.
The make stage is where the procured materials are assembled to form the final product. The focus lies on making the process efficient ensuring quality, cost and time control. It is a continuous improvement process where in output needs to be maximized keeping input low ensuring high quality.
The delivery stage is when the finished products are either delivered to be stored in a warehouse or to final customer. This stage focuses on managing inventory level, orders and transport.
The final stage which is the return stage, involves the taking back of items. Items are taken back for multiple reasons; recycling, quality issues, disposal etc.

2.2 Supply chain management principles

Supply chain management originated in the manufacturing industry as a paradigm that integrates manufacturing, procurement, logistics and distribution. It is the management of product and work flow through the various departments from manufacturing to customer delivery through integration and collaboration at various levels ensuring higher delivered value and lower costs to the customer. SCM compared to traditional forms ensures complete optimization through throughput, inventory, material and costs. It is a formal process that enables organizations achieve collaboration both upstream and downstream. SCM strategizes to bring all suppliers, manufacturers and vendors together to achieve transparency, visibility, knowledge sharing, trust, information flow and co-operation. The first step toward achieving the above is to move from procuring suppliers through lowest cost to procuring them based on quality and develop a relational based contract. But this is not as easy as it is said; in business money is the main driver that leads to insecurity and distrust among members, (Khalfan, McDermott, & Cooper, 2004) in their article suggest that the best way to break the barrier is through soft skill development and improved communication. A well-managed supply chain can lead to 10%-17% reduction in costs (Vrijhoef & Koskela,2000) reinstating the importance of optimizing this department. Its growing popularity and benefits in other industries led to researchers in the construction industry to adopt it within their scope of work.

2.3 Supply chain evolution in construction

The construction industry up until the 90's was grappling with cost over runs and heavy waste being generated across their supply chain. It was then that researchers started looking towards the manufacturing industry to adopt their supply chain management practices to make the construction supply chain more effective and efficient.

According to Malik Khalfan (2004) it was the mid 90's that the construction industry based on research carried out, started implementing supply chain management (SCM) in their practice. SCM mainly focuses on integration of all the various departments that constitute a supply chain to the point where Maqsood and Akintoye (2002) suggest that SCM is just another word for partnering. Construction supply chain consists of waste and problems mainly caused due to myopic control, this problem gets enhanced due to the interdependency of events and delay caused in one event manifests in terms of costs over run and delays in another (Vrijhoef & Koskela,2000). Though there is interdependency, the highly fragmented nature of it makes it difficult to cooperate and coordinate activities. To add to fragmentation in works, the complexity, exclusivity and its ever-changing dynamics has always posed problems that cannot be fully resolved using any one type of management technique.

Before the adoption of SCM the other paradigms that were present in the construction industry were Total Quality Management, Concurrent Engineering, Business Process Redesign and Just in Time Delivery. SCM is a build-up of these mentioned paradigms, Saad et al. (2002) in their article mention how the construction department moved to SCM without trying and testing the other paradigms enough.

But these paradigms allude to integration and collaboration as the main strategy to achieve reduced costs, lead times, construction time etc. SCM is more all-encompassing strategy that takes in to account the principles of the various strategies. This very nature of SCM has made it a more attractive option to implement in the construction industry.

2.4 Supply chain management in the Construction industry

As mentioned earlier SCM took prominence in the construction industry in mid-90. But the construction industry is very different from the manufacturing industry in approach and design, the manufacturing industry churns out volumes of similar or differentiated products which most of the time require the same expertise, material, process and is in the same location. This has led manufacturing industries to develop long term contracts with their suppliers and distributors, but construction industry is known to produce differentiated products situated in distinct locations for a set period with greater dynamics than the manufacturing industry requiring different knowledge and expertise every time. This very short term, fragmented and differentiated nature of the construction industry along with government tendering rules has made long term collaboration with suppliers and contractors difficult (Dubois & Gadde, 2002). The knowledge sharing and trust build up amongst the parties involved is never fully exploited (Dubois & Gadde, 2002). But on the outset, it could be compared to a manufacturing industry given that both produce a product for an end customer.

Hans Voordijk,(2003) in their article compare the supply chain of an aerospace industry and construction industry. The paper elaborates on the similarities and the practices that can be adopted from the aerospace industry to the construction industry. The article concludes by stating that both industries are not that different and there is potential for Xeroxing practices to construction industry.

The Xeroxing of SCM from manufacturing to construction industry has had large reaching benefits. Malik Khaflfan,(2004), mention how SCM helps streamline objectives to achieve common goals to improve productivity and reduce waste, share problems to coming up with more enhanced solution due to collaboration, reduces stress and aggravation, develop a no blame culture; mutual understanding and enhanced reputation.

2.5 Differences in supply chain in manufacturing and construction

As mentioned earlier, SCM originated in the manufacturing industry as a ripple effect of just in time delivery(JIT) in the Toyota production system (Shingo, 1988). SCM is predominantly logistics but also encompasses other departments (Cooper, Lambert, & Pagh, 1997)
The manufacturing supply chain and construction supply chain have some distinguishing characteristics. In a construction supply chain unlike manufacturing a single product for a single client is being produced or built, every construction project is different from the other unlike manufacturing wherein it is mass production most of the times, the location of production is different every time in construction whereas in manufacturing it is always in one factory location, construction projects last longer and spans years in comparison to manufacturing, and economies of scale doesn't exist in construction (Serpell & Heredia, 2004). But the fundamental similarity of both industries is that they both produce a product for end customer use, there is customer demand and each of the industries supply to meet the demand. Below the construction and manufacturing supply chains are depicted.

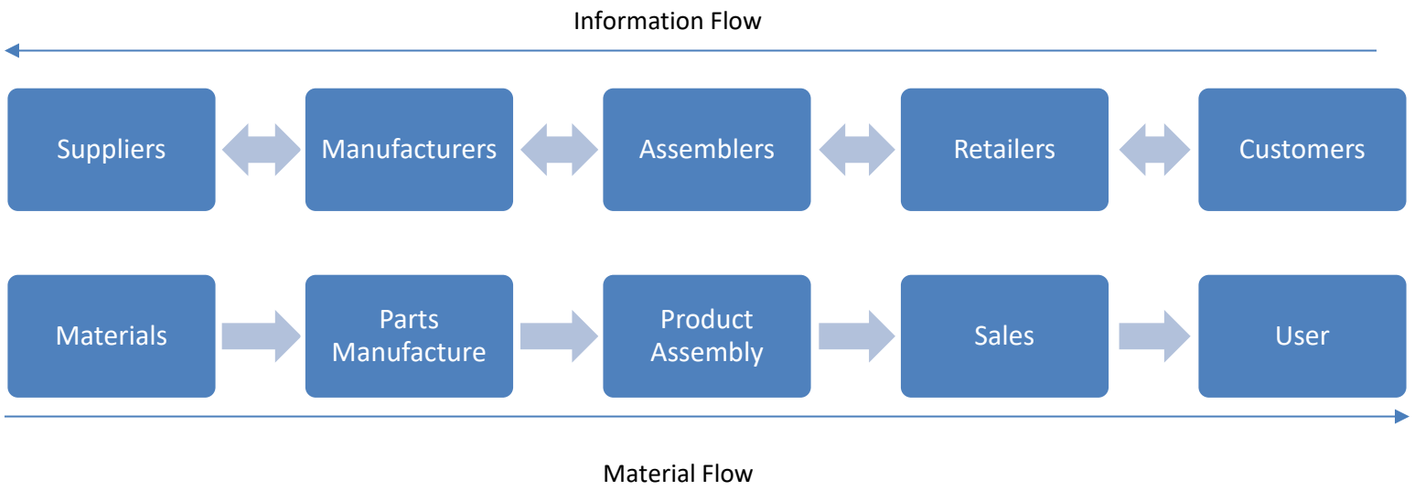

Figure 3: Supply chain of manufacturing company (Ruben Vrijhoef, 2000)

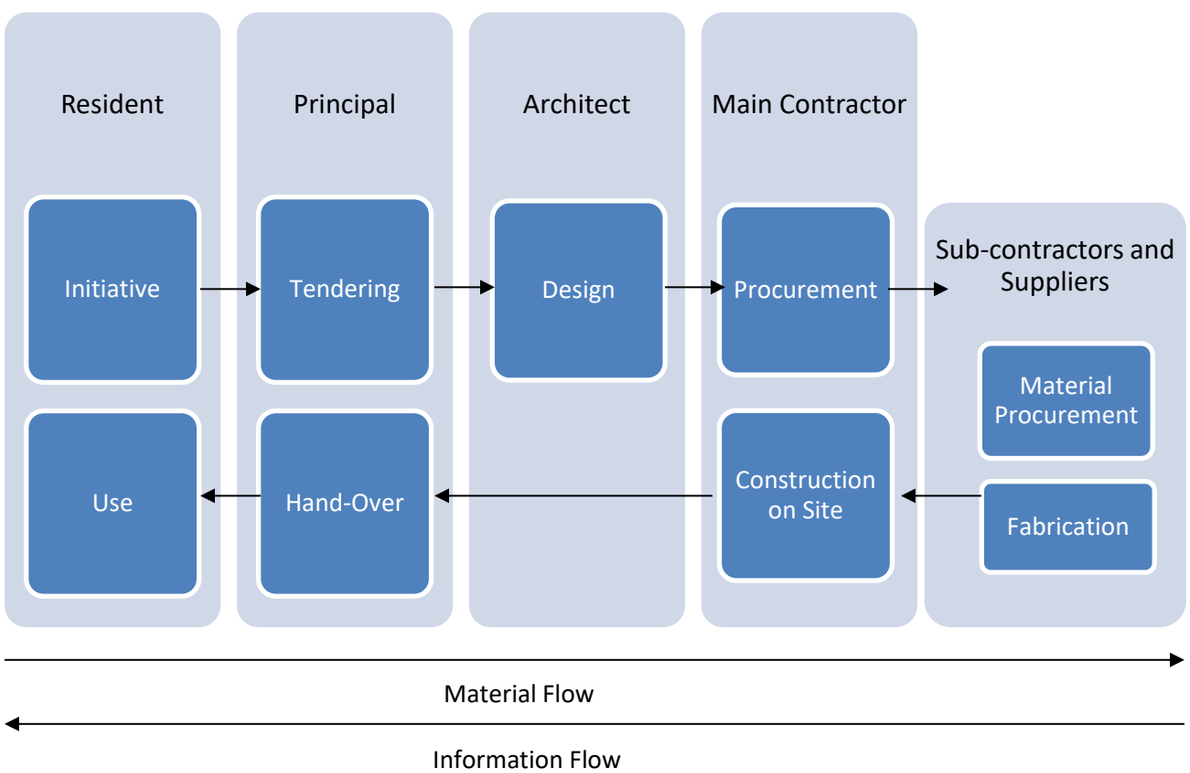

Figure 4: Supply chain of Construction Company (Ruben Vrijhoef, 2000)

2.6 Logistics in Supply chain management

Logistics has been defined by professionals from industries as the process of delivering materials to the right location at the right time in the right quantity and quality at the lowest costs or as the process of managing transport, inventory of materials in supply chain through value adding methods to end user (Lundesjö, 2015).Though supply chain functions involve production, marketing, sales, purchasing, logistics, R&D and finance, most research focuses on logistics and purchasing thereby reinstating the importance and dominance of it in SCM and supplier-buyer relations (Rezaei, Ortt, & Trott, 2015).Logistics comprises of five key elements; transport, warehousing, inventory, packaging and information processing. Transport forms the major component of Logitics (Meier, Zahurul Islam, Aditjandra, Zunder, & Pace, 2013). There are three aspects in construction logistic that need to be coordinated to ensure successful project delivery and they are; complete project logistics, supply logistics and onsite logistics (Sobotka, Czarnigowska, & Stefaniak, 2005). The logistics department of a construction project account for 60-70% of the total budget (Bell & Stukhart, 1986). Efficient management of logistics not only reduces operational costs but also increases labor productivity thereby reducing construction delays and costs further (Norman, Agapiou, Clausen, & Notman, 1998). The costs involved in logistics and the importance of it in labor productivity reinstates the need for optimizing this department of Supply Chain to reduce costs.

Environmental pollution caused by construction projects and construction transport in specific has been a rising issue in Europe, and the EU is setting stringent targets to reduce CO2 emissions especially in the transport sector of construction as it accounts for 30-40% of total transport (Vrijhoef). Transport is the primary cause of emissions in logistics and other aspects such an inventory also contributes to emissions (Antoni, Perić, & Čišić, 2015). In line with the above said, reducing GHG emissions in construction should start in the logistics department and specially the transport sector as major gains are visible in this area.

From the above said it can be concluded that Logistics plays and key role in costs and GHG emissions of a supply chain. Inventory and Transport are the two prime sectors of logistics wherein initial benefits can be achieved. Below, the emergence of Costs and GHG emissions in a construction supply chain logistics will be explained.

2.6.1 Costs

Supply chain management covers a broad array of activities but is largely dominated by logistics (Vrijhoef & Koskela,2000). Logistics is a major contributor to the construction costs. In a typical construction project, material would cost 50-60% of total costs and transport would account for 30% of these costs (Ying, Tookey, & Roberti, 2014).

Construction projects are carried out in fixed locations where materials, equipment's and resources are delivered. A building construction process is complicated in terms of the components involved, multiple components need to be assembled to form the final product, each of these components require materials that need to be procured, delivered and assembled. Logistics predominantly deals with procuring, storing, packaging and distribution of these materials. In relation to this the primary costs incurred are; loading, transport, handling, unloading, storage, packaging, maintaining and distributing. The secondary cost incurred are machinery costs, costs of information sharing, costs of personnel, costs of material damage and opportunity costs of inventory (Amornsawadwatana, 2005).

From the above-mentioned costs, Transport and inventory form a substantial chunk of construction costs, which if not managed well affect the overall efficiency of the workforce which will in turn inhibit delivering the project on time, budget and quality (Almohsen & Ruwanpura, 2011).

Logistics management can negatively affect the overall construction process if not managed well. Inefficient material delivery is one of the major contributor to project delays; late delivery, unreliable supplier, damaged material, poor planning, inferior quality control, inefficient communication are the constituents of inefficient material delivery (Afshari, Khosravi, Ghorbanali, Borzabadi, & Valipour, 2011). Optimising transport and inventory will help reduce these costs across the logistics department of a supply chain.

To conclude, the value to the end customer is focused on giving products to the customer at the least possible costs there by maintaining a profitable price benefit ratio. Hence, steps to optimise key departments like logistics is important to achieve overall efficiency in a construction process.

2.6.2 GHG emissions

Greenhouse gas emission happens at every stage of a logistics process. It spreads from material procurement to the end of life recycling phase. The supplier decision, ensuring the supplier is procuring materials that are responsibly sourced, the energy used in manufacturing of the product, the type of mode used for delivery, the use of inventory and the end of life recycling are the various stages that lend to GHG emissions.

The national and international regulations in relation to GHG emissions has also resulted in many organizations looking towards reducing their greenhouse gas emissions (Dunphy, 2015).Globally, construction accounts for 40-50% of the total GHG emissions (Seo, Kim, Hong, & Kim, 2016), a large part of these emissions arise from the material manufacturing, transportation and construction stages (Jeong, Lee, & Huh, 2012).Construction transport alone accounts for almost 10% of these GHG emissions (Ying, Tookey, & Roberti, 2014)

For improving the reporting of GHG emissions of companies, the GHG protocol has defined the emissions under three different scopes:
Scope 1: Direct Emission; direct emission is a result of operations and activities owned by the company, in the case of this report would primarily be transport.
Scope2: Indirect Emission, indirect emission is result of electricity consumption which is purchased. This in the case of the report will relate to electricity used in inventory, site assembly and equipment use.
Scope 3: It refers to other indirect emissions which are a consequence of the operations of the company, they arise from sources owned and operated by another company (Green House Gas Protocol).

As per the GHG protocol the causes of GHG emission can be categorized under the 3 scopes:
Scope 1:

- Fuel consumption
- Production of electricity or heat
- Emissions from running electrical appliances and materials

Scope 2:

- Use of purchased electricity

Scope 3:

- Employee commute
- Emissions from manufacturers
- Emissions because of third party work

As mentioned earlier the value to end customer is focused on lowering costs. But with growing awareness of environmental changes, adopting green in daily activity has become value adding to customer. The customer is ready to pay the additional amount if he in turn is receiving the added value through going green.

Though the emergence of GHG emissions is associated with transport, the other sectors like manufacturing, electricity consumption and waste disposal also emit GHG's but the focus will be on logistics.

The calculation and reporting of GHG emissions can be done in multiple ways. LCA is used for estimating the GHG emissions emerging from product production and storage. For calculating the emissions from transport, there are two methods; energy based approach and activity based approach. Energy based approach focuses on the amount of fuel used or burnt this is hard for most organisations to keep track of and hence the activity based approach is adopted, the activity based approach is calculated using the distance travelled, weight of the good being delivered and the transport specific GHG emission factor. The transport specific emission factor is an important aspect of the formula as there is a significant difference for different transport modes.

Total Emissions = Distance x Weight (or Volume) x Emission factor (Weight, Volume or Distance)

Apart from transport, the other sources of GHG emissions are product manufacturing stage, energy used in manufacturing the product, storage, assembly then end of life. This is called the product life cycle emission. This can be significantly reduced by ensuring responsible procurement of materials, designing for easy manufacturability, assembly and dis-assembly ensuring low usage of equipment thereby using less electricity.

2.7 Logistics and its effect on costs and GHG emissions

The section below will elaborate on the key elements of logistics and its effect on costs and GHG emissions.

Logistics management comprises of five key elements (Meier, Zahurul Islam, Aditjandra, Zunder, & Pace, 2013):

- Transport management
- Warehouse management
- Inventory management
- Packaging and unitization
- Information Processing

2.7.1 Transport Management

Transport is an important phase in construction logistics and one of the phases most overlooked during the planning stages (Ahmadian, Akbarnezhad, Rashidi, & Waller, 2014). One of the main reason for project delay as per literature and academia is the delayed delivery of materials to site (Fallahnejad, 2013), hence efficient planning of transport of materials to site is important to ensure timely delivery of projects. However, timely delivery of materials to site is a difficult job considering the uncertainties and number of parties involved in a construction project.

With globalization, mass consumption, economies of scale of production and increasing importance of outsourcing, have resulted in products being manufactured in areas that do not coincide with area of demand emergence. This has resulted in the need for additional transportation (Suchanek, 2016). The longer the distance between supplier and consumer greater is the transport costs; these also affect other aspect of the logistics department such as inventory costs. Transport also accounts for a huge portion of the construction GHG emissions and is also a sector for potential gains. Michael Browne in his book the challenge of construction Logistics categorizes the product characteristics into three distinct categories that will define the distribution pattern:

- Volume to weight ratio: low volume to weight ratio products are cheaper to ship compared to higher ratio as the former tend to fully utilize the carrying capacity of a vehicle.
- Value to weight ratio: Higher value to weight ratio tend to lower transport costs as higher value is being delivered compared to lower value to weight ratio.
- Special characteristics: The fragility, perishability and toxicity of a product also determine the distribution pattern.

Construction process in general is long and during the course of the process materials will be transported to site in phases, these need to be planned in advance to ensure the materials are being delivered at the right time when required and labor is not idle (LIST, 2017). Retail construction projects are carried out in bustling city center where access and delivery becomes a challenge.

Apart from delivery distance and volume shipped another important aspect that affects costs and GHG in transport is the mode of transport adopted. Transport modes affect costs and GHG emissions. Truck and air are expensive and emit higher CO2 emissions compared to rail and sea respectively (Anten, Van Amstel, & Verweij, 2014).

Opting rail over truck and sea over air might not be possible in all cases given accessibility issues hence; intermodal transport can be a strategy to adopt to ensure reduced emissions and lowered costs.

Another important aspect of transport that affects GHG emissions is the loading factor. Trucks running full, emit lower GHG per product shipped than trucks that run half empty (McKinnon & Piecyk, 2010). (Meier, Zahurul Islam, Aditjandra, Zunder, & Pace, 2013), mention the key components of transport management which will be elaborated below.

Transport management comprises of five key elements.

- Infrastructure
  Transport infrastructure is the availability of roads, railways, waterways and airways to carry out transportation. Infrastructure plays a key role in transportation as in certain cases required infrastructure is not available to carry out transport. The development of transport infrastructure is highly dependent on the government bodies of region.

Costs: The availability of good infrastructure for transportation reduces costs as there are wider options to choose from, there is accessibility to every location thereby eliminating the need to use special ways to get to certain remote locations and well-maintained infrastructure means less strain on vehicles thereby reducing the load on vehicles which in turn saves on fuel and maintenance costs.
GHG Emissions: The availability of rail or waterways to transport goods results in lower GHG than truck or Air. But in certain situations, as there is no existing railways or waterways connecting two places, truck or airways are chosen which tend to emit higher GHG emissions.

- Transport Mode Options
  Transport mode options is the use of different modes of transport; rail, water, air, road, intermodal etc. The choice depends on costs and time required to deliver items.
  Costs: The choice of mode of transport plays and key role in total costs of transport. Air transport is the most expensive option out of the existing but is also the fastest, road on the other hand is the common mode transport opted which is cheaper than air and takes longer time to deliver than air but is faster than Rail and Sea. On the other hand, though rail and sea take longer time to deliver they are considerably cheaper.
  GHG emissions: Opting for rail and sea over truck and air have significant benefit in terms of GHG emissions as the former have lower emission factors.

- Modal transfer points
  Modal transfer point refers to locations where mode of transfer needs to be changed for further distribution. Modal transfer point is connected to the last element in transport management which is Routing and Scheduling.

- Load planning
  Load planning refers to the loading unit on the cargo and stacking on the cargo. Efficient stacking of cargo units has a major impact on costs and GHG emissions. Costs and emissions can be reduced as efficient load planning helps reduce number of shipments, most organizations are using manual load planning which has proven to be inefficient as it is time consuming, load planning needs to consider the ability to stack cartons, the size of cartons and type of packaging based on which the type of truck needs to be chosen (Krishna & Sahay, 2017). Efficient load planning also ensures fuller trucks thereby reducing LTL (Less than truck load) shipments which in turn reduce GHG emissions arising from running half empty trucks. Another important aspect of load planning is distribution of weight, there is a certain load per meter square that can be placed on a truck which needs to be adhered to ensuring truck safety (Costa & Captivo, 2016)
  Costs: Stacking more cargos efficiently reduces costs of transport per pallet and also reduces fuel consumption.
  GHG emissions: reduced fuel consumption intern results in lower GHG emissions.

- Routing and scheduling
  Transport routing and scheduling plays a key role in transport management. Planning the optimal routes and scheduling have significant impact on costs and GHG emissions. Vehicle routing needs to take into consideration multiple aspects such as, time of delivery, driving time constraint, truck load that can service the various locations and pick & delivery options (Sbihi & Eglese, 2007).
  Costs: Efficient planning of routes and scheduling pick up and deliveries can reduce costs if done efficiently. Circuit delivery can be achieved with preplanning and scheduling the pick and deliveries, which reduces costs as trucks pick up good and deliver goods thereby eliminating empty truck returning after delivery.

GHG emissions: efficient planning of routes and scheduling circuit delivery can reduce GHG emissions as it eliminates longer inefficient routes chosen, there are lesser trucks on road and trucks are not returning empty.

2.7.2 Warehouse Management

Warehouse management contrary to inventory management refers to the choice of location, size, number, type and handling system within a warehouse. Warehouse is a crucial part of logistics management that helps in efficient distribution of goods, warehousing is expensive in terms of required labor and equipment (More, 2016). In construction, purchasing and storage of materials are integral to the success of a delivering a construction project hassle free (Scherer & Schapke, 2011).Warehouse management entails receiving materials, stacking them using handling systems, maintaining stock count and withdrawing from stock when required (Shabtai, Bock, & Stoliar, 2014). Below the key elements of warehouse management are mentioned.

- Location
  The location of the warehouse is crucial for business operations. The warehouse needs to be strategically located to service the various sites. The location of the warehouse impacts delivery costs, time and GHG emissions based on its distance from the location of construction.
  Costs: Based on the region of operation, the warehouse needs to be strategically located to ensure it is effectively located to all construction location. The farther the construction location from warehouse the greater will be the delivery costs.
  GHG emissions: As mentioned in costs the greater the distance between construction location and warehouse the higher will be the emissions per shipment.
- Number
  Many organizations operate with more than one warehouse for servicing their construction locations. The number of warehouses and its effect on cost and GHG can vary from one organization to another. Some operate from multiple warehouses as projects are being carried in different countries and servicing from one single warehouse can increase transport costs and time.
  Costs: More the number of warehouses, the higher will be the costs of maintenance and storage but this need to be analyzed in conjunction with transport distance and costs. The costs of warehousing need to be weighed against transport costs to know if more number of warehouses are cost efficient or not.
  GHG emission: Warehousing lends to GHG emissions via the use of electricity to maintain and run the warehouse. The more the number of warehouses an organization uses the greater will be the emissions, but like costs these need to be weighed against transport GHG emissions to study if multiple warehouses are green friendly or not.
- Size
  The size of a warehouse is an essential element in warehouse management. The warehouse shouldn't be too big or small for storing goods.
  Costs: Excess unused space would mean increased costs for an organization as space that is being paid for is not being utilized. Small warehouse would mean not enough inventory storage space which could potentially lead to low stock or no stock.
  GHG Emissions: If the warehouse space is not being utilized, unnecessary electricity is being utilized wherein there is no stock. This leads to higher GHG emissions for space that is not being utilized.
- Type
  This refers to the type of goods being stored if it is refrigerated or if they garment or electrical appliances etc.
  In general storage of refrigerated items consumes more electricity thereby emitting more GHG emissions.

- Cargo Handling System
  Cargo handling system is the use equipment's within a warehouse that help in maintaining and operating a warehouse like decks, truck docks etc.

2.7.3 Inventory Management

Construction involves the use varied materials that requires inventory storage, especially in the case of retail store development where multiple store constructions require the same materials. Having inventory of materials helps meet dynamic demand and costs benefits by negating escalation in material costs. But over stocking can lead to materials having to be thrown away due to lack of demand and increased inventory costs, hence a right balance needs to be struck. Materials constitute 40% of the total construction costs, and stocking material inventory helps in meeting construction uncertainty (Jung, Han, Soon Im, & Kyu Ryu, 2007).
Inventory management involves making the following decisions (Meier, Zahurul Islam, Aditjandra, Zunder, & Pace, 2013):

- What to stock?
- Where to Stock?
- How much to stock?

How much to stock is a major decision to make in terms of costs and GHG emission optimization. There are two concepts in inventory stocking, the "pull" and the "push". The pull technique is just in time delivery wherein products are delivered only when required and hence there is zero inventory which saves on inventory costs but increases transport costs as small lots are delivered frequently. The push concept is stocking materials based on forecasted demand; this incurs inventory costs but has lower transport costs as bigger lots are delivered at lower frequency (Meier, Zahurul Islam, Aditjandra, Zunder, & Pace, 2013).

Michael Browne in his book the challenge of construction logistics categorizes inventory costs under three key elements:

- Physical cost of stock holding
- Opportunity cost of stock holding
- Costs of good loss during storage

The inventory capacity also determines transport required as smaller the inventory then less material storage space which means faster depletion of materials thereby increasing replenishing frequency. Inventory storage and transport are interlinked and hence need to be looked at as part of a bigger picture.

Inventory management and the strategic decision of how much to stock, where to stock and what to stock and its effect on costs and GHG Emission will be elaborated below.

- What to stock
  Based on the operations of organizations, the items that are used more frequently and have greater lead times are stored to stock.

Costs: Stocking items that have low demand and are easily perishable will lead to increased costs and items being written of or disposed due to damages. The choice of item to be stored needs to be made considering lead time, demand and fragility.
GHG emission: maintaining more than required material and fragile material that have higher chance of damage results in wastage of electricity used to maintain these products.

- Where to stock
  Where to stock is a two-part decision. The first one is the location of warehouse and second is the location of storage within the warehouse. Storing items that are used frequently in lower racks makes accessibility easier and negates the need of equipment's to access them if placed in the upper racks. This reduces costs and GHG emissions arising from operating the equipment's.

- How much to stock
  How much to stock is another key decision related to lead times and frequency of use. The number of items to be stocked needs to be accurately forecasted and stored.
  Costs: Storing more than required items will lead to increased storage costs and items being written off which lead to sunk costs of money spent on purchasing the items.
  GHG emissions: maintaining over stock consumes electricity which leads to higher GHG emissions.

2.7.4 Packaging and unitization

Packaging the product and unitizing is an important aspect of logistics and this decision is highly dependent on the value of the product. The costs for packaging and unitizing high value goods will be higher and raw material cost must be relatively lower. The type of packaging has an impact on GHG emission dependent on the material used for packaging. There are ecofriendly alternatives available for packaging that have lower GHG emission arising from manufacturing and final disposing. Packaging has an impact on the efficiency of logistics as packaging information, protection and standardization affects the other operations in logistics such as transportation, inventory and warehousing (Saghir, 2004).

- Unit Size
  Standardizing the unit size will decrease handling costs, loading and unloading time and increases choices of transport mode thereby decreasing need for special equipment (Saghir, 2004). Hence standardizing the unit size not only reduces costs but help achieve lower emission through options in modal transport choices. Standardization also decreases material handling costs at the warehouse.
- Protective packing
  Protective packaging will help reduce damage to product in transit but also adds to the weight of the shipment thereby increasing transport costs and in turn GHG emissions, it also affects the stack ability in the container. Tradeoffs need to be made depending on the cost of good damage and effects of protective packaging.
- Packaging Information
  Information regarding packaging size, weight and type will reduce shipment delays and time spent on tracking shipments (Cooper, Lambert, & Pagh, 1997).

2.7.5 Information processing

Efficient information processing and sharing is important to achieve integration in a logistics process. Information sharing provides everyone involved with comprehensive knowledge of the supply chain that enables efficient decision making, the information shared should be reliable, complete and useful (Nowakowska-Grunt & Nowakowska, 2012).

- Information system
  Information system is the platform adopted by organization to share relevant information and process them. Electronic Data Interchange(EDI) and web technologies are the most generic form of information sharing system adopted by organizations. They increase the efficiency of logistics planning and decision making (Lotfi, Mukhtar, Sahran, & Zadeh, 2013).

- Forecasting
  Forecasting is the processing of information to ensure supply meets demand. Accurate forecasting will ensure the production of right amount of goods so that there is no surplus that will result excess costs or shortage which will result in lost revenue.

2.8 Discussion

Clear majority of building GHG emissions arises from the operational phase, but over the years with growing technology the building industry has been able to curb the emissions from the operational phase with efficient design and use of better appliances. What has been neglected and has little research is the non-operational phase, which constitutes the material procurement and construction phase. Reduction in these initial stages will have greater impact over the entire life cycle of the building (Dunphy, 2015).

Scope 1 emissions are directly influenced by own operations of the organization and is a department where major gains can be realized if well organized and one third of global CO2 emissions is caused by transport activities (Pejić, Lerher, Jereb, & Lisec, 2016) of which construction sector is a major contributor.

Transport is considered a very important phase in construction as it can delay a project if not well managed and accounts for 20% of total project cost (Ahmadian, Akbarnezhad, Rashidi, & Waller, 2014). As it can be inferred from above, efficient transport and inventory management has positive effect on the site installation phase or the construction phase as timely material delivery ensures there is no idle labor or machinery. Transport and inventory lend to scope 1 and scope 2 emissions respectively wherein there is potential to optimize, control and steer as per needs.

2.9 Why Lean SCM and Green SCM over Sustainable SCM

Sustainability is defined by the Brundtland commission as

"Sustainable development is the kind of development that meets the needs of the present without compromising the ability of future generations to meet their own needs"

There are three discourses that help achieve sustainability; environment, economic and social discourses. Sustainability over the years has been associated mostly with the environmental discourse; it's the relationship between human beings and the nature surrounding them. The social discourse as the definition of sustainability mentions future generation; it is taking note or ensuring social equity in terms of health and resources. The economic discourse is related to organizations and firms who need to make choices that are profitable but also benefit society and nature (Giovannoni & Fabietti, 2013). (Halldorsson & Kovacs, 2010) Classify sustainable supply chain into two perspectives. Micro perspective that focuses on reverse logistics, carbon footprint reduction and supplier management and a macro perspective that deals with the business environment of a supply chain.
From the above it can be noted that sustainability focuses on three aspects which are also called the triple bottom line, this report focuses on reducing carbon footprint which is a sub aspect of the micro perspective of SSCM. Adopting a sustainable supply chain approach will broaden the scope of the thesis whereas the aim of the thesis is to reduce GHG emissions and costs. These are related predominantly to environmental and economic discourses. Hence instead of choosing sustainability as paradigm for this report, lean and green paradigms are adopted which narrow down the focus to greenhouse gas emission and cost reductions.

2.10 Lean supply chain management

Lean SCM originated in the Toyota car manufacturing industry and has ever since been copied to the context of other industries which want to enjoy the similar benefits that come with application of Lean SCM principles, the main key performance indicator for Lean SCM practices is costs (Lerher, Pejic, Jereb, Kramberger, & Rosi, 2016). Lean SCM system aims to reduce "Muda","Mura" and "Muri" which in turn adds value to the final product. Muda is waste, it is process related wastes that need to be brought to light and mitigated appropriately. The goal of Lean SCM is to remove non-vale adding activities to reduce production costs thereby delivering increased value to customers (Villarreal, Garza-Reyes, Kumar, & Lim, 2016). Seven types of Lean principle waste have been identified;

- Transport
- Inventory
- Motion
- Waiting
- Overproduction
- Over processing
- Defects
- Skills – 8th waste added later.

The system must be analyzed to eliminate the above possible waste emergence. The first toward achieving this is by following the 5 lean principles;

Identify the value: Chalking out customer needs. This will help structure the process centered on the customer, what do they expect? What is the ideal price point?

Map the value stream: This involves mapping the entire process and intermediate activities involved from material procurement to assembly and then final delivery. This process will help in figuring out the interdependency, the various steps involved and then removing the steps that do not necessarily fit.

Create flow: following the value stream map wherein all the waste has been identified and removed, the next step would be to smoothen the flow, making it "U" shaped by removing all the bottle necks and making sure the process is less convoluted. This can lead to huge process efficiency.
Establish pull: after a systematic flow has been created the next step is to ensure that the products are being built or produced to the customer demand and there is no stock pile up or inventory over load. Rather than pushing the product, the products must be pulled.

Seek perfection: The above-mentioned steps need to be perfected on a regular basis. The process is deemed lean only if it is being adopted by various members in the organization. It must go through a bunch of iterations to ensure perfection and complete permeability of the concept.
The above mentioned 5 steps; the first two steps identify value and the first part of value stream is analysis steps to understand the organization and its orientation, the current process or practice and understanding the organization as a system. The second part of value stream map and the following three steps; create flow, establish pull and seek perfection are activity implementation steps. This is where real time activities or changes need to be brought about in the current functioning
Once the waste has been recognized the various lean tools and techniques can be used to tackle each type of waste realized.

2.10.1 Wastes and Lean practices

Transport
This is the waste arising from unnecessary movement of materials, people and equipment that do not add value to the final customer. Sending incorrect materials, damaged material from one location to another are examples of transport waste. Transport requires, personnel, equipment and machinery which are wasted when unnecessary transport is carried out which results in additional costs (Okpala, 2014).
The major causes of transport waste as delineated by (Okpala, 2014) are; maintaining different warehouses, heavy batches, complicated material handling, inefficient layout and over-production.

Practices to reduce transport waste
The article by (Remigio, Azevedo, & Cruz-Machado, 2010) mentions the various lean practices that have been mentioned by other authors and they will be used here.

- *Just in Time*: is one such practice that ensures wasteful transportation, wasteful in terms of unnecessary as it focuses on delivering when it is needed.

- *Procurement consolidation:* consolidation plan that brings together materials at one location and then deliver it is another practice that ensures unnecessary transportation
- *Cross docking/compound delivery*
- *Milk run/circuit delivery*
- *Third party logistics*

Inventory

This waste is a result over stocking which results in increased inventory space and stock holding costs. Excessive inventory risks products becoming obsolete, damaged, and stolen (Okpala, 2014) . The main reason for excessive inventory is lack of planning and forecasting.

Practices to reduce Inventory waste

- *Supplier long term relationship*
- *Increased information sharing*
- *Vendor managed inventory*
- *Lot size reduction*

Motion

It is the unnecessary motion of people searching or unnecessarily moving around to complete a task. This thereby results in time being wasted and as result increased project costs. The main reasons for waste emerging in this sector is, poor layouts, workforce not trained well and inefficient process design.

Practices to reduce Motion waste

- *High involvement work systems*
- *Information sharing*

Waiting

This waste is generated when manpower and machinery are idle because information, resources, material or supplies aren't available on time. This leads to huge cost over runs and project time delays. The main reasons for the emergence of waste in this sector is due to; shortage of material, inefficient planning or because of other six wastes (Lantech, 2013).

Practices to reduce Waiting waste

- *Concurrent engineering*
- *High involvement work system*

Over production

Producing more than what is required leads to one of the worst Lean wastes. More than demanded goods are produced where supply exceeds demand and hence results in waste and idle inventory. Over production like excessive inventory ties down

costs, it also results in product going obsolete, increased damage and deteriorating quality. Reducing wastes from over production, help reduce costs, makes system more responsive and efficient, inventory is not cluttered and valuable resources are not wasted (Okpala, 2014).

Practices to reduce over production waste

- *Demand of customer real time*
- *Demand stabilization*
- *Production planning and control technology*

Over processing

Over processing is a waste that uses more resources than what is required. A more expensive and complicated option is chosen when a cheaper and quicker process can be adopted. Over processing adds no additional value to the final product and is considered a waste.

Practices to reduce over production waste

- *Supplier involvement in product development*
- *Design for manufacturability*
- *Parts/work standardization*

Defects

It is very common form of waste that results in product that is defective. In the construction industry, this could be translated to products that arrive to location defective (broken) due to improper packaging or sending the wrong item.

Practices to reduce defect waste

- *Supplier relationship*
- *Training and development*
- *Built in quality system*
- *Customization*
- *Total quality management*

Human potential

It is the underutilization of employee's talent in an organization. Not recognizing talent and encouraging innovation.

Practices to reduce human potential waste

- *Employee training and development*
- *High involvement work system*

2.10.2 Lean in construction supply chain

First appearance of Lean SCM in construction was seen in supply chain. Up until then traditional SCM practices where being followed and the increasing popularity of Lean SCM led to the adoption of it to the construction industry. The productivity of the construction industry has been decreasing over the years, a study conducted in the UK suggested that up to 30% of construction is rework, labor efficiency is only 40-60% and 10% of materials are being wasted (Aziz & Hafez, 2013). The existence of this waste has resulted in decreased productivity and hence practitioners have turned to lean to improve the current situation.
The benefits of applying lean to the construction industry according to Odgaard(2005) is:

- Job satisfaction
- Health and Safety
- Consensus
- Fewer conflicts
- Better quality
- Higher profit
- Reduced Building Time
- Customer Satisfaction
- Information/knowledge sharing

But the complete diffusion of Lean SCM into the construction industry like in the manufacturing industry hasn't happened, most research attribute this to the lack of knowledge and research in the field on lean construction. A lot of research exists in Lean manufacturing but not as much when it comes to Lean construction (Barker, 2008). The existence of a supply chain for just the duration of a single project is another reason why practitioners haven't been able to integrate Lean fully.
Looking at Lean SCM through the value price model by Hans de ridder, it increases value to final customer by reducing the costs. There by maintaining a low price to cost, value to price and value to cost ratio.

2.10.3 Lean Logistics

Integrating Lean SCM principles to logistics management has resulted in cost and waste reduction thereby increasing productivity (Porter & Van der Linde, 1995). The waste reduction aspect of Lean logistics is associated with it being Green, but not all Lean SCM practices are Green SCM. The article by Gustave M Ugarte 2016, empirically prove that Lean SCM practices of just in time delivery increase greenhouse gas emissions. From literature three main Lean Logistics practices can be delineated:

Just in Time Delivery ((Sugimori, Kusinoki, Cho, & Uchikawa, 2007), (Shah & Ward, 2003), (Wu & Dunn, 1995))
This is based on pull system wherein the product is manufactured as orders are placed and shipped directly to site thereby eliminating the need for intermediate warehousing. The material is delivered to site just in time and then stored for short duration. Materials are delivered in time for use and hence buffers need to exist to satisfy work flow requirements both upstream and downstream thereby reducing inventory costs and unnecessary transportation and onsite material handling (Ballard, Tommelein, Koskela, & Howell, 2002).

Zero Inventories
The Japanese manufacturing industry who introduced Lean, believed that inventory holding was a source of waste generation and hence needs to be eliminated. But over the years the need for inventory has risen to avoid risk, multiple orders and Shipments (Obermaier & Donhauser, 2012). Hence Lean practices have moved away from zero to inventory optimizing the lot size of existing inventory to keep it to a minimum (Silver, Pyke, & Peterson, 1998).

Vendor managed Inventory ((Kainuma & Tawara, 2006), (Anand & Kodali, 2008))
The supplier has direct access to manage inventory levels. The supplier is responsible for keeping track of items on stock and replenishing them when required. Vendor managed Inventory contradicts with Just in Time practice of Lean, but it certain cases given the high demand and requirement for a certain product or materials, inventory is required to meet immediate demand and achieve cost benefit through bulk procurement. VMI has proven to have benefits for both the supplier and buyer, but the supplier requires time to reap this benefits as the process changes need to be made and the new process takes time to get accustomed to the given environment (Dong & Xu, 2002). VMI is highly dependent on Information sharing. There should be transparency and both parties involved need to be aware of the relevant details without any distortions (Lee, Padmanabhan, & Whang, 1997). The report by (Dong & Xu, 2002) empirically proves that VMI help save inventory costs and make the process more efficient.

Third party Logistics (Anand & Kodali, 2008)
Third party logistics is the outsourcing of transport to another company who in most cases is a logistics provider. Owning and operating transport has a lot of capital attached and helps organizations focus on their field of work thereby reducing operational costs and increasing efficiency (Shi, Zang, Arthanari, Liu, & Cheng, 2016). The use of third party logistics renders transportation cheaper and trucks are fuller when compared to using owned and operated vehicles.

EDI (Electronic Data Interchange) information Sharing ((Anand & Kodali, 2008), (Gurumurthy, 2009))
To achieve integration and collaboration, information sharing between parties involved is very important with high transparency. With ever improving technology it has become easier and more efficient to implement information sharing. EDI is one such provider for increase real time data sharing between parties that help organizations collaborate and make decisions (Schneider, 2010).

Earlier under transport waste it was noted that one of the main reasons for waste emerging in transport is maintaining different warehouses. Operating from different warehouses that are located close to each other is not value adding and increases the movement of material and information flow from one warehouse to another. Hence, lean suggest the use of single warehousing which will be considered another Lean logistics practice.

2.10.4 Position of costs and GHG emission in Lean

Lean SCM principles concentrate on costs reduction by reduction of wastes but this does effect GHG emissions as well, transportation is one such wastes that is tackled in Lean SCM which also results in reduced GHG emissions. Transportation contributes to maximum GHG emissions across the supply chain, but is not the only source, the product manufacturing and development is also a source of GHG emissions which is not considered in Lean SCM. In general, Lean SCM is very cost oriented and doesn't give importance to the Green SCM aspect of sustainability or people. The article by Stuart D Green; *The dark side of Lean* speaks of the negative impact of Lean SCM that is not documented or spoken enough as industries are blindly moving towards implementing it in the hope of achieving the benefits that Toyota did. Stuart states how every researcher of

Lean Management forgets that it was developed in Japan, a culture that is totally different from many and which emphasizes on work more than personnel and social time. This is not the case in most other countries wherein work and personnel life balance is of importance. The author states that organization that have implemented Lean management outside the context of Japan have witnessed elevated level of employee frustration and work over load which beats the point of implementing Lean management in the first place. Whilst Lean philosophy of being flexible, encouraging team work, and striving for quality is well recognized and appreciated, many find that it translates into control, exploitation and surveillance in practice (Green, 1999).

The article goes on to suggest how practitioners have taken Lean SCM to be positive and have ignored that lean doesn't consider key factors such as traffic congestion, pollution and the human costs of Lean (Green, 1999). Just in time delivery of Lean SCM is one such principle that neglects Traffic, truck load, consolidation etc. that contribute to the GHG emissions. Lean SCM deals with the internal factors of an organization and neglects the extended effect of it. Lean SCM solely will not suffice in gaining competitive advantage as it neglects a huge dimension which is sustainability. Out of the three P's of sustainability Lean SCM caters to the profit and loosely to the other two that is people and planet which is a secondary beneficiary of its activities that tackle profit.

The seven wastes of Lean principles do not mention material waste and people skill waste. Though the latter was added later, it still doesn't talk about material waste which contributes to huge chunk of process waste. Other wastes not mentioned could be communication waste, though this can be part of human skill waste. Material waste during production, packaging waste, end of life disposal etc. are key factors that are not considered by Lean principles. Another waste that is not a focal Lean waste but has been researched upon in the past is the waste of resources, which is water, electricity etc. turning off machines once the work is done ensuring proper usage of water and turning lights off in a work place is also part of the supply chain that needs to be given importance.

In conclusion, it can be seen Lean SCM indirectly contribute to parts of the Green SCM initiatives but not fully as it neglects the extended effect of Lean. Lean solely will not suffice in gaining competitive advantage as it neglects a huge dimension which is sustainability. Out of the three P's of sustainability, Lean SCM caters to the profit and loosely to the other two that is people and planet which is a secondary beneficiary of lean activities that tackle profit.

2.10.5 Lean wastes that affect GHG emission

Out of the eight Lean wastes the ones that directly affect GHG emissions are transport, over production, and inventory. Though these do not aim to reduce harmful emissions but invariably end up contributing to the reduction of it to a certain extent though not completely.

Transport waste focuses on reducing unnecessary transport of materials; this in terms of going green translates to lower transport frequency thereby reduced emissions. But this is not completely true as Lean principle by unnecessary transport mean delivering a product only when it is required for immediate use, this is called just-in-time. This focuses on delivering products to a place when required just in time, this increases the amount of transport required as there is no postponement of delivery to ensure better consolidation (Hallam & Contreras, 2016).

Over production focuses on not producing more than what is required, this in terms of green translates to lowered energy consumption as the right number of products are being produced.

Inventory focuses on reducing inventory storage again this means less energy required to store the materials in terms of lighting, air conditioning and equipment handling.

The above mentioned three wastes apart from cost reduction also reduce GHG emissions. Transport is the one waste that swings both ways. It can positively and negatively impact GHG emissions. Herman, (2016) in their article refer to Just in time and its effect on GHG emission. The article suggests that just in time is environmentally beneficial if it is a local supply chain, but with globalization the construction supply chain is becoming global in which case just-in-time is not preferred when wanting to be environment friendly.

2.10.6 Lean principles that help in reducing costs and GHG emissions

All Lean principles work toward reducing costs through waste reduction but the wastes that indirectly tackle GHG emissions are transport, over production, defects and to a certain extent Inventory. The functional attributes delineated in the beginning will be used to see how Lean SCM practices affect costs and GHG emissions.

<table>
<tr><th></th><th>Practice</th><th>Costs</th><th>GHG</th></tr>
<tr><td>Transport management</td><td></td><td></td><td></td></tr>
<tr><td>Infrastructure</td><td rowspan="4">No Specific Practice</td><td rowspan="4">No Effect on costs</td><td rowspan="4">No Effect on GHG emissions</td></tr>
<tr><td>Transport Mode</td></tr>
<tr><td>Modal transfer Points</td></tr>
<tr><td>Load Planning</td></tr>
<tr><td>Routing and scheduling</td><td>Third party logistics, Just in Time</td><td>Third party logistics ensures that trucks are fully loaded whilst sending out shipments.
Just in time helps reduces costs on inventory.</td><td>Third party logistics which ensure fuller trucks will have positive effect on GHG
JIT has negative effect on Transport GHG.</td></tr>
<tr><td>Warehouse Management</td><td></td><td></td><td></td></tr>
<tr><td>Location</td><td>No Specific Practice</td><td>No Effect on costs</td><td>No Effect on GHG emissions</td></tr>
<tr><td>Number</td><td>Single Inventory</td><td>Single inventory lowers costs and inventory is better utilized.</td><td>Single inventory in turn leads to lower GHG emissions.</td></tr>
<tr><td>Size</td><td rowspan="3">No Specific Practice</td><td rowspan="3">No Effect on costs</td><td rowspan="3">No Effect on GHG emissions</td></tr>
<tr><td>Type</td></tr>
<tr><td>Cargo handling System</td></tr>
<tr><td>Inventory management</td><td></td><td></td><td></td></tr>
<tr><td>What to Stock</td><td rowspan="2">No Specific Practice</td><td rowspan="2">No Effect on costs</td><td rowspan="2">No Effect on GHG emissions</td></tr>
<tr><td>Where to Stock</td></tr>
</table>

How much to Stock	Vendor managed inventory	As mentioned in JIT. Vendor managed inventory and minimum inventory will ensure lower inventory costs.	Minimum inventory means less products stored hence less use of electricity to maintain optimal conditions for the goods. This will reduce scope 2 emissions.
Packaging & Unitization			
Unit size	No Specific Practice	No Effect on costs	No Effect on GHG emissions
Protective Packaging			
Handling System			
Information Processing			
Information System	EDI information Sharing	Information sharing as mentioned earlier has positive effect on costs reduction	Information sharing as mentioned earlier has positive effect on GHG emission reduction
Control	No Specific Practice	No Effect on costs	No Effect on GHG emissions
Forecasting			

Table 1: Lean practices in Logistics

2.11 Green supply chain management

Green supply chain management(GSCM) is a new topic in the field of supply chain management. It emerged because of depleting natural resources and growing global warming that has become a significant issue in today's day and age. GSCM as it will be referred to further in this report aims to integrate environmental thinking into supply chain management. It focuses on reducing environmental damage caused by the supply chain of various industries and organizations; it is the logical progression of Lean, Agile and Resilient supply chain management paradigms. It is highly influential in terms of achieving competitive advantage as customers are attaching more value to environmentally served products.

The green supply chain management focuses on material procurement to end of life of the material and is based on Life Cycle Analysis(LCA). GSCM can be achieved by implementing the R's; Reduce, Reuse, Re-Cycle. As mentioned in Literature, the basic principles of GSCM are:

Green Procurement

Green procurement is the environmentally conscious method of purchasing materials. It emphasizes on purchasing materials that have been responsibly sourced, the materials are reusable or recyclable, the supplier has an ISO 1400 certification, the materials have no toxic content, and they are preferably bio based and have a positive impact on the environment. Supplier selection should no more be focused on just costs and quality but should have environmental specifications as one of the main drivers too. The green goals set by the company needs to be communicated to the various suppliers and they should be trained to ensure there is holistic spread of green across the supply chain.

Practices

- Certification of supplier's environmental management system
- Environmental collaboration and monitoring of suppliers
- Sourcing materials from ethically source
- To communicate to supplier environmental goals
- Green network

Green Manufacturing

Green manufacturing focuses on optimal use of material, industrial equipment's and energy. The use of virgin materials and techniques that emit low CO2 into the environment and working toward avoiding rework is what green manufacturing preaches. Green manufacturing is affected by the design and process adopted. The analysis of these two aspects and improvement on these will help in ensuring a green manufacturing system. Manufacturing that uses the least amount of material, equipment, human effort, energy and rework yet satisfying the final needs in terms of quantity and quality is Green manufacturing.

Practices

- Supplier ISO 14000 certification
- Responsible use of natural resources
- Environmental friendly resources and processes
- Filters and controls for emissions
- Internal recycling of materials
- Integrate total quality environmental management
- To use less resources
- To recover material and remanufacture

Green design

Green design entails designing and material choices that are environmentally conscious. Designers should consider the implications of their design on required amount of material, time, machinery, type of material and specific design details. Design for re-usability, re-manufacturability, dismantling etc. is the concepts that need to be thought of whilst implementing Green design. The design should ensure the least use of materials and maximum use of environmental friendly material. LCA is an approach that can be used to test the greenness of a product design as it will take into consideration the entire lifecycle of the design.

Practices

- Product designers and suppliers to work together to eliminate product environmental impact
- Design for reduced consumption of energy and resources
- Environmental friendly raw materials
- Design for dis-assembly
- Use LCA for product design

Green Packaging

Green packaging involves using environmental friendly packaging material that can be reused. Avoiding over usage of carton boxes and moving to a more reusable and recyclable material. Use of light weight packaging is another practice of green packaging, as lighter the shipment is lower the emissions per package shipped.

Practices

- Use recyclable pallet for material delivery
- Optimize packaging
- Eco labeling

Green transport

Green transport is to optimally use transport. Using environmental friendly transport, ensuring the trucks are fully loaded and not running empty. Using alternative low emission transport are green transport principles

Practices

- Use of green logistics guidelines
- Invest in vehicles with reduced environmental impact
- Plan vehicle routes to reduce emission
- Use rail instead of road and water instead of air

Reverse Logistics

Reverse logistics entails the taking back of materials and products back to the supplier or manufacturer for reuse and recycling purpose. Reverse logistics emerged from the concept of circular economy, to make sure materials are part of a circular rather than linear loop, thereby reducing load on landfills.

Practices

- Encourage suppliers to take back packaging
- Customer returns packaging materials and pallets
- To recover materials and products from customers

2.11.1 Green Supply chain management in construction

The construction industry is considered to have irreversible impact on the environment, it not only adds to pollution and natural resource consumption during the construction phase but also in its operational phase. Hence, they harm the environment throughout its life cycle (Ojo, Mbowa, & Akinlabi, 2014). Green supply chain management emerged in construction because of the above said along with government regulations, growing customer awareness and competitive advantage in the market (Chun, Hwang, & Byun, 2015). The concept of GSCM emerged in the United States in the late 90's, its main target was to reduce the consumption of natural resources during construction and operation phase (Mingqiang &

Zuxu, 2011). The adoption GSCM in construction ensures reduced operational energy use and waste generated thereby maintaining indoor and outdoor environment (Beldek, Camgöz-Akdağ, & Hoşkara, 2016).

The benefits of GSCM in construction as per (Emmett & Sood, 2010) are:

- Lowered costs
- Higher efficiency
- Competitive advantage
- Reduced risks
- Improved quality
- Improved transparency
- Increase customer satisfaction

The infusion of GSCM in construction industry has been steady paced (Ojo, Mbowa, & Akinlabi, 2014). The adoption of GSCM in construction has been encouraged by the existence of green building certification system like LEED and BREEAM (Pandey, 2015). These certificates help organizations project their Green goals there by gaining positive market response. Though the industry is fast catching up with imbibing Green, there does exist barriers in implementing them; lack of awareness and poor commitment from top management are two of the main reason why the industry hasn't been able to fully integrate this paradigm (Ojo, Mbowa, & Akinlabi, 2014).

2.11.2 Green Logistics

Green logistics is the set of practices and principles that help reduce environmental footprint arising from transportation, material handling, packaging and waste management (Rodrigue, Slack, & Comtois, 2008). Green logistics encompasses measuring and reducing environmental impact of different transportation strategies, different waste generated and resource consumed (Eglese & Sbihi, 2009).

Reverse logistics is a part of green logistics, the materials are sent back to a location earlier in the supply chain thereby reducing waste (Rogers & Lembke, 2001). Reverse logistics is associated with closed loop supply chain; the materials that are taken back are then recycled, remanufactured, or repaired to be reused. Hence taking back of materials when compared to the forward supply chain forms a closed loop and hence reverse logistics is associated with closed loop supply chain (Govindan, Soleimani, & Kannan, 2015).
To elucidate the common practices of green logistics, literature study and literature case studies of companies was carried out.

Multi Modal Transport ((Anten, Van Amstel, & Verweij, 2014), (Seroka-Stolka, 2014))

It is the transportation of goods using more than two modes of transport. Truck has higher GHG emissions than rail or sea and multi modal transport can be used in which materials can be partially transported by truck and partially by rail or sea to reduce GHG emissions.

Reworking Route taken ((Zhu, Sarkis, & Lai, 2008), (Holt & Ghobadian, 2009), (Ratnajeewa & Bandara, 2015))

The shorter the distance travelled the lower is the GHG emission. Hence it is important to rework the routes to choose the most convenient and optimal route for delivery.

Better Packaging for fuller trucks ((Wiese, Luke, Heyns, & Pisa, 2015), (Seroka-Stolka, 2014), (Zhang, Thompson, Bao, & Jiang, 2014), (Ratnajeewa & Bandara, 2015))
Optimal packaging can increase stacking efficiency on trucks which thereby reduces the number of trucks to deliver goods and in turn reduces GHG emissions.

Electric vehicles ((Zhang, Thompson, Bao, & Jiang, 2014), (Ratnajeewa & Bandara, 2015))
Electric vehicles have significantly lower GHG emissions than trucks.

Consolidation plan ((Wiese, Luke, Heyns, & Pisa, 2015), (Seroka-Stolka, 2014), (Ratnajeewa & Bandara, 2015))
Consolidating shipments can reduce GHG emissions and per pallet costs of transportation

Minimum inventory ((Zhang, Thompson, Bao, & Jiang, 2014), (Marklund & Berling, 2017))
Green practice of minimum inventory is to stock only required amount which will save on materials getting wasted and electricity consumption.

Truck Pooling (Ratnajeewa & Bandara, 2015)
Truck pooling is when logistics providers share information amongst themselves to consolidate shipments in vehicle to ensure higher truck occupancy.

2.11.3 Costs in GSCM

The focal point of GSCM is not costs, but going green does have costs benefits but there are a few practices that might spike costs. Buying recyclable materials, bio based materials or opting for environmental friendly processes might turn out to be more expensive than usual.

There has been contradicting research in this aspect of green supply chain management. (Zhu, Sarkis, & Lai, 2008) argue that GSCM doesn't have economic benefits when implemented but (Geng, Mansouri, & Aktas, 2017) refute the statement and state that the research by Zhu was carried in a time when GSCM was in its nascent stages and early implementation will require investment thereby increasing operational costs and negatively affecting economic performance. But recent literature by (Hung, Chen, & Chung, 2014) state that there is positive relation between GSCM and economic performance. The extensive literature review on GSCM carried by (Geng, Mansouri, & Aktas, 2017) conclude that though a higher initial investment is required the benefits such energy saving, customer outreach, waste reduction and operational efficiency outweigh the initial costs thereby making it profitable. The study also further states that GSCM practices reap economic benefits when there are greater intra-organizational environmental practices.

Research on economic benefit of GSCM implementation in the construction industry is scarce. Article by (Ojo, Mbohwa, & Akinlabi, 2015) study the implementation of GSCM in the South African construction industry. The study was conducted by interviewing construction project managers, Contractors and Engineers. The results suggested that 40 % of the interviewees

thought GSCM had positive impact on the construction economic performance and 28.6% person thought GSCM has a major effect on financial performance, 7 % of the respondents had a neutral outlook and the rest suggested that there is a negative relation between GSCM and Financial performance. But the majority agree that there is a positive relation between GSCM and financial performance in the construction industry.

In terms of the value price model, GSCM decreases costs as per above literature and gives additional value to customer as customers add additional value to green products. There by reducing the price cost ratio and value costs ratio.
Hence the focus will be to combine lean and green to give maximum value to customer maintaining a high price benefit ratio.

2.11.4 Green principles that help in reducing costs and GHG emissions

Though the focus of GSCM is on reducing environmental impact it does reduce costs to an extent but not completely, certain green practices do need more initial investment than others. In the long-term green has proven to have costs benefits.

In the construction sector, going green has significant costs reduction in the operational phase of the building. The focus of the Green paradigm is on GHG reduction, as mentioned earlier transport is not the only sector that contributes to harmful emissions, but the manufacturing stage, storage and the operational phase also contribute to harmful emissions. Paints used on walls and products emit VOC's which can be categorized as harmful emissions. These are the aspects that need to be considered whilst aiming to reduce harmful emissions.

	Practice	**Costs**	**GHG**
Transport management			
Infrastructure	No Specific Practice	No effect on costs	No effect on GHG emissions
Transport Mode	Use of Rail and Sea over Truck and Air Truck Pooling	Rail and sea are cheaper than truck and Air thereby lowering costs. Truck Pooling will ensure fuller trucks hence lower costs.	Rail and sea have lower GHG emission compared to roadways and airways. Fuller trucks will lead to lower GHG emissions per item shipped.
Modal transfer Points	No Specific Practice	No effect on costs	No effect on GHG emissions
Load Planning	Fully loaded trucks	Fully loaded trucks reduce costs per pallet shipped	Fully loaded trucks reduce GHG emissions as the truck emission factor per good decreases with increase in load
Routing and scheduling	Rework routing and plan for circuit delivery	Reworking routes to opt for efficient and shorter distances reduces costs and circuit delivery of picking and delivering goods also reduces costs as additional	A lot of trucks on their way back after delivery are running empty and in circuit delivery this is avoided and hence reduces GHG emissions

		vehicles are not running to deliver goods.	
Warehouse Management			
Location	Rework warehouse location based on geographic operation	The closer the warehouse is to location of geographic operation lower are the delivery costs	Closer proximity reduces distance travelled hence reduces emissions.
Number	No Specific Practice	No effect on costs	No effect on GHG emissions
Size			
Type			
Cargo handling System	Energy efficient cargo handling systems	Use of equipment's that use less electricity will help reduce costs	Less use of electricity is low GHG emissions
Inventory management			
What to Stock	No Specific Practice	No effect on costs	No effect on GHG emissions
Where to Stock			
How much to Stock	Minimum inventory, forecast based stocking	Inventory holding costs money	Maintaining stock requires electricity which emits GHG's
Packaging and Unitization			
Unit size	No Specific Practice	No effect on costs	No effect on GHG emissions
Protective Packaging	Eco friendly packaging	Protective packaging will warrant the need for additional packaging which is more expensive.	Eco friendly materials emit lower GHG emissions when disposed and are reusable.
Handling System	No Specific Practice	No effect on costs	No effect on GHG emissions
Information Processing			
Information System	Full transparency and complete view of supply chain.	Greater the knowledge and information sharing higher are the chances for cost savings	
Control	No Specific Practice	No effect on costs	No effect on GHG emissions
Forecasting	Forecast materials required for stocking		

Table 2: Green practices in Logistics

Chapter 3 – Framework

In this chapter Lean SCM and Green SCM principle and practices are compared to see where they converge and diverge. The paradigms are analysed against the five key elements of logistics in section one, following which a literature review is carried to establish the synergy between both paradigms. The last section encompasses the formulation a synergistic implementation strategy of both paradigms.

3.1 Lean SCM and Green SCM comparison

Lean SCM and Green SCM paradigms have different focuses but at the outset both intend to reduce waste and increase efficiency (Hallam & Contreras, 2016). (Dues, Tan, & Lim, 2013) In their article talk about the synergies between Lean principles and Green principles and how one can lead to the other. The article suggests that adoption of Lean practices make adoption of Green practices easier and vice versa though there are some diverging aspects that cannot be reconciled. Integrating Green with Lean according to (Garza-Reyes, Villarreal, Kumar, & Molina, 2016) is a natural progression to organisations that already have lean, as both tend to reduce waste. Bergmiller GG and McCright PR article on Lean manufacturer's transcendence to Green manufacturing mention that organisations that implement Lean practices and Green practices simultaneously achieve greater results than organisations that implement only Lean practices, the study also suggest that the full potential of Lean principles and Green principles is known only when they are both implemented together. But Lean principles and Green principles have fundamental difference in their approach to waste reduction, as mentioned earlier and as per research the only aspect where both paradigms find themselves digressing is environmental emissions, Lean principle of pull and JIT increase transport frequency whereas as Green principle focuses on reducing transport frequency (Venkat & Wakeland, 2006). Lean practices increase only scope 1 emissions and help in curbing scope 2 emissions and have no effect on scope 3 emissions. In term of costs the points where both paradigms digress is material procurement stage, Green SCM focuses on procuring responsibly sourced materials which at most times result is higher initial costs.

Below the Lean and Green practices elucidated in the previous section will be compared.

	Lean	**Green**
Transport management		
Infrastructure	No Specific Practice	No Specific Practice
Transport Mode	Lean doesn't specify the use of any transport mode	Use of Rail and Sea over Truck and Air
Modal transfer Points	No Specific Practice	No Specific Practice
Load Planning	No Specific Practice	Fully loaded trucks
Routing and scheduling	Third party logistics, Just in Time	Rework routing and plan for circuit delivery
Warehouse Management		
Location	No Specific Practice	Rework warehouse location based on geographic operation
Number	Single Inventory	No Specific Practice
Size	No Specific Practice	No Specific Practice
Type	No Specific Practice	No Specific Practice
Cargo handling System	No Specific Practice	Energy efficient cargo handling systems
Inventory management		
What to Stock	No Specific Practice	No Specific Practice
Where to Stock	No Specific Practice	No Specific Practice
How much to Stock	Vendor managed inventory	Minimum inventory, forecast based stocking

Packaging and Unitization		
Unit size	No Specific Practice	No Specific Practice
Protective Packaging		Eco friendly packaging
Handling System		No Specific Practice
Information Processing		
Information System	EDI information Sharing	Full transparency and complete view of supply chain.
Control	No Specific Practice	No Specific Practice
Forecasting		Forecast materials required for stocking

Table 3: Lean and Green Comparison

3.2 Points of Digression and Convergence

Article by (Dues, Tan, & Lim, 2013) state how whilst trying to implement a combination of both paradigms it is hard to fully implement both and certain trade-offs need to be made depending on the organisation. Innately both paradigms intend to give customer the best value but have different fundamental approaches and views. If a synergistic implementation of both need to be achieved a certain trade-off needs to be made. To do so the paradigms need to be analysed to check were they digress and were they converge.

Transport Management

Infrastructure

This aspect is not in the control of any organisation as the availability of infrastructure fully depends on the government bodies of the country and varies from country to country. Both aspects gain from having good infrastructure as it aids in implementing strategies without having to worry about lack of resources. Green principles specify the importance of choosing rail and sea over truck and air, but the lack of railroad connectivity inhibits implementing this strategy.

Transport Mode

Lean SCM practices do not specify the use of transport modes, green on the other hand mentions the use of rail and sea over truck and air, given that the latter have lower GHG emission. Rail and sea are cheaper but slow compared to truck or air when it comes to delivering and not all locations are well connected through railways and waterways making implementing this strategy difficult. But a suitable alternative will be to use electric vehicles which have lower emissions than trucks. Both paradigms do not digress or converge in this aspect hence making it easy to implement the Green SCM strategy.

Modal Transfer Points

Modal transfer points are decisions that need to be made at locations were the mode of transport needs to be changed due to accessibility issues. While choosing rail and sea there will have to be modal transfer points where shipments will have to be transferred to trucks to deliver to the site. At modal transfer points, there is handling costs that will be incurred, hence whilst choosing the green option of sea and rail over truck the costs incurred at modal transfer points need to be accounted for. But the costs of shipping with rail and sea are cheaper than that of truck, hence an analysis needs to be made to see if the costs of shipping and handling at modal transfer points are cumulatively lower than shipping directly by truck.

Load planning

Both paradigms converge in this aspect. Lean principle of third party logistics is to ensure fuller trucks are running and Green principle is to fully load the trucks to reduce emission per pallet shipped. Fully loaded trucks also reduce costs and hence in this aspect both paradigms are converging.

Routing and scheduling

Both paradigms digress in this aspect as Lean principle of just in time delivery contradicts with Green principle of circuit delivery and consolidation. To implement circuit delivery shipments, need to be consolidated and just in time delivery implies delivering items to store when required, this increases frequency of shipments to store. Green SCM tends to reduce transport frequency. When it comes to routing, both paradigms agree with choosing the optimal route for delivery and reworking the route to find the most suitable one.

Warehouse management

Location

The location of warehouse needs to be dependent on the geographical location of operations. The paradigms have no points of digression in this aspect. Location of warehouse is important to increase efficiency to add value and eliminate transport related waste to reduce green gas emissions.

Number

Lean SCM practices of single inventory mean operating from single inventory. But given the global nature of supply chains single inventory in one location may not be the most optimal solution. This aspect there is no point of digression or convergence for both paradigms.

Cargo handling system

Warehouse cargo handling systems need to be energy efficient. Eco-friendly energy efficient cargo handling systems are available that consume less electricity. The use of cargo handling system also depends on the design of the warehouse. There is no point of digression in this aspect.

Inventory Management

Where to stock

Lean SCM proposes zero inventories, but certain items given the long lead times and high demand need to be stocked to be more agile in operations. Green SCM on the other hand proposes minimum inventory, stocking items based on forecast. The other decision in where to stock, is stocking of material within the warehouse. Items on higher demand and frequency of use need to be stored in locations that have easy access than storing materials with low demand and frequency, because this will eliminate the need for special machinery and additional personnel to access materials.

How much to stock

As suggested earlier Lean principle of zero inventory and Green principle of minimum inventory digress in this aspect.

Packaging and Unitisation

Unit size

Both paradigm stress on the need for fuller trucks to reduce costs and GHG emissions and packaging plays a key role in ensuring efficient stack ability. There are no points of digression in this aspect as efficient standard packaging are value adding as they lower costs and is also green as trucks can be stacked efficiently.

Protective packaging

Lean practices do not tackle this aspect but Green practices on the other hand suggest the use of eco-friendly packaging material that can be reused and recycled lowering end of life emissions. But protective packaging can add to the overall weight of the shipment increasing emissions and occupying more space thereby increasing costs. Hence depending on the value of the product a trade of needs to be made on the kind of packaging required.

Information Processing

Information system

Lean practices of complete integration and information sharing using EDI services also help achieve Green practices as greater the information sharing between parties greater is transparency in the supply chain. Both paradigm do not digress in this aspect and there is potential for simultaneous implementation.

Forecasting

Forecasting demand for material is important specially when stocking. All the relevant information from various stakeholders need to be received and processed to get a ball park idea of how much inventory needs to be stocked.

3.3 Does Lean SCM lend itself to Green SCM and vice-versa?

Articles by (Al-Aomar & Weriakat, 2012) suggest how Lean principles lays the platform for Green principles. (Hallam & Contreras, 2016)states that organizations who have implemented Lean practices find implementing Green practices easier as Green practices are an extension of Lean practices. The theory that Lean practices sets an operational and cultural environment that is conducive to implementation of Green practices has been suggested by the US environmental protection agency. But they also go on to point out the fact that Lean practices doesn't innately consider environmental aspects and performance, it was introduced in an era when environment cautiousness wasn't a concern. It was the era of industrialization where companies were competing to gain market share and being cost and time efficient was the only way of achieving it. But with growing demands, it needs to adapt to the times and the present is the time for environmental cautiousness. The only way for Lean principles to sustain is by infusing it with Green principles to make it relevant in the present day. This way Lean practices needs to be tweaked a little to incorporate Green aspects, what needs to be noted is that most Lean practices already pave the way for Green practices, (King & Lenox, 2010) mention Lean practices and Lean logistics help achieve environmental performance and further state Lean paradigm is Green paradigm. To support this (Bergmiller & McCright, 2009) suggest that organizations that implement one paradigm find implementation of the other paradigm easier. As mentioned in trade-offs, the only place where lean and green diverge the most is in the department of transport and inventory. But by emphasizing on Green aspect the Lean principles can be tweaked, Lean principles like value stream mapping sheds light on waste that are not just process related but also product related. So, with this line of though it can be concluded that Lean principles does not necessarily lend itself to green but it does lay a platform for the incorporation of Green principles.

3.4 Synergy between Lean SCM and Green SCM

Synergy in comparison to collective benefit means implementing two practices or paradigms to achieve more than just the sum of the individual benefits. In synergistic approach, one and one should make three or greater.
Lean SCM as mentioned above intends to reduce costs thereby increasing value to the final consumer on the other hand Green SCM increases value by going green as customers add value to green product and processes, but this cannot be said for all customers. So, a right balance needs to be struck between the both and in terms of synergy this means by combining both, the final value to customer is greater than just the sum of both.
Lean SCM and Green SCM have innated differences and hence for a synergy to exist trade-offs need to exist, these trade-offs always need to be aligned to final customer.
There have been many articles that have analyzed the synergy between both paradigms. (Hartini & Ciptomulyono, 2015) In their article review literature on Lean SCM and Green SCM with respect to the synergy. The article concludes by stating that implementing both paradigms does have synergistic benefits.
(McCright & Bergmiller, 2009) Study the impact of green practices on their lean results. A statistical analysis was carried out to prove that all co relations had a positive relationship. The major conclusion from the study was that Green manufacturing further helps Lean manufacturing in achieving reduced costs.

3.4.1 Synergistic Implementation of Lean SCM and Green SCM paradigms

The logistics department of a construction process can be broken down into five key aspects.

- Transport management
- Warehouse management
- Inventory management
- Packaging and unitization
- Information processing

Each aspect has key decision-making steps that affect costs and GHG emissions. The section below will propose a framework for implementing Lean and Green strategies harmoniously for synergistic benefits.

Transport management

Transport management is an important aspect of logistics as it involves making key decisions such as choosing transport modes, routing and scheduling and efficient loading plan. Regarding implementing Lean and Green paradigms there are no aspects that diverge in this department. While making transport mode choices rail and sea should be opted over truck or air, this decision depends on existing infrastructure and time needed to get the goods to site. Not all locations are connected through railways or waterways in which case there is no option but to opt for roadways, in this situation opting for electric trucks for delivery helps reduce GHG emissions. Rail and Sea though have lower GHG emission and costs less compared to road; they take longer and cannot be used in situations where there is an urgent need for goods to be delivered.

Load planning needs to be efficient wherein full truck loads are ensured to reduce frequency of shipments thereby reducing costs and GHG emissions. Load planning is connected to palletizing and unitization, a truck is divided into loading units before placing pallets, each loading unit is assigned one pallet. Pallets can be stacked one above the other if they are compactly packed; this reduces unnecessary air space in a truck. This is one of the reasons that makes shipping products with low volume to weight ratio cheaper and environment friendly as the product has high density which negate unnecessary air space. On the

other hand, shipping high volume to weight products over a long distance can be more expensive and result in higher GHG emissions. To summarize the above said, while loading the trucks stack ability and compact packaging should be done to ensure complete loading and minimum air. With development of technology there are a multitude of software's that help load planning, Easy Cargo is one such software that helps in load planning. Another important aspect that helps load planning is information sharing as lean suggests, greater the transparency in a supply chain the easier it is to consolidate shipments and reduce the number of Less than Truck Load(LTL) shipments.

Routing and scheduling, routing decision entail choosing the most efficient route for delivering goods, the route taken can help reduce emissions and costs, hence before delivery plans the route to be taken is important. When it comes to scheduling deliveries, Lean practices of just in time delivery and Green practice of circuit delivery diverge. Circuit delivery is achieved by consolidating shipments and planning pickup and drop-offs because of which they are connected to routing wherein the route chosen should consider the points of delivery and pickup to form an efficient circuit. But circuit delivery is possible when materials are being delivered and picked up for stock, in cases of store construction suppliers deliver items to store directly as they cannot be stocked or there is a strict deadline that needs to be achieved, in these cases just in time delivery can be practiced if the deliveries are local. In a local supply chain, just in time delivery help reduce inventory costs.

Warehouse Management

Location of an organizations warehouse is a strategic decision wherein proximity to location of operations is important. Lean SCM suggest the use of single inventory which is also because the paradigm was designed in a scenario where deliveries were being made to one location from supplier that were local, but while operating in global environment multiple warehouse and distributions hubs are required to service the multitude of locations. This is a strategic decision that needs to consider proximity. A strategy to choose the right location for a warehouse is out of the scope of this report and hence has been left out.

Inventory Management

From the trade-off analysis, it is evident that one aspect that is diverging is inventory management. Any construction supply chain is a make to order supply chain, wherein a building or fit out project is carried when demanded by client. The materials used in the fit-out project can be distinguished into, engineered to order (ETO), Made to Order (MTO), Assembled to Order (ATO) and Made to Stock (MTS). MTO are items that are available on request from supplier, ATO items when requested are assembled based on request using standard components, MTO are items that need to be made bespoke based on request and standard components cannot be uses and finally ETA is wherein a more detailed design with engineering specifications are submitted for manufacturing (Tommelein, Ballard, & Kaminsky, 2008). The items can further be differentiated based on lead times and classify them as critical items or noncritical items. Long lead time items are considered critical whereas short lead time items are considered non-critical. In which case ETA's and MTO's fall in the former category and MTS and ATO fall in the latter category. The above items are procured either to stock or procured to order by a construction organization. The PTS is where materials are procured based on forecast and is dealt by an internal procurement team, PTO is when materials are ordered bespoke for individual projects that cannot be stocked, and this is mostly orders placed by project managers, project coordinators and GC. Every product used in a construction project can be distinguished based on PTS and PTO. PTS is chosen for products where one knows the quantity required for a given period, products that have long lead times, wherein the cost of stocking is lower than the cost of not receiving it when ordered. PTS is also adopted in case of global supply chains as it reduces the number shipments and the related document preparations.
Procure to order is chosen when the demand of the product is not known, lead time of the product is short where in the costs of waiting for a product is less than stocking, and is also preferred in case of local supply chain. Procure to order is in

tandem with the Lean principles of just in time delivery. There are other aspects that play a factor such as high frequency demand and low frequency demand. So, it can be concluded that critical items are procured to stock whereas non-critical items are procured to order. Thereby this will reduce the risk of materials availability delays, what also needs to be considered is the location of supplier, in case of a global supplier then PTS is preferred for green reasons and in case of local suppliers PTO is preferred abiding by the lean principle of JIT. Hence, the three key aspects that determine if product needs to be PTO or PTS is Critical or non-critical, Demand and Supplier location (Global or Local).

Lean principles and practices are favored in the case of local supply chain as it also helps achieve Green objectives without much of a compromise but in the case of global supply chain this gets harder as Lean practices of JIT doesn't favor Green objectives as greater the distance then greater is the harmful effect of JIT on environment. So, by segregating products based on the categories, lean and green strategies can be distributed separately amongst these with lesser compromise and trade-offs.

Once the decision is made if items need to be PTS or PTO the next step is the storage of the PTS items and management of inventory items, Lean SCM lays emphasis on single inventory and Vendor managed inventory. Single inventory helps in achieving Green principles of consolidation and vendor managed inventory ensures continuous replenishment of stock making sure items are not out of stock.

Another dimension of, where to stock is stocking items within a warehouse. Warehouses predominantly have a racking system where cartons are labeled and stored. The cartons are distributed across different racks hence items that are easily accessible need to be high demand and high frequency of use. Placing high frequency items on the higher shelves would require extra personnel and in certain cases machinery which is not value adding and not environmental friendly on a regular basis.

Once the decision on what to stock and where to stock are made the next critical decision is how much to stock. Lean SCM proposed Zero inventory, but this is not feasible given the lead time of certain items and the demand of those items. Green SCM on the other hand proposes minimum inventory, inventory should be kept to a minimum and to ensure this stock need to be ordered based on forecast and previous trends.

Packaging and Unitisation

Load planning of trucks relates to packaging and unitisation. Packaging needs to be optimal for ensuring efficient load planning and full trucks. Palletising shipments is important to ensure goods are not being damaged and are transportable. Considering Green SCM motives, Palletising should be eco efficient and reusable, this will reduce end of life emissions of the pallets.

Information processing

EDI information sharing within the various stakeholders will ensure transparency within the supply chain. With emergence of technology 4.0 there are multiple software and technology that can be used to improve information sharing and stakeholder collaboration, amazon web services is one such platform that helps information sharing amongst stakeholders.

3.5 Lean SCM and Green SCM Framework

Below the five phases and the practices have been mentioned summarising the above explained. Each of the stages different stakeholders will be involved who might not be involved in the next stage. But as Lean principle suggest there needs to be integration between every stage, information and knowledge sharing for improved project delivery.

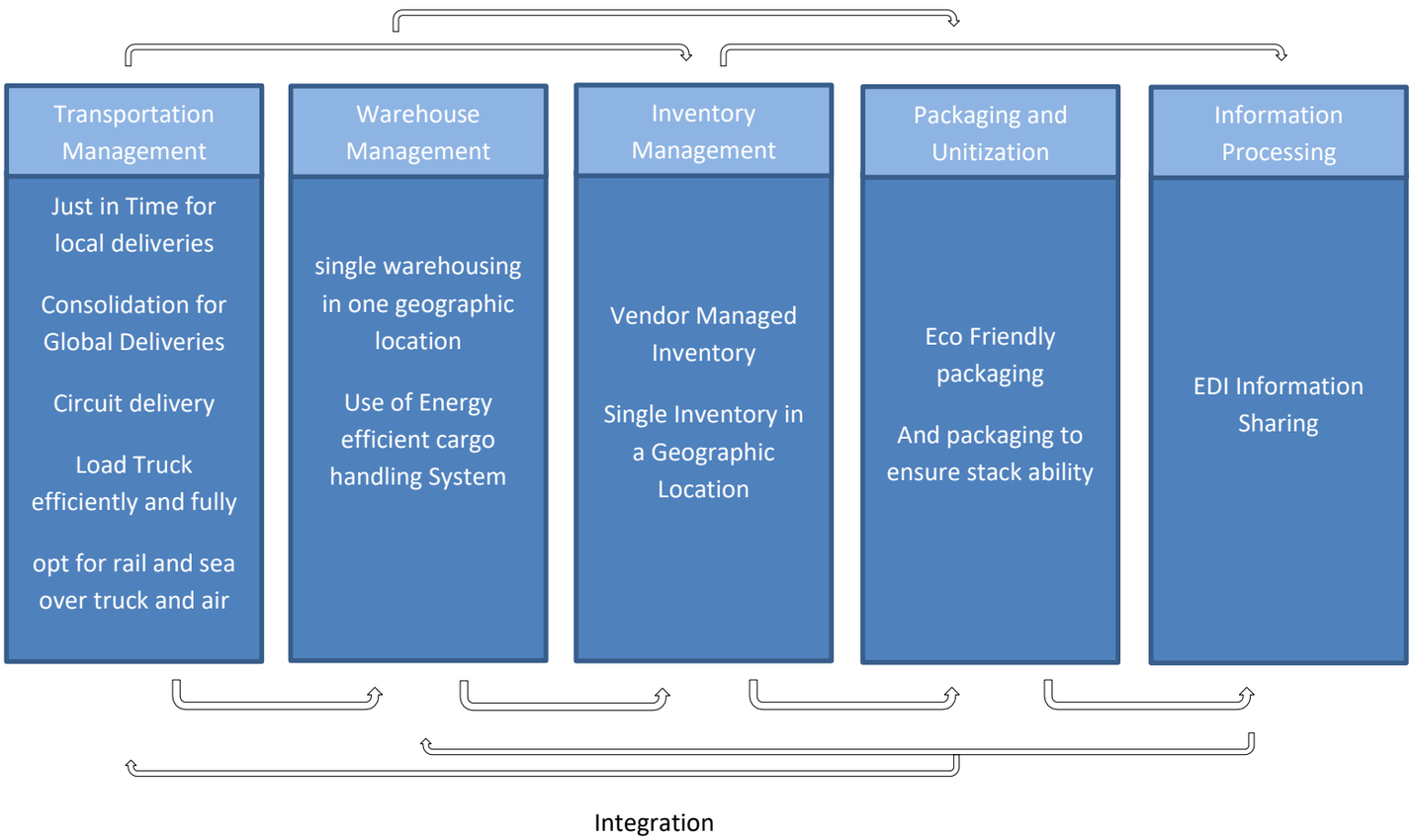

Figure 5 : Lean and Green Framework

Chapter 4 – Case Study

In this chapter, the developed framework will be tested in a case company PVH. An introduction the company is given in section one followed by carrying out a stakeholder analysis to establish the views of various stakeholders in relation to logistics management. Then the existing problem and benefits of implementing the proposed strategy is analysed using a Soft System Methodology. Once the benefits of the proposed strategy in terms of costs and GHG emission was known an ISM model was developed to study the interdependency between the practices and establish the hierarchy of practices.

4.1 Introduction to Company

To test the hypothesis PVH has been chosen as the case company. PVH, the global headquarters of Tommy Hilfiger and European Headquarters of Calvin Klein, build stores in and around Europe. The department of store development consists of Project Managers, Project Coordinators, Concept team and Procurement. Each of these stakeholders has a position in procuring or ordering materials for a store development process but not necessarily liaise with each other to ensure coordinated material delivery to site. They also have no control over the costs involved in material transport and the resultant Green House Gas(GHG) emissions. With the growing need to be sustainable and acquire competitive advantage it is of interest to have control over these factors. To achieve this, it is important for better internal stakeholder collaboration and process flow of orders, through implementation of Lean and Green SCM.

The below diagram is an overview of the materials procured for store development. The focus of the thesis will be on the flow of material outlined in red below.

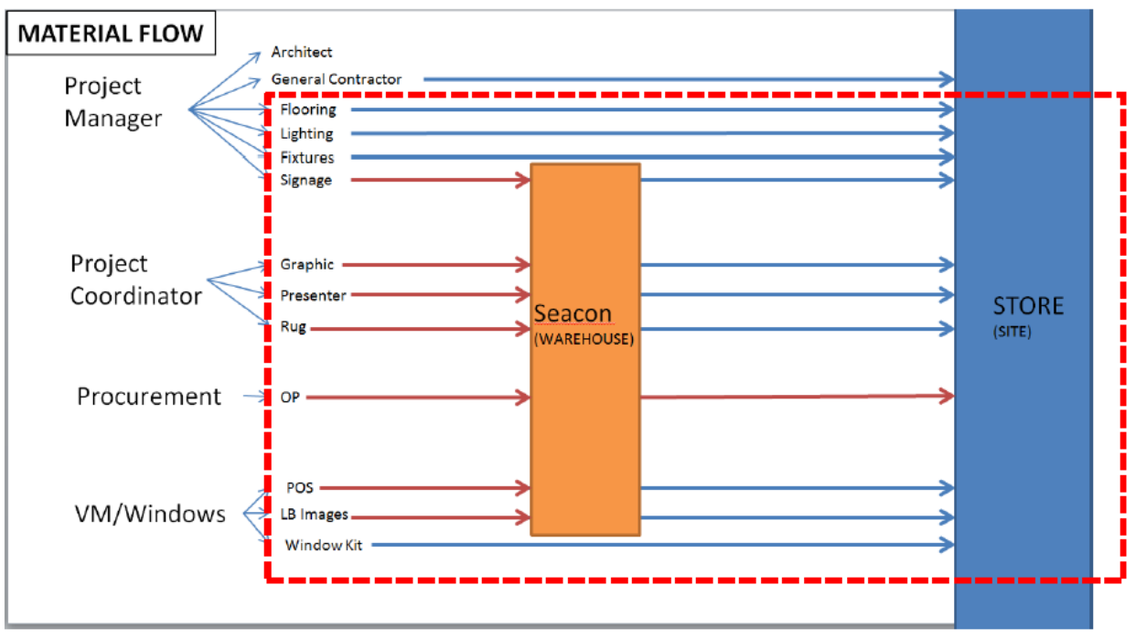

Figure 6: PVH Material flow

4.2 Implementing Lean and Green supply chain in PVH store development process

Mossman suggested that good Logistics planning is crucial to construction as builders can focus on what their good at, that is building, rather than worrying and spending time thinking about delivery.
As discussed earlier parallel implementation of both paradigms have synergistic benefits as per literature. To gain competitive advantage PVH is looking to optimize the Logistics by going Lean SCM and Green SCM.
With this line of thought, working on the supply chain to improve it will potentially benefit the company regarding costs saving and reduced carbon footprint. The organization up until now doesn't directly deal with transport and are not aware of the total spend on transport and its environmental effects. With the establishment of the sustainable store program and to have competitive advantage it is of prime importance to know the total costs of supply chain involved in the construction of a store and its environmental implications.

The Logistics currently is being carried out by third party, but it is of interest and importance to know the course taken by materials and supplies to reach site and map the entire supply chain.

Currently PVH has a central warehouse (Seacon) in Netherlands where items are stored and cross dock from external supplier at times happen. Seacon uses external transport services. Hence as of now the company is unaware of the details of the transport company, the cost of transport, number of trips taken and the environmental impact of this. Materials are procured from around the world, like China, India etc. Each of these has different methods of material transport which need to be considered. In addition, PVH constructs stores in and around (Russia, Middle East, and South Africa) Europe. The supply chain needs to be analyzed specifically for each of these countries.

Most stores are built in bustling urban areas or malls where there is no space for material storage or accessibility, so Just in Time (JIT) delivery needs to be used to ensure there is no waiting time and materials are not being damaged due to improper storage. The total delivery process needs to be carried out in such a way that labor is not idle and materials are transported JIT.

This requires reviewing of the current process and re-framing it to ensure efficiency is acquired. But this is not possible without the support of the employees involved in the process; the current process and practice followed by each department needs to be mapped out. Internal and external supply chain needs to be mapped out, focusing on separation of vehicles, machinery and people.

4.3 Methodology

The supply chain of store development from the start to the end was mapped out. This gave an overall picture of all the stakeholders involved and information and material flow path.

This was followed by interviewing the stakeholders to get their perspective on current logistics management of the organization. This gave an understanding of where every department stands and what their requirements are.

Following this historic data was collected to carry out a spend analysis to see the top five suppliers in terms of transport. Seacon the logistics provider emerged at the top, which was expected and the other suppliers were mostly fixture suppliers who deliver to store directly. A two-supply flow analysis will be carried out, one is the overall store development process and second two individual cases will be studied.

For flow one analysis, Seacon was contacted to get their total Inbound and Outbound for January and February 2017, bi-weekly meeting was set up with Hay Dings the account manager for Seacon to collaboratively strategize. The data received from Seacon was an extensive excel file with every line depicting an inbound or outbound. To make sense of the received data, pivot tables were developed to carry out a trend analysis and chalk out the existing waste emerging from the current process.

Pivot Tables: It is a Data Processing tool that organizes and summarizes large amount data from spreadsheets or databases. It helps organize and group data.

The trend analysis brought to fore the existing problem regarding logistics, next Lean SCM and Green SCM were reviewed in relation to the organizations current practice to see the potential benefits in terms of costs and GHG. Next two individual projects in UK were chosen for supply-flow two analyses, to see how Lean SCM and Green SCM practices benefit an individual project in terms of costs and GHG. A soft system methodology(SSM) will be adopted to carry out the above-mentioned analysis.

SSM: It is a seven step methodology that enables modelling of organization models usually used problem solving or initiating change within an organization.

To understand the interdependency between Lean SCM practices and Green SCM practices in the context of the organization an Interpretive Structural Model(ISM) will be developed.

ISM: It is a six step methodology developed to establish a relationship between variables which relate to an issue or a problem. A series of subordinate relationships between the variables are established to understand the hierarchical dependency.

4.4 Current Supply Chain

The store development process was observed from close quarter as a project coordinator for 2 months before getting a good understanding of the process and the stakeholders involved. The store development has two teams, one that deals with the Tommy Hilfiger(TH) stores and the other the Calvin Klein(CK) stores, the only people common to both teams is the Project Manager(PM) and Project Coordinator(PC). The teams that are differentiated for both are; Architects, Concept team, Suppliers and Procurement, the contractor is chosen based on a closed tender procedure. But the process for both are the same hence a general supply chain map was created.

The company builds stores in and around Europe; there are four teams present that are responsible for different regions. One team deals with projects in the Middle East and Russia, the second deals with projects in Italy, France, Spain and eastern EU countries, the third deals with UK and the Scandinavian countries, the fourth team is responsible for Germany, Belgium Switzerland and Austria. Recently the company acquired China hence a fifth team has been set up that is responsible for designing and construction of stores in Asia pacific zone. But this thesis will mainly focus on the three teams that deal with projects in EU. The team dealing with projects in Middle East and Russia will be loosely touched upon.

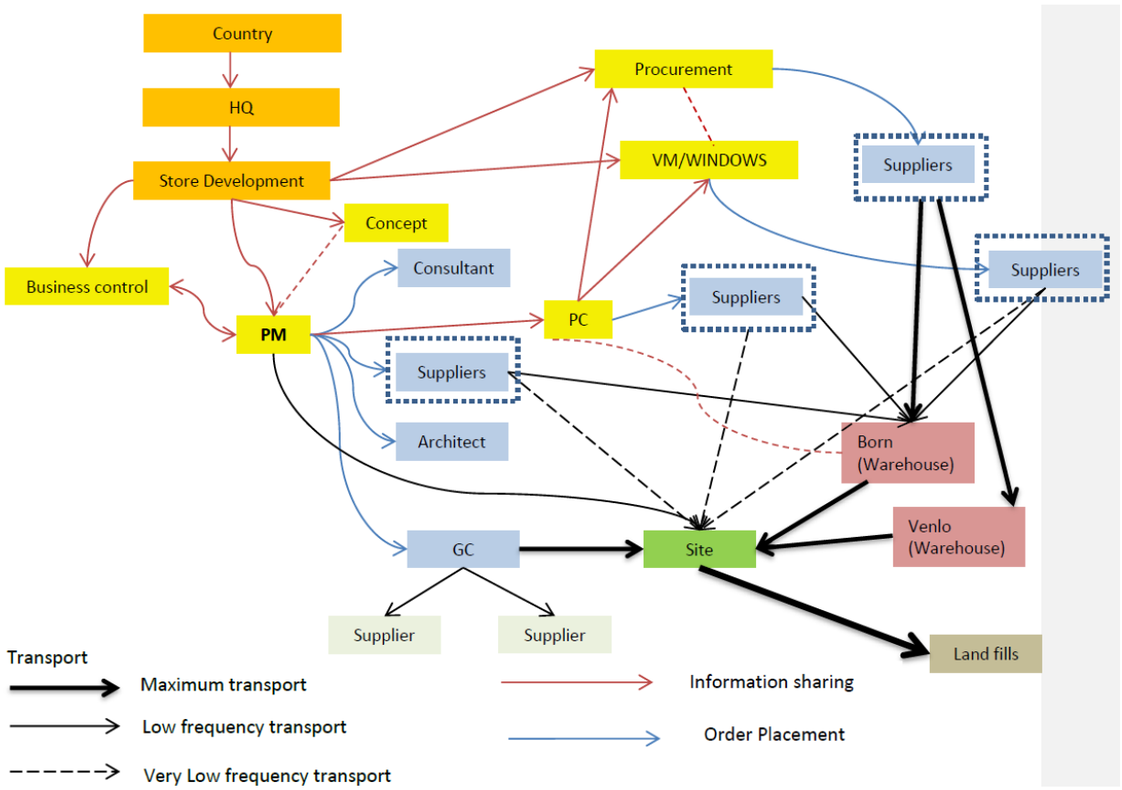

Figure 7: Organisation Supply Chain

Internal Team

The department of procurement deals with the procurement of generic items that are used in every store, primarily related to props and interior products. The products are procured to stock. The suppliers are global; materials are procured from China, India, UK and mainland EU. The materials are procured and stored in two warehouses located in Born and Venlo, Netherlands.

The PM is responsible for procuring items that are bespoke to the store. This includes the important interior fit out items, lighting, fixtures, flooring and other props. He is also responsible for procuring the contractor, HVAC, Electrical consultants and managing the site activities.

The PC one the other hand is responsible for ordering other minor items and coordinating deliveries to site. PC liaises with the PM to ensure items are being delivered to site on time. The PC and PM procure products to order. The suppliers are generally from mainland Europe.

The PC and PM procure materials that are either directly delivered to store or cross docked at Seacon depending on lead time and project opening date.

Suppliers

There are number suppliers that each department deals with; procurement, PM, PC and Contractor. The contractor procures the basic materials and equipment's whereas the major materials are procured by the company. And hence more focus will be placed on the suppliers that deal directly with PM, PC and procurement. The historic data from 2016 was used to select

the top suppliers of the company based on total cost spent on transport and the suppliers were contacted for further information on the details of their outbound transport to calculate the total GHG.

Seacon (Warehouse and logistics)

The warehouse was contacted for both inbound and outbound shipments received; the data was analyzed to see the trends in inbound and outbound shipments and mode of transport used. There are two warehouses at present, one situated in Born and the other Venlo. The analysis pointed out shipments were being received and sent out without proper consolidation plans.

Site

The PM plans the delivery date of materials to site. Materials are delivered to site as separate shipments from different suppliers, a few are sent via the warehouse after consolidation. As these stores are built in bustling cities there are always strict delivery restrictions and times, to receive materials by truck. The other issue that has emerged from sites is materials getting lost on site and improper storage of materials.

4.5 Stakeholder Analysis

A stakeholder analysis has been carried after interviewing the stakeholders based on their views on transport and inventory management, their requirement and current problems regarding logistics was asked and is documented in the table below. After the interview one aspect that seemed to be common amongst all stakeholders was the lack of importance given to being green though they considered it important. The stakeholders chosen for the interview where the ones who have direct control over logistics section, influence it and are affected by it.

- PM
- PC
- Procurement Team
- Warehouse (Seacon)

Stakeholders	Requirement	Problems	Power
Project Manager	Transport to site on time and low cost. Products delivered in excellent quality and fitted well.	Transport to outside EU countries very difficult, customs issues. Delicate products received broken on site. Poor site management, delivery restrictions to abide by specially UK.	Power to steer a project to be greener and opt for green choices and control budget accordingly
Project Coordinator	Transport to site on time, costs and quality. Inventory has enough stock of items	Consolidating shipment. Products partially delivered to site, products getting lost on site. Inventory not managed well, lot of items not on stock.	Coordinate shipments in such way to ensure full trucks there by reducing costs and GHG

Procurement	Store rollout up-to-date to ensure items are stocked optimally.	Items on stock not used, items being ordered from outside. Stock items being written off. Multiple people placing orders hence lack consolidation.	Consolidate shipments appropriately and forecast store requirements
Warehouse	Advance booking of inbound shipment and cross dock and advance notice of items to be	Incomplete information received, over load of certain stock items.	Sustainable managing of warehouse, transparency regarding costs and combining deliveries

Table 4 : Stakeholder Table

From the above stakeholder analysis, the few aspects that were bought to the fore were that the project coordinator has power in steering project to be sustainable and cost efficient, but requires the support of the other departments. He is also the only person who has a link with everybody on a stakeholder network map. The second aspect is that every stakeholder is willing to take the extra step to accommodate greenness and leanness in their daily activities and acknowledge the pitfalls of the current system. The external team especially the warehouse that is also the logistics provider is ready to embrace sustainability and make the necessary changes.

One stakeholder not mentioned in the analysis is upper management. Due their tight schedules interviewing them was left out of the scope of the project, but through other members of the team it can be concluded that if a business case is strong enough they are ready to drive it through all layers and make it of prime importance.

Transport Data collection

The first data collected was retrieving historic transport data of all stores in terms of costs. The GHG emission calculation requires transport distance, weight and type of transport. This data was hard to retrieve from suppliers, but partial data was retrieved from the warehouse wherein the distance and weight was available but mode of transport and the type of truck or sea freight used wasn't available. So, an estimate of GHG emissions was made with the data available, of course there will be a certain error in the calculation. But the transport from warehouse is only small portion of the transport, there are suppliers who directly deliver to store and GHG emission arising from this is hard to collect due to non-availability of data.

The data helped in chalking out the top suppliers based on transport costs, countries from where maximum inbound takes place and countries wherein maximum outbound takes places. Costs according to product shipped, lighting, flooring, fixtures, signage, etc. the other aspect that was brought to light was the potential for better consolidation plans as the warehouse logistics manager also revealed that most trucks are not full when sent out.

Inventory management data

Inventory data was related to gathering information regarding how frequently orders for stock is being placed, is there enough on stock at every given time. How many items on stock are not needed anymore, and how many projects suffered due to non-stock items.

Case Study

Two stores were studied in detail for greater insight and clear understanding. The stores chosen for the study was one TH and CK project, the TH project was the first BREEAM rated store.

4.6 Analysis of current supply chain

To analyze the current supply chain of PVH existing tools were researched upon and the two tools that came to the fore were SCOR model developed by the supply chain council and Soft System Methodology.

The SCOR model which stands for Supply Chain Operations Reference is a tool used to assess, improve and make management decisions. It helps chalk out a business process to meet customer demands (Hudson, 2004). The SCOR model was developed specifically for the manufacturing industry. The SCOR framework constitutes of 5 parts; plan, source, make, deliver and return. A construction supply chain differs from the plan, source, make, deliver and return frame. This led to the development of builders SCOR by Micael Thunberg and Fredrik Persson from the University of Linkoping. The Builders SCOR has very little research and ambiguous implementation techniques.

Soft System Methodology was developed by Peter Checkland from the University of Lancaster, it adopts a systems approach to problem solving and is used for driving change in an organisation (Visee, 2014). Construction projects is known for its complexity and difficulty in management, the SSM method helps analyse and take actions on specific problems by understanding the perceptions of the various stakeholders involved (Maqsood, Finegan, & Walker, 2001). The Soft System methodology has been used in many cases to potentially solve construction and in specific logistics related problems and hence this case study will be analysed using the SSM tool.

4.6.1 Soft System Methodology

Soft system methodology emerged as need to apply system thinking to problem solving. It was developed in the University of Lancaster. A seven-step tool based methodology was proposed to analyze a given a problem.

Step one: This step entails defining the problem situation, to define the problem situation existing data was analysed and trend analysis was carried out to chalk out the existing problem.

Transport and inventory management hasn't been given importance in the store development process. There is no set reporting or tracking method in place, there is no overview of spend on transport and it isn't a major concern of most stakeholders involved though it accounts for large part of the construction costs. Over the course of time inventory level has been a major issue as inventory is either being over stocked with materials later being written off or there is a shortage of materials requiring direct express shipment by supplier increasing costs. The transport on the other hand is being handled by logistics partner Seacon; the company has no overview of transport and its related costs and GHG emissions. There is lack of coordination within the company due to which, the warehouse is receiving orders from multiple locations from within the company and are finding it difficult to consolidate and report accurately back to the company. In addition, Seacon has two warehouses wherein company goods are stored. Optimising logistics process has proven to have costs and environmental benefits giving the organisation competitive advantage. The purpose of this PGR is to review the complete use of transport and logistics services within the Retail department of PVH Europe B.V. By analysing and grouping the various activities, an accurate spend analysis can be performed. Below the existing problem is defined in detail.

To identify the existing problem and related Lean SCM and Green SCM wastes, a two-flow supply analysis was carried out. The first-supply flow analysis entailed analysis of the overall logistics spend of the store development process, second-supply flow analysis was studying two individual projects in specific to chalk out the waste emerging at project level. The store construction process has a two-flow material procurement. The first one is the procurement department who procure to stock, second is the PM and PC who procure materials for individual projects and get them delivered to site just in time or via cross-dock. Hence to get a comprehensive idea of the current logistics both these flows were analysed. The Figure below is the depiction of the current supply chain.

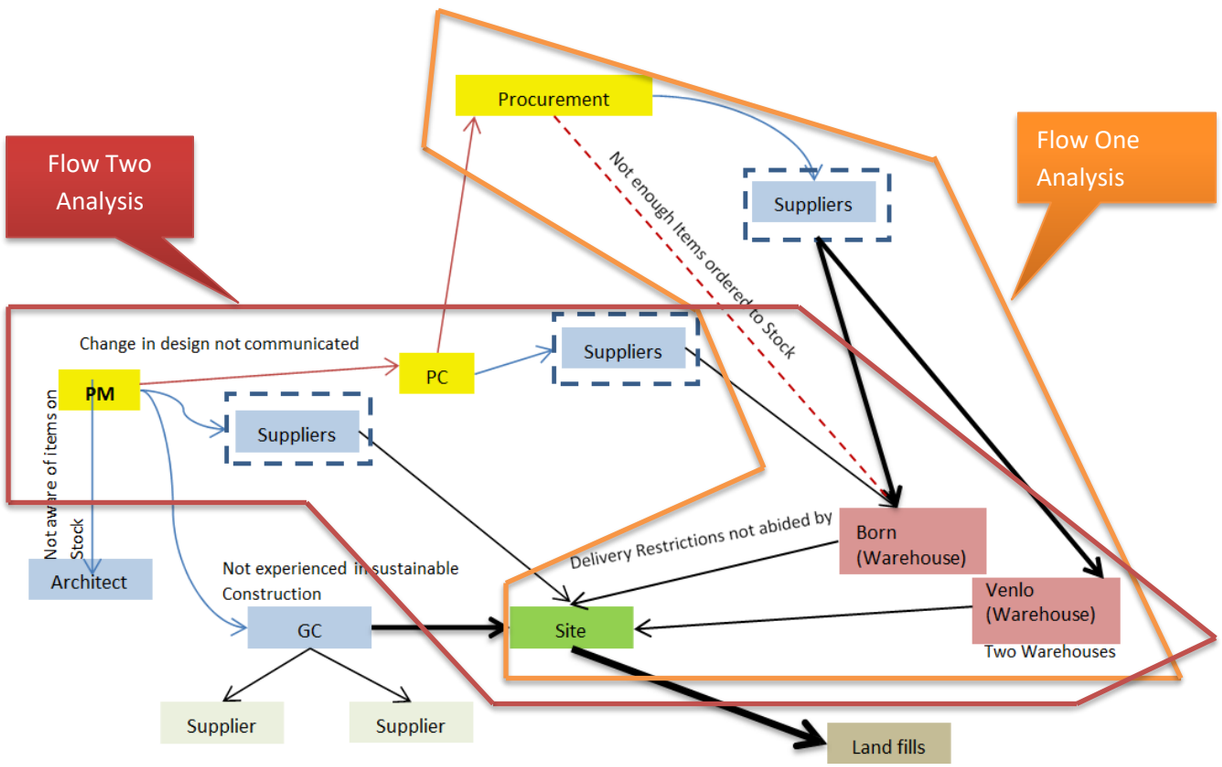

Figure 8: Focus of Case Analysis

Flow-One

For the first-supply flow analysis, a spend analysis on transport was carried by the procurement department. The analysis showed the top suppliers that the company uses and amount of transport and inventory that is being spent on these companies. The analysis brought to fore that Seacon the logistics provider is the highest in terms of transport costs and inventory which was expected, but there were few other suppliers who deliver goods directly to site, deliver items to stock or cross dock using their own transport which also accounts for a sizeable amount of transport costs. The table below shows the total costs spent on transport

CURRENT STATUS

Spend Analysis Top 10 Suppliers

Supplier	Total costs		Percentage
Seacon Logistics B.V.	€	1,169,210.71	29.79%
Image Builders B.V.	€	742,531.90	18.92%
Alan Nuttall Ltd.	€	613,606.10	15.64%
Teamwork - Interiors B.V.	€	453,604.06	11.56%
EYELEVEL s.r.o.	€	376,668.88	9.60%
IDW GmbH Duisburg-Toronto	€	81,276.30	2.07%
HH Associates Ltd.	€	78,381.08	2.00%
KeyTree Limited	€	74,560.00	1.90%
Shop & Store Concept GmbH	€	55,803.00	1.42%
Soopl Nederland B.V.	€	47,246.41	1.20%

Figure 9 : Spend Analysis

As it can be seen from the above table, the warehouse (Seacon) accounts for almost 30% of total transport costs. And the following suppliers are all fixture suppliers who deliver products to site directly or inbound to Seacon.

The next step in analysing the problem revolved around getting transport details from Seacon to do a trend analysis to see the several types of waste emerging from the current process. To make a trend analysis the historic data of 2017 and for ease of analysis the inbound and outbound for the month of January and February was analysed. The information requested from Seacon was:

- Essential information:
  1. Place and date of loading and unloading (get distance)
  2. Total Weight (to calculate GHG)
  3. Sender and Customer
  4. Number of pallets (to know the volume)
  5. Loading and Unloading Date (to calculate frequency of shipments)
  6. Costs of shipments

- Data analysis

1. Top Suppliers that deliver to Seacon
2. Frequency of Delivery
3. Volume shipped
4. Country that receives maximum shipments
5. Number of shipments sent out in a day and a week
6. GHG emission Calculation

Total Emissions = Distance x Weight or Volume x Emission factor (Weight, Volume or Distance)

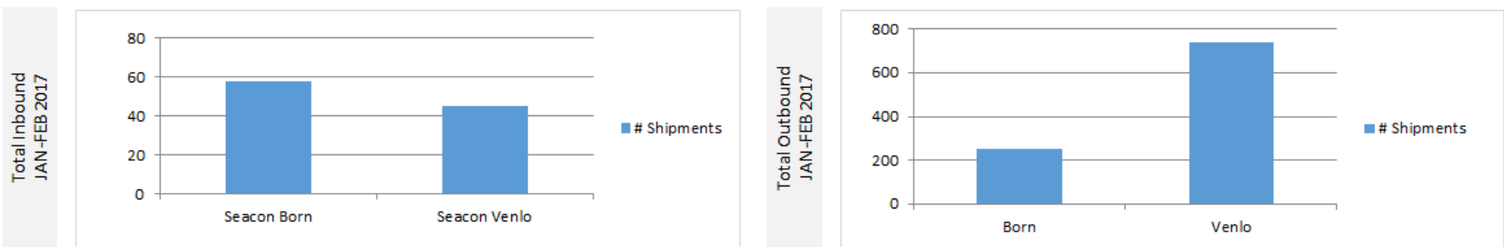

Figure 10: Warehouse Inbound and Outbound Graph

The above graphs pictorially represent the volume of shipments being sent to both warehouses, the amount of inbound to Born is higher than to Venlo but outbound from Born is lower than from Venlo. The frequency of shipments leaving Venlo is higher than frequency of shipments leaving Born.

The reason for greater inbound to Born is because more suppliers deliver to Born than Venlo. The warehouse at Born service the sites during the construction phase, whereas the items in Venlo are consumable which stock items for the operation of a store after construction and hence have larger amount of outbound. But the shipments leaving Born and Venlo are going to the same location, but due to two different warehouses the shipments are not consolidated.

Inbound wastes

CURRENT STATUS		
➢ Total Inbound		
Warehouse	**# Shipments**	**# Pallets**
Seacon Born	58	951
Seacon Venlo	45	2865

Inference
➢ *Number of trucks to Born - 64*
➢ *Number of Trucks to Venlo - 191*

Table 5: Total Inbound

CURRENT STATUS

➢ Total Inbound Venlo

Row Labels	# shipments	Sum of # of Pallets
China	1	1
France	1	110
Netherlands	5	80
Portugal	19	1253
United Kingdom	18	445

Inference

Average pallets coming in to Venlo from Portugal and UK

- *Portugal – average 59 pallets – 4 truck load*
- *UK – average 36 pallets – 3 truck load*

Table 6: Total Inbound Venlo

CURRENT STATUS

➢ Total Inbound Born

Row Labels	Number of shipments	Sum of # of Pallets
Netherlands	28	354
United Kingdom	19	49
Germany	5	31
Turkey	3	212
Switzerland	3	10
Lithuania	1	1

Inference

Average pallets coming in to Venlo from Portugal and UK

- *UK – Average 3 pallets – 1 truck Load*
- *Germany- Average 5 pallets – 1 Truck Load*

Table 7: Total Inbound Born

The number of shipments and pallets help us estimate the number of trucks coming into both the warehouses. To get a ballpark idea, it was assumed that 15 pallets make one full 40ft truck; from the data collected it was evident most shipments were made by 40ft trucks. The loading capacity of 40ft truck varies from 20-24 pallets if standard EURO pallets of size 80 X 120 are used. But as not all plates are EURO sized and some are larger, the expertise of the logistics provider was used to arrive at the value 15 for calculation purposes. In two months, 64 trucks deliver to Born and 191 trucks deliver to Venlo. Shipments to Venlo are higher volume shipments using 3 to 4 trucks whereas the shipments to Born are one truck wherein on an average each truck carries 3 or 5 pallets which are not full truck loads. The data gathered from warehouse and suppliers who send the inbound specify that most trucks are only partially full. What can also be noted is that countries deliver to both warehouses; especially the UK there is inbound happening to both warehouses from UK and hence there is potential for consolidation if the warehouses were merged.

Further focussing on UK, the table below depicts the shipments from UK to Seacon. The first table shows the days in which shipments were being made to Born and Venlo on the same day. The second table shows, the different customers from within the company who request for deliveries to warehouses, it can be noted that customers within the organisation are not consolidating their orders before placing with supplier due to which multiple shipments from the same supplier are being sent to the same location on days that are not that far apart. This increases costs and frequency of shipments which increase GHG emissions.

CURRENT STATUS

- Total Inbound UK

Row Labels	Born	Venlo	Grand Total
1/5/2017	1	1	2
1/12/2017	1	1	2
1/23/2017	1	1	2

Total Inbound Per Sender

Customer	Sender	Country	Unloading place	Unloading Date	# of Pallets	# of Cartons
HILCONAMS	IDP Direct	UK	Venlo	1/11/2017	33	1080
HILCONAMS	IDP Direct	UK	Venlo	1/12/2017	18	530
HILCONAMS	IDP Direct	UK	Venlo	1/16/2017	21	664
HILCONAMS	IDP Direct	UK	Venlo	1/17/2017	2	56
HILFIGEREUROPEAMS	ARNO GB	UK	Born	1/18/2017	13	515
HILFIGEREUROPEAMS	ARNO GB	UK	Born	1/19/2017	2	4
CALVIAMS	ARNO GB	UK	Born	1/23/2017	1	1
CALVIAMS	ARNO GB	UK	Born	1/24/2017	1	1
HILFIGEREUROPEAMS	ARNO GB	UK	Born	1/25/2017	1	50

Table 8: Total Inbound UK

Outbound Wastes

CURRENT STATUS

- Total Outbound

Warehouse	# Shipments	# Pallets
Born	410	1032
Venlo	1317	1617

Inference

- *Number of trucks from Born - 69*
- *Number of Trucks from Venlo - 107*

Table 9: Total Outbound

CURRENT STATUS

- Total Outbound Venlo

Warehouse	# Shipments	# Pallets
Germany	278	326
Spain	161	135
Italy	155	166
France	125	84
Poland	109	71
Netherlands	101	101
United Kingdom	88	87

Inference

- *Germany average 3 pallets – Total 1 truck*
- *UK average 3 pallets – Total 1 Truck*

Table 10: Total Outbound Venlo

CURRENT STATUS		
➢ Total Outbound Born		
Country	# Shipments	# Pallets
Netherlands	150	678
Germany	49	76
United Kingdom	48	17
Spain	39	26
Italy	22	62
France	21	40
Russia	11	21

Inference
➢ *Germany average 3 pallets – Total 1 truck*
➢ *UK average 3 pallets – Total 1 Truck*

Table 11: Total Outbound Born

As in the inbound analysis it was assumed that 15 pallets make up one truck. From both warehouses, it is evident that Germany and UK are the biggest markets and it also because most stores are constructed in these two countries. The outbound from both warehouses it is evident that a shipment on average has three pallets which is less than a full truck load. This increases truck frequency thereby increasing GHG emissions and costs of shipments. From the above table, what is also evident is that shipments are delivered for example to Germany and UK from both warehouses to the same stores, hence combining warehouses will help consolidation.

The table below shows an example of deliveries to UK on the same day, the senders from within the organization do not consolidate their orders due to which multiple shipments are being sent out.

Customer	Loading place	Country	Unloading Date	# of Pallets	# of Cartons
HILFIGEREUROPEAMS	Born	United Kingdom	1/13/2017	1	12
CALCONAMS	Venlo	United Kingdom	1/13/2017	1	2
CALCONAMS	Venlo	United Kingdom	1/13/2017	1	6
CALCONAMS	Venlo	United Kingdom	1/13/2017	1	6
CALCONAMS	Venlo	United Kingdom	1/13/2017	1	12
HILCONAMS	Venlo	United Kingdom	1/13/2017	1	25
CALSISAMS	Born	United Kingdom	1/16/2017	1	21
CALCONAMS	Venlo	United Kingdom	1/16/2017	0	1
HILCONAMS	Venlo	United Kingdom	1/16/2017	1	22
CALVIAMS	Born	United Kingdom	1/24/2017	2	15
HILCONAMS	Venlo	United Kingdom	1/24/2017	3	8
HILCONAMS	Venlo	United Kingdom	1/24/2017	3	9
HILCONAMS	Venlo	United Kingdom	1/24/2017	3	15
HILSISAMS	Born	United Kingdom	1/16/2017	2	4

Table 12: Outbound UK

Inbound and Outbound Wastes

WEEK	inb3	inbv	out3	outv	Grand Total
1/12/2017	3	2		1	6
1/16/2017		1	2	2	5
1/23/2017	2	4		2	8
1/24/2017	2		1	3	6
2/3/2017		6	4	4	14
2/16/2017		1	1	3	5
2/17/2017		1	1	2	4
2/20/2017		10	12	2	24

Inb3 – Inbound Born

Inbv – Inbound Venlo

Out3- Outbound Born

Outv – Outbound Venlo

Table 13: Inbound and Outbound

The above table is another example of inbound and outbound from UK where shipments are being delivered to warehouse from UK on the same day as shipments are being sent out to UK from warehouse. From the table above it is evident that circuit delivery is possible if coordinated and single party does both inbound and outbound.

Waste emerging from other processes

From the existing stock count and cross dock items it was brought to fore that some items on stock are not being used and orders for the same items are being placed with suppliers bespoke. One such item is floor carpets, though the carpets are on stock most project coordinators order carpets bespoke from supplier and cross dock to warehouse. The main reason being the carpets on stock are of a particular size, were as on the detailed floor plan the architects use different sizes due to which project coordinators order them directly from supplier. The non-utilization of such items has made operations within the warehouse difficult as carpets are stored in the lower rack which is the prime location for storing items on high demand, but as these carpets aren't being used it is using up valuable space and items that are on high demand are placed above and accessing these items has led to additional personnel, time and machine requirement. The use of additional personnel and time is non-value adding and hence is considered a Lean waste and use of additional machinery consumes electricity and lends to Green waste.

Another important waste emerging from stock management is low stock count of certain products that have very long lead times. This is one of the reasons multiple deliveries are made to site, this increase costs and GHG emissions, apart from low stock some items arrive damaged to stores, especially the special lighting fixtures made from glass.
Apart from the above-mentioned process related wastes, neither the company nor the logistics providers are considering reusable and ecofriendly alternatives to packaging, delivery and internal operations.

The above-mentioned problems are related to stock and warehouse logistics, but during store construction the GC procure materials and the project manager procure materials which get delivered to site directly. The logistics chain of GC materials is hard to control and hence choosing a GC who is lean and green in his approach is important to ensure eco-efficient logistics. The logistics supply chain of the project manager is within the operations of the organization and hence controllable. Below the logistics related waste arising from the PM side will be explored.

Flow-Two

The key issues with logistics arising from the PM side is that, the same PMs manage both CK and TH stores which in most cases are in the same location, but they treat the projects in isolation. Due to which deliveries are done separately when there is potential for consolidation especially in cases where both brands share the same supplier. This negligence has led to extra trucks delivering goods and non-value adding work while processing orders. Two projects from UK one CK and TH were studied to delineate the existing wastes. The projects will be explained below to chalk out the logistics related waste.

Tommy Hilfiger and CK Store Leeds, UK

Location

The stores are in Leeds, UK in the bustling neighbourhood of Harewood Street. The store is in the Victoria Gate Mall; it is a retail development that opened on 20th October 2016. The mall has 35 stores in total and two of which that belong to PVH

will be discussed. Given that 35 stores are being constructed at the same time in a bustling city, there were strict delivery restrictions that had to be abided by:

No delivery restriction for size. Lift is needed as there is no loading bay. Delivery time must be announced to landlord at least three days prior to delivery. Landlord provides a strict time window when loading area is available. The entire centre is opening on same day so everyone wants to deliver on same few days.

Figure 11: Location of Victoria Gate Mall

Figure 12: Location of TH and CK store

TH Store

The TH store was pilot project in the companies venture to be sustainable, it was awarded a BREEAM very good certificate. The focus of the BREEAM certification was on the construction process and materials procured, the logistics was neglected. The BREEAM certificate also reflected the negligence on logistics as the project didn't score in the transport section.The Project Manager and Project Coordinator for this store are seated in the company headquarters that is in Amsterdam, Netherlands.

The Project Architect RPA is a UK based company and all TH projects are designed by RPA.

Project Details
Budget of the store: 802,000 Euros
Net SQM: 231 m2
Opening date: 20th October 2016
Project Duration: 15th June 2016 – 20th October 2016

The delivery details (Distance, pallets, costs, supplier, origin) of all shipments have been mentioned in Appendix A.

CK Store

The CK store was a traditionally managed project and was not Green rated. The main reasons for not Green rating this project was costs, getting a green rating incurs additional costs given that external consultants and supplier green certificates are required. The per sqm costs of the TH project was greater than that of the CK project due to the additional Green costs. As mentioned in the TH project the PM and PC are seated in Amsterdam. The Architect for CK stores is HouseHamHenderson an architectural firm located in Madrid, Spain.

Project Details:

Budget of the store: 343,300 Euros
Net SQM: 110 m2
Opening date: 20th October 2016
Project Duration: 22nd June 2016 – 20th October 2016

The delivery details (Distance, pallets, costs, supplier, origin) of all shipments have been mentioned in Appendix B.

Wastes from individual projects

The two projects were analyzed to see the number of deliveries that were made to site, the country of origin of these deliveries, costs of deliveries, inventory costs and GHG emission per delivery.

The current process in the company is that, the suppliers that PM deals with the deliveries are made directly to site but suppliers that PC deals with Cross dock to Seacon from where they are sent out as one shipment. The GC also procures materials, but as they procure locally they get the goods delivered just in time. The goods procured by the GC, there was no available data of and hence this is left out of the scope of the analysis.

One of the main reasons for choosing the two projects for a case study was because I had firsthand experience managing the project as a Project Coordinator. Before starting my Graduation Thesis in the company, I had been working as a store development intern for six months in the company and the mentioned cases were my first project to handle as Project

Coordinator under the guidance of the senior project coordinators. The experience of placing orders liaising with project manager and site personnel to ensure deliveries to site was happening in time and costs gave me further insight into the current working process of the organization and its drawback while considering principles of Lean SCM and Green SCM.

To gather the relevant data, SharePoint of the company was accessed wherein every purchase order and invoices are recorded. Due to inconsistent data regarding recorded weights, they have been left out. The lack of data on weights makes estimating GHG emission hard as weight is a crucial factor whilst considering GHG emission. But for analysis sake the change in emission factors with increased loading will help conclude if an action helps reduce GHG emission or not.

The construction site is at the Hub of the city and many stores are going to be opened at the same time and every store construction would require materials coming and leaving the site. Hence the mall authorities had strict delivery restrictions.

Delivery restrictions in the UK need to be strictly abided by, certain deliveries were refused and had to be sent back and forth due to delivery restrictions not being obeyed. Due to strict delivery restriction project in UK have a local Distribution Hub that houses supplies for a certain period before delivery to store.

The warehouse had a few items not in stock due to which 5 different shipments had to be sent out for the TH store of which two where express shipments to ensure materials get to store in time. The CK store again due to item not being on stock two different shipments were sent. Though the two stores were being constructed in the same location, the shipments from warehouse were sent on different days to the stores as the orders weren't consolidated within the department before being placed.

Most suppliers from the Netherlands and from other regions sent separate shipments, there was no consolidation. To deliver goods to UK custom paperwork needs to be filled out, which costs money, and every supplier charges the company for these additional costs.
The shipments were sent out via trucks predominantly and express deliveries were through air.
The contractor procured for the job was not familiar with sustainable construction.
The Architects weren't aware of the size of the items on stock and hence had used materials in design that were different from the ones on stock due to which materials from supplier had to be procured bespoke.
Many suppliers have delivered more than once to store due to incorrect communication and damage of products.

Lean SCM Practices in the current process

The current logistics processes in the organization do not follow Lean practices, but just in time practiced by PM's is the only Lean SCM abiding practice in the organization.

Green SCM Practices in the current process

The current logistics process in the organization do not follow Green practices, the BREEAM rated store followed only Green practices in the store construction materials and operational phases but neglected the Green practices in the logistics department.

Lean and Green Waste

	Lean waste	Green waste
Transport management		
Infrastructure		-
Transport Mode		All shipments by truck when there is possibility of sea and air.
Modal transfer Points		-
Load Planning	Inefficient loading - non-value adding.	Lack of consolidation, hence poor load planning. Half Empty trucks
Routing and scheduling		Routing not paid attention.
Warehouse Management		
Location	-	-
Number	Double warehouse that doesn't add any value	Double warehousing leads to poor consolidation
Size	-	-
Type	-	-
Cargo handling System	Multiple handling due to multiple orders. Inefficient time and personnel use	Not using energy efficient cargo Handling System
Inventory management		
What to Stock	-	-
Where to Stock	Slow moving stock placed on lower racks thereby occupying prime location in a warehouse	-
How much to Stock	High inventory of certain items, certain items low stock. No balance.	Items on stock not used
Packaging and Unitization		
Unit size	-	No optimal pallet dimension and packaging
Protective Packaging	-	Non-Eco-friendly packaging
Handling System	-	-
Information Processing		
Information System	Lack of information sharing and integration within organization	Lack of Transparency
Control	-	-
Forecasting	Poor forecasting of materials	-

Table 14: Existing Lean and Green Waste

The above analysis establishes the current problems in the organization in relation to logistics; the step two of SSM will now be used to analyze the situation deeper to figure out the Lean SCM and Green SCM practices that can be implemented to reduce costs and GHG emissions.

Step two: Make a rich picture of the stakeholder views and problems identified in step one. A rich picture pictorially explains the inter-relationship between various stakeholders and brings to light certain nuances that are otherwise lost or not heeded to.
To develop a rich picture the data presented previously under stakeholder analysis and problems identified in Step one will be used, which was developed from interviewing various stakeholders, information gathered from team meetings and observing the store development process.

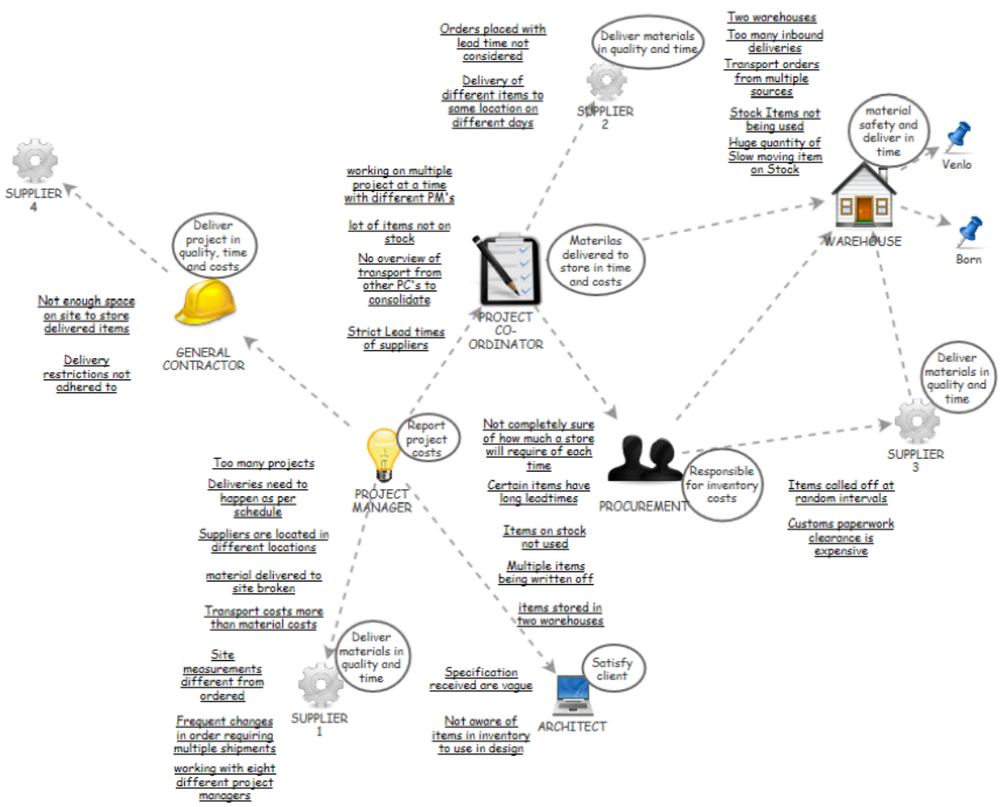

Figure 13: Rich Picture

Step three: Following the rich picture the next step would be too formulate a root definition. This help in narrowing down the focus and define a scope around which problem solving needs to take place. To help formulate a root definition a CATOWE method is suggested.
C – Customer – The party who will be affected by the project is the customer.
In this case, the organization is one of the customers as they own and operate most of the stores. The second customer is the franchise partner who owns the store after construction.
A – Actor – The entities involved in carrying out the project are the actor.
The main actors in the project are the Project managers, Warehouse, Project Coordinators and Procurement. These four actors are finally responsible for orders and deliveries. The procurement team is responsible for inventory levels.
T – Transformation – The main changes that need to happen for the new system.

The three-transformation process that the organization needs to adopt is Transparency in operation, cooperation and information sharing.
O – Owner – The person who is responsible for the project.
The Project manager and the logistics provider which is the warehouse are the main owners of the problem. The project manager as he controls the schedule and the budget of the project and logistics provider as they are responsible for storing inventory and arranging transport.

W – World View – How does this project affect the bigger picture, the reason for carrying out the project.
The project helps company gain competitive advantage by being eco-efficient. Reducing GHG emissions also impact the society by a large.

E – Environmental constraint – the entities or organization that might hinder the project.
The project is beneficial for not only the organization but also the society.

If the formulated root definition fails to address the above then it needs to be reworked.
Root definition:
"The change process initiated by the organisation who with help of project managers, Warehouse, project coordinators and procurement team will ensure reduced costs and GHG emissions arising from logistics through increased transparency, cooperation and information sharing helping the company gain competitive advantage and benefiting the society abiding by company policies and national policies."

Step four: The step is to develop a conceptual model of a line of action.
The rich picture brought to light the real problem and the perspectives of the various stakeholders. In step four of SSM a conceptual model is developed that will help solve the problem for which the Lean SCM and Green SCM framework developed in the previous section considering trade-offs and synergistic benefits will be used to compare the proposed framework to current practice in the company.

Step five: Compare the conceptual model to the present as is situation.

Conceptual Model	**Present situation**
Local deliveries will be delivered Just in Time	Most local deliveries are delivered Just in Time
Consolidate shipments for global deliveries	Global deliveries procured by PM delivered Just in time to site
Circuit delivery	Vendor deliver using their trucks and circuit delivery not being practiced
Use rail and sea over truck	Most shipments by Truck
Use electric vehicle	Currently electric vehicles not being used
Inform Architects regarding Stock list	Architects are not aware of items on stock.

Single Inventory	Two warehouses in close proximity, Born and Venlo.
Energy Efficient Cargo System	Traditional cargo system used.
Third party logistics.	Currently carried out by third party logistics.
Vendor Managed Inventory	Procurement team deals with material procurement
Eco friendly Packaging	Traditional packaging materials, carton boxes.
Packaging to ensure stack ability	Importance not given to packaging
EDI information Sharing	Currently there is no system to enable EDI information sharing
Appoint a member to consider transport consolidation.	Transport sent out on request no one over looking to consolidate.
Intra department coordination.	Each department works in isolation.

Table 15: SSM conceptual model

Step six: Mention the changes that need to be implemented. In step five the conceptual model and the as is situation were reviewed. In this section based on gap between conceptual and as is situation certain action point will be listed. The actions listed were derived from market research and by discussing with stakeholders within the organization through a focus group session.

Conceptual Model	**Present situation**	**Action**
Local deliveries will be delivered Just in Time	Most local deliveries delivered Just in Time	All local deliveries to be arranged for JIT
Consolidate shipments for global deliveries	Global deliveries procured by PM delivered Just in time to site	Based on geographical location of site plan consolidation of shipments
Circuit delivery	Vendor deliver using their trucks and circuit delivery not being practiced	Plan pick-up and delivery route to ensure trucks are not entering empty
Use rail and sea over truck	Most shipments by Truck	opt for rail and sea over truck.

Use electric vehicle	Currently electric vehicles not being used	For local deliveries and short distance deliveries opt for Electric modes
Inform Architects regarding Stock list	Architects are not aware of items on stock.	Set up a system wherein architect receives stock list.
Single Inventory	Two warehouses in close proximity, Born and Venlo.	Merge both warehouses will help in consolidation
Energy Efficient Cargo System	Traditional cargo system used.	Invest in energy efficient cargo handling system.
Third party logistics.	Currently carried out by third party logistics.	Transport by third party logistics makes reporting difficult and achieving environmental goals hard. Hence investing in own vehicles to plan pickup and delivery is an option but requires capital and makes achieving full trucks harder.
Vendor Managed Inventory	Procurement team deals with material procurement	Appoint a member to ensure full trucks and truck pooling will also help achieve fuller truck loads.
Eco friendly Packaging	Traditional packaging materials, carton boxes.	Switch to environmental friendly reusable packaging.
Packaging to ensure stack ability	Importance not given to packaging	Optimal packaging technique to be adopted. Existing technology to efficiently stack trucks is available that should be used.
EDI information Sharing	Currently there is no system to enable EDI information sharing	With technology 4.0 multiple EDI sharing platforms have been released. Organization needs to implement a suitable one.
Appoint a member to look into transport consolidation.	Transport sent out on request no one over looking to consolidate.	Once both warehouse in merged, there will not be a need of all the employees as operation will be carried from one location. The extra employees in this case can handle only consolidation.
Intra department coordination.	Each department works in isolation.	PC's to coordinate with each other and plan deliveries and place orders.

Table 16: SSM Conceptual model and Actions

Step seven: Take the necessary actions.

The actions mentioned in the above table as per focus group discussion will have to be implemented. To ensure successful implementation of strategies, all stakeholders within the organisation need to embrace the change process.

4.7 Benefits of implementing the proposed actions

The benefits of implementing the mentioned actions will be analysed against the entire store development process first, then two individual projects one CK and one TH project from UK will analysed to see how the strategy affect individual project at a micro level.

4.7.1 Lean Practices

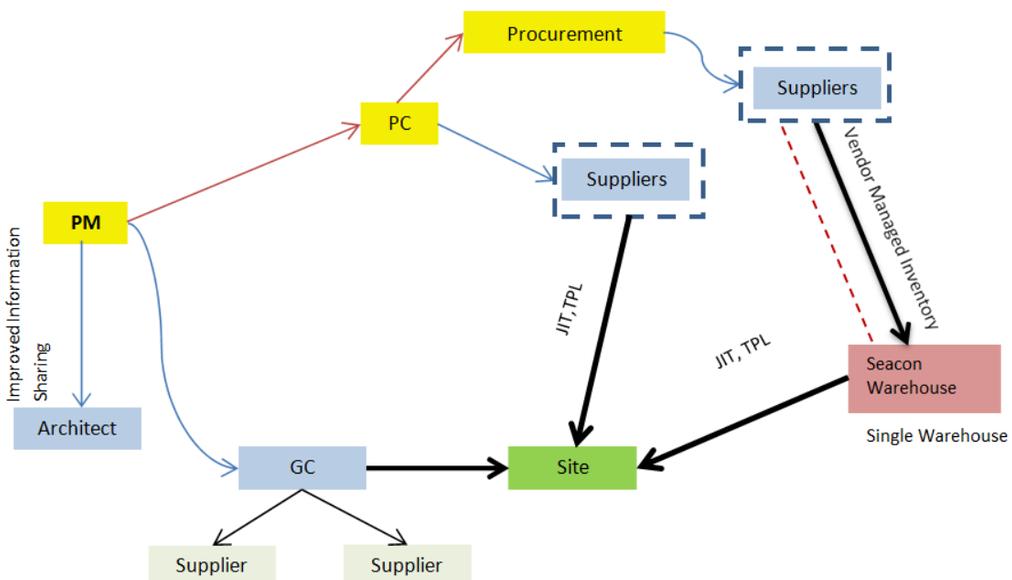

Figure 14: Lean SCM Practices

The above diagram is a representation of a fully Lean SCM process. A stream lined flow is maintained wherein there is only one person that is the PC in charge of ordering materials to get them delivered just in time to store. The suppliers who deliver to stock as certain items given lead times cannot be delivered just in time, are managed by the vendor themselves negating the need of the procurement department to keep track of all stock. Below the benefits of implementing Lean SCM in flow-one and flow-two logistics will be analyzed.

Flow-One: Lean Practices

<u>Increased Information sharing</u>

- Architect receives stock list
  In the months of January and February seven stores opened. Each of these stores carpets were ordered bespoke from supplier and the carpets on stock weren't used. By sending in the stock list to the architects they will be aware of the items on stock and use the right dimension in the drawing thereby reducing need to order items bespoke.

- Transport Costs: This will reduce transport costs of supplier having to deliver. The carpet supplier for TH is Tiftix a supplier located in Turkey, the delivery costs of carpets to the warehouse in Netherlands were the items are cross docked is on an average 250 euro. The carpet supplier for the CK project is Hagros a supplier located in the Netherlands and the transport costs are relatively cheaper at an average of 40Euro. Hence if items that are on stock are used these additional costs on transport can be saved on. Which is about 1120 Euro (250*4 + 40*3) given four TH projects and three CK projects were opened in that month.
- Inventory Costs: This will reduce inventory holding costs of cross dock items.
  Every item that is cross docked, Seacon charges a handling and holding fee. In case of carpets, warehouse fee of the items on stock are being paid and an additional charge is being paid for cross dock items. Hence inventory charges can be reduced of cross docked items and stock will be used up lowering inventory holding costs further till it is replenished. Seacon handling and holding costs
  Handling: € 5.00 per coli to cross dock
  Documents: € 65.00 per truck/container
  This sums up to 75 euro per cross docked shipment in case of carpets as they come in two coli or packages, a saving of 525(75*7) euro could be made considering the cross dock for the seven projects that were opened.
  Apart from costs this also reduces the time spent by personnel on unloading, making place and labelling of goods.
  GHG Emissions: Lower transport results in lower GHG emissions
  The reduction in deliveries results in lesser shipments which translate to lesser number of trucks thereby reducing GHG emission. GHG emission can be calculated by
  Total Emissions = Distance x Weight/Volume x Emission factor (Weight, Volume or Distance)
  As the focus is on carpets, four projects used Tiftix as a supplier for carpets and three projects used Hagros.
  The distance between turkey where Tiftix is located and Netherlands is 2700 km.
  The shipments on an average weight will be considered "W".
  The mode of transport used is truck. The emissions factor for a partially full truck is 75 g/ton.km
  The total emission per shipment will amount to = 2700*W*75*0.0011(convert to g/ton) = W*222.75 g/ton.km
  This multiplied by 4 shipments from Tiftix would be= W*222.75*4= W*891 g/ton.km of emissions could have been reduced.
- EDI information sharing
  Transport and Inventory Costs: The increased information sharing will help in consolidating orders within the organisation which will help reduce transport frequency which in turn will reduce costs. The benefits of order consolidation will be explained later.
  GHG Emissions: The reduction of transport frequency will reduce GHG emissions.

Third Party Logistics(TPL)

TPL is the practice of outsourcing logistics services to an outside organisation. They are independent companies who provide logistics services to multiple companies and are tied by long-terms contracts (Papadopoulou, 2001).

Transport costs: TPL services are proven to be cheaper than use of own and operated vehicles as they are managed by professional logistics providers. A study conducted by Capgemini Consulting on third party logistics in 2017 revealed that 75% of organisations who use TPL have reported lower logistics costs. With the advent of technology 4.0 and growing competition TPL providers are using technology to enhance customer value and are taking steps to increase efficiency.

GHG emissions: The use of third party logistics will help ensure fuller trucks, but over the years research has shown that most truck run half empty as mentioned in the literature survey. A survey conducted by Eurostat in 2012 show that 30% of the truck in Netherlands are running empty and on an average the EU 28 countries ,22% of the trucks are running empty (McKinnon & Piecyk, 2010). Emissions increase as the truck occupancy decrease (McKinnon & Piecyk, 2010). But TPL providers all over the world are committing to green goals, (Lieb & Lieb, 2010) study the extent to which TPL providers incorporate Green initiatives, the study revealed that TPL providers all over the world are committed to Green goals and have launched programs to have a positive impact on the environment. Hence, the use of TPL reduce GHG emissions not only through fuller trucks but also through other processes.

Merge Warehouses

Transport costs: Merging warehouses without consolidating orders and shipments is not going to reduce transport costs. Hence warehouse merger will have an impact on transport costs only if shipments and orders are consolidated, but the warehouse merger help better consolidation of shipments.

Inventory costs: From meeting with the warehouse representative it was evident that the warehouse in Born there is surplus unused space that belongs to PVH, whereas in Venlo the warehouse space dedicated to the company is almost fully being utilized; warehouse costs are paid per square meter of space. Hence even if allocated space is not being used the organization must pay for the unused space, with merging warehouses the unused space will decrease as the single warehouse in Sq.M will be lower than the sum of both warehouses, and surplus from Venlo will utilize the additional space.

GHG emissions: As mentioned in transport costs warehouse merger in conjunction with consolidation will reduce transport frequency thereby reducing GHG Emissions arising from transport. The optimal use of warehouse space will reduce the use of unnecessary electricity thereby reducing GHG emission arising from electricity use.

Just in Time

The costs and GHG emissions of Just in time delivery will be analyzed later in flow-two.

Interdepartmental coordination

Interdepartmental coordination will ensure single shipments are being sent by suppliers in each week or day. There are four departments within the organization that order materials from suppliers. The first division in departments is based on the two brands TH & CK and each of these have two departments; store design and development and Shop in Shop. This makes it four independent departments. To make an estimate of the benefit of interdepartmental coordination, the data focus will be on inbound from UK in the months January and February.

Customer	Sender	Unloading Date	Week
HILFIGEREUROPEAMS	ARNO GB LIMITED	3/7/2017	Week 10
HILFIGEREUROPEAMS	ARNO GB LIMITED	3/7/2017	Week 10
CALVIAMS	Blacks	3/1/2017	Week 9
CALSISAMS	Blacks	3/1/2017	Week 9

CALVIAMS	Alan Nuttal Ltd	2/24/2017	Week 8
CALSISAMS	Alan Nuttal Ltd	2/24/2017	Week 8
CALVIAMS	Alan Nuttal Ltd	2/24/2017	Week 8
CALSISAMS	Alan Nuttal Ltd	2/24/2017	Week 8
HILSISAMS	ARNO GB LIMITED	2/22/2017	Week 8
HILSISAMS	ARNO GB LIMITED	2/22/2017	Week 8
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/25/2017	Week 4
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/25/2017	Week 4
CALVIAMS	ARNO GB LIMITED	1/24/2017	Week 4
CALVIAMS	ARNO GB LIMITED	1/24/2017	Week 4
CALVIAMS	ARNO GB LIMITED	1/23/2017	Week 4
CALVIAMS	ARNO GB LIMITED	1/23/2017	Week 4
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/19/2017	Week 3
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/19/2017	Week 3
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/18/2017	Week 3
CALVIAMS	ARNO GB LIMITED	1/18/2017	Week 3
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/18/2017	Week 3
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/9/2017	Week 2
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/9/2017	Week 2
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/5/2017	Week 1
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/5/2017	Week 1
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/4/2017	Week 1
HILFIGEREUROPEAMS	ARNO GB LIMITED	1/4/2017	Week 1

Table 17: Inbound Daily

As mentioned in the problem definition there is multiple deliveries from the same supplier on the same day to Seacon due to uncoordinated order placement. If the orders within the organization were coordinated via a coordinated order placement method then instead of multiple orders on a single day, one delivery per day can be planned or even one delivery per week. Instead of 27 deliveries it could be reduced to 12 deliveries if orders were consolidated daily, and 7 if consolidated on a weekly basis.

Transport and Inventory Costs: The reduction in frequency of shipments will reduce costs of shipments. As the frequency reduces, the handling costs at the warehouse will reduce as they charge per truck that comes into their warehouse. They charge 65 Euro per truck that enters the warehouse. Instead of 27 deliveries if the deliveries could be reduced to 12 by consolidating daily, costs could be reduced by 975 Euro (65 * 15 (lesser deliveries)). If the deliveries were consolidated on a weekly basis, the number of shipments will reduce to 7, the costs could be reduced by 1300 Euro (65*20).

GHG Emissions: The lower the frequency of trucks lower will be the emissions. Coordination of orders increases consolidation and truck loading thereby reducing GHG emissions. By increasing the loading capacity on a truck, the emission factor per good shipped is lowered thereby reducing the overall GHG emission.

Vendor managed Inventory

As mentioned in the problem definition, there have been multiple cases wherein due to low stock multiple shipments to site have had to be sent. The procurement department needs to keep track of stock of multiple items and each item has a different lead time, there have been occasion wherein procurement has overlooked the stock count of certain items in comparison to the number construction sites on the roll out. But in case of vendor managed inventory each supplier will be responsible for their stock level, if the supplier is aware of the projects on roll out then depending on lead time they can send stock replenishment reminders to the procurement team.

Transport Costs: This will reduce transport costs of multiple shipments being sent to site due to low stock, out of the seven projects opened in the two months Six projects back orders had to be sent due to low stock. Back orders are normally sent with express delivery as they need to reach site before opening. Hence, optimum stock quantity could have reduced the need for these express deliveries thereby reducing costs.

GHG Emissions: The lower the number of shipments sent the lower will be the emissions. Express delivery is sometimes made by Air which further increases the emission in comparison to truck.

The transport costs and GHG emission reduction will further be discussed when analyzing the individual projects.

Use Local Suppliers

Lean SCM suggests the use of local suppliers to arrange just in time deliveries which help in being more efficient and reduce costs of inventory.

Transport costs: Use of local suppliers will help lower transport costs as shorter distance will be travelled. But this is hard to implement given the global nature of construction projects and in retail store construction uniformity needs to be maintained between stores across the globe and hence use of different suppliers will not help achieve this.

GHG Emissions: The use of local suppliers will also reduce GHG emissions as shorter distances will be travelled. The longer the distance travelled for goods delivered the emissions will increase as they are directly proportional to each other, given the formula; Emission$\uparrow$= Weight * Distance$\uparrow$* Emission factor.

Flow-Two: Lean Practices

To analyze the benefits of Lean SCM practices on per project basis, certain calculation regarding costs and GHG had to be made. For GHG calculations emission factors of trucks had to be derived based on loading, this data was derived from (Anten, Van Amstel, & Verweij, 2014) and (McKinnon & Piecyk, 2010). All deliveries for the project were made by truck, Seacon warehouse uses a 40tonne truck which is 60-65% full, and hence the emission factor for the warehouse delivery was considered 65 g/ton-km (McKinnon & Piecyk, 2010). Items cross docked to Seacon are made by small suppliers who are not logistics providers, hence use small personnel vans for delivery to Seacon. The emission factor of a small van or car is greater than that of a truck, and the standard emission factor for vans is 75 g/ton-km.

Just in Time

Just in time delivery of Lean practice is eliminating the need of consolidation centres and warehouse to save on inventory and storage costs and get materials to site when required for immediate use. Just in time delivery increases number of deliveries to store and is cost effective in terms of transport and inventory and eco-friendly in terms of GHG reduction whilst considering local deliveries but in the case of global suppliers delivering Just in time turns out to be expensive and harmful to environment.

In case of the two projects Just in time delivery increases the number of shipments to both stores to 49 main shipments. This will reduce inventory holding costs of 5 euro per coli and 65 euro per truck, but directly shipping to store is very expensive and is more than the savings made on inventory, which is why Lean SCM proposes local suppliers, but in the case of retail store development to maintain uniformity in all stores a long-term relation is established with a single supplier.

The two stores, goods ordered by PM were delivered just in time to store and goods ordered by PC were delivered via the warehouse. The suppliers also charge higher for transport compared to warehouse as they are not logistics providers.

- TH store

Inventory Costs:

Three suppliers cross docked to Seacon. The holding costs and inventory for these shipments were 210 Euro (5*3 + 65*3)[5 euro per coli, 65 euro per truck] this will be eliminated in case of just in time.

Transport Costs:

But transport to store directly will cost more than to the warehouse, as UK is farther than the Netherlands to the three suppliers, as all three suppliers are located in the Netherlands. The warehouse charge less per pallet shipped when more pallets are being shipped.

The transport costs of goods to the warehouse were 130 Euro in total. In case of direct delivery to the UK the suppliers on an average charge 180 Euro and use either DHL service or vans as these are small shipments. The total costs of shipment then rise to 540 Euro (180*3) which is higher than the savings made on inventory.

GHG emissions:

By using just in time delivery, the truck occupancy from Seacon is reduced which in turn leads to higher emission per item delivered, thereby increasing the GHG emission. The emission factor considered was 65g/ton.km but with reduced

occupancy the emission factor will be greater than 65g/ton.km (Mckinnon, 2015). The transport services used by the Suppliers are either vans or other services like DHL, in case of van the emissions are higher compared to truck (McKinnon & Piecyk, 2010)

- CK store

Inventory costs:

One supplier cross docked to Seacon. The Holding costs and Inventory for these shipments were 70 Euro (65*1+5*1) which will be eliminated in case of JIT.

Transport costs:

The supplier that cross docked to warehouse is situated in Netherlands and the delivery costs to warehouse were 40 euro. In case of direct delivery to UK the delivery costs on an average will be 180 Euro. This is greater than inventory costs.

GHG emissions:

As mentioned in the TH project reducing the number of items leaving Seacon reduces truck occupancy thereby increasing the emission factor per item shipped. This will increase the GHG emission.

Vendor managed Inventory

As mentioned in the flow-one analysis due to inefficient stock management multiple shipment have had to be sent out to a store. In the case of the TH and CK project In Leeds, due to low stock level for the TH store five shipments had to be sent and the CK store 3 shipments had to be sent. The use of vendor managed inventory is an effective way to ensure sufficient items are on stock in which case the number of deliveries from warehouse could have been reduced to just 1 shipment per project.

- TH store

Transport costs:
The costs of additional shipments cost 2818 euro, the last shipment was an express delivery and cost more. If all items were on stock the additional shipments could have been avoided thereby saving money. The total transport costs could have also been reduced as per pallet costs reduce when more pallets are sent out.

GHG emissions:
As mentioned earlier every item in one shipment or truck would have reduced GHG emission as truck occupancy would have been greater. The emission factor of the truck would have been lower than 65 g/ton.km thereby reducing harmful emissions.

- CK store

Transport Costs:
The costs of additional shipments amounted to 1400 Euro which could have been avoided.

GHG emission:
As mentioned in the TH store sending more shipments in one truck increase occupancy thereby reducing emissions.

Single Inventory
The benefit and GHG reduction of single inventory was explained earlier and hence will be left out of this analysis.

Increased information sharing
As mentioned earlier, rugs are one product that are procured to stock but aren't used due to different sizes mentioned on the Design plan. Below per project benefit in terms of costs and GHG emission will be analyzed.

- TH Project

Inventory costs
Seacon charges 5 euro for one coli and 65 euro for documents which is 70 euro for the ordered rugs. These 70 euros could have been saved in case the items on stock were used.

Transport costs:
Using the rugs from inventory would have avoided the need to order them bespoke from supplier. The transport costs of the rug ordered from supplier was 250 Euro. This could have been avoided if items from stock were used.

GHG emission
The GHG emission arising from the delivery could have completely avoided, the frequency of trucks on road is also reduced which reduces over all GHG emissions.

- CK project

Inventory costs
As mentioned in the TH project a saving of 70 euro could have been made.

Transport costs
The supplier for CK charges around 40 Euro for delivery to the warehouse which could have been saved, though this is a small amount in terms of costs it impacts GHG emissions of a project which needs to be avoided.

GHG emissions
The GHG emission arising from the delivery could have completely avoided, the frequency of trucks on road is also reduced which reduces over all GHG emissions

4.7.2 Green Practices

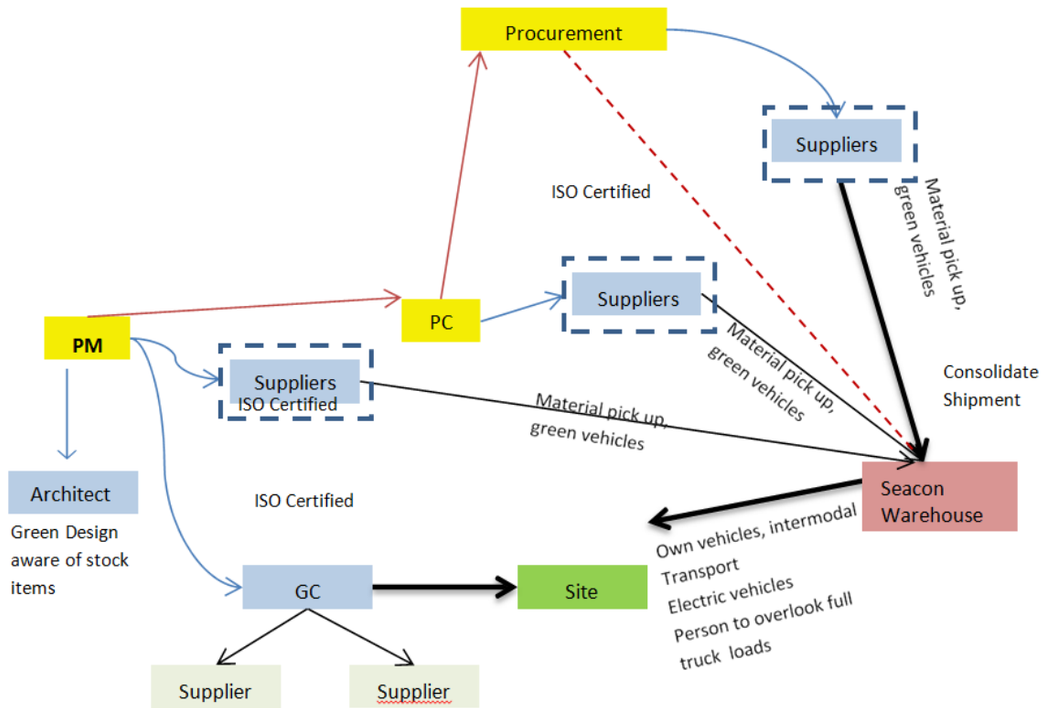

Figure 15: Green SCM Practices

Green SCM

Green transport and distribution emphasize on consolidating shipments, having a local distribution center, planning circuit deliveries, investing in eco efficient vehicles, practicing intermodal transport, ensuring suppliers and GC are green certified and maintaining vehicles.

Flow-One: Green SCM Practices

Supplier ISO certification

Selecting suppliers with an ISO certification will ensure materials are being procured, manufactured and delivered in an eco-efficient way. But choosing ISO certified suppliers or suppliers who opt for a green approach costs more than normal suppliers. The two projects which will be discussed later, one is the first BREEAM rated project and second is a normal traditionally managed project. The per square meter costs of the BREAAM rated project was more than the per square meter costs of the traditionally managed projects as the BREEAM rated project required using suppliers with Green certificates.

ISO certification will help lower GHG Emissions. But increases initial costs.

Plan Pickup and Delivery – Circuit Delivery

As mentioned in the problem definition section at multiple occasions' deliveries are made to the warehouse from one country and deliveries from Seacon are made back to the same country this makes circuit delivery possible which will ensure fuller trucks returning.

WEEK	inb3	inbv	out3	outv	Grand Total
1/12/2017	3	2		1	6
1/16/2017		1	2	2	5
1/23/2017	2	4		2	8
1/24/2017	2		1	3	6
2/3/2017		6	4	4	14
2/16/2017		1	1	3	5
2/17/2017		1	1	2	4
2/20/2017		10	12	2	24

Inb3 – Inbound Born

Inbv – Inbound Venlo

Out3- Outbound Born

Outv – Outbound Venlo

Table 18: Inbound and Outbound - Circuit Delivery

The above table is an example of deliveries from UK and to UK on the same days. In case of circuit delivery for each warehouse, if a single truck was delivering and picking up orders of one warehouse then the aim is to ensure just one truck is leaving and entering each of the warehouses. So, in a day the total inbound and outbound from two different warehouses should amount to 4 shipments and 2 trucks in total. The table above shows a total of more than 4 shipments a day, the goal is to reduce this amount. By planning pickup and delivery, the total number of trucks on road will reduce, but to ensure only one shipment is leaving and entering the warehouse, the lean practice of interdepartmental coordination will need to be implemented as it will help consolidate orders. The lack of order consolidation within the various departments has led to, for example 12 shipments being sent out on the 2/20/2017 to the same country. Hence circuit delivery in conjunction with interdepartmental coordination will help reduce delivery frequency.

Transport costs: Transport costs will reduce as more shipments are being sent in one truck and less empty truck are returning.

Inventory costs: As the frequency of deliveries reduces the handling costs at the warehouse will reduce per truck thereby reducing warehouse charges.

GHG emissions: Fuller trucks, consolidation, less empty trucks returning and lowered frequency help reduce GHG emission as the emission per good shipped decreases as the loading on truck increases.

Truck Pooling

Truck pooling is an idea suggested as in retail store development most projects are in new malls and shopping centers wherein multiple brand stores are being constructed to open on the same day. The European headquarters of few of these brands is the Netherlands for example Nike, G-star etc. By collaborating with other brands deliveries can be optimized, the warehouse also deals with other clients apart from PVH so if orders from other clients and orders from PVH can be consolidated with approval from the parties involved costs and emissions can be reduced significantly.

Appoint Additional person

Most of the strategies mentioned above require an additional pair of eyes to consolidate the orders coming in, to plan delivery and pick up routes and ensure full trucks. An additional person apart from carrying out the mentioned tasks will also keep track of the company's emissions. To ensure successful implementation of the strategies a dedicated person needs to be

appointed, but this would mean additional salary and OPEX requirement. But with the Lean SCM strategy of Warehouse merger, the employees will now move into one warehouse. The born warehouse has four people working for PVH and the Venlo warehouse has three people, with the merger there will not be a need for seven people as operations will be carried from one location, in this case the additional two employees can be appointed to ensure consolidation and GHG emission reporting. Lean SCM strategies help save resources that can be used to achieve green goals.

Intermodal Transport

Intermodal transport is the use of rail and sea for a certain distance and then switching to truck for the rest. The use of rail and sea is not only cheaper but also more environmental friendly as the emissions per g/ton.km of rail and sea is lower than that of truck. But the downside of this strategy is time; delivery by truck is quicker than rail and sea. But with growing awareness of GHG emissions arising from road transport, railway lines are being constructed for better connectivity to transport goods. The Rhine-Alpine Corridor connecting Netherlands, Germany and Italy is one such initiative (Commission, 2015).

Transport costs: Transport using rail and sea is cheaper than truck or air.

Inventory costs: The costs of handling will increase as at given junction where mode of transport needs to be changed additional personnel will be required. But these costs are negligible compared to savings made on transport as per the warehouse representative.

GHG emissions: Emissions arising from rail and sea are significantly less compared to truck.

Electric vehicles

The GHG emission of Electric vehicles is hard to calculate as there are a lot factors that need to be accounted for, such as source of electricity, electricity generation fuel mix, time of charging and type of vehicle (McLaren, Miller, O'Shaughnessy, & Wood, 2016). GHG emission of electric trucks is estimated to range from 25% to 89% lower than normal trucks (Lee, Thomas, & Brown, 2013). Electric vehicles cannot be used for long distance deliveries; the usual range is 100 – 150 km (Nesterova & Quak, 2013). Hence local deliveries can be achieved with electric freight services, reducing the emissions by a minimum of 25% for the local deliveries.

Pack cartons in truck efficiently

Packing cartons in a truck efficiently to ensure fully loaded trucks plays an important role in reducing GHG emissions. There is two type's truck loading efficiency; productivity which is the measure of output (ton-km) to input (Fuel, labor and vehicle) and utilization which is the ratio of capacity used to capacity available (Caplice & Sheffi, 1994). High productivity and utilization rate not only help reduce costs but also reduce GHG emissions per pallet shipped. Article by (McKinnon & Piecyk, 2010) represent the reduction in Carbon emission with increase in payload and increase in truck occupancy. The table developed by Alan Mckinnon shows that 46% of GHG emission can be reduce using a fully occupied truck compared to a 50% empty truck.

Reusable Eco-Friendly pallets

Pallets for a major component of Logistics Industry, they are usually made of wood, plastic or corrugated paper. Plastic cartons have a higher carbon footprint due to method production and the raw material used, one the other hand wooden pallets carbon footprint emerges from the various chemical surface treatments that are used. Wooden pallets though reusable

and recyclable suffer from this aspect as their treatment methods are not eco-friendly (Philip & Kurisunkal, 2010). Currently in the organisation wooden pallets are being used but over the years eco-friendlier alternatives are being introduced into the market, pallets made out of coconut husk, fibre slip sheets and corrugated paper pallets are eco-friendly options compared to plastic or wood and companies that manufacture these claim that the eco-friendly alternatives are cheaper than wooden or plastic pallets.

Flow-Two: Green Practices

Geographical consolidation

The General contractor procures materials locally and gets it transported to store directly. The PM and PC procure materials from suppliers all around Europe. Some of the company suppliers are located in UK, for this particular project consolidating all the shipments in the warehouse situated in Netherlands would mean double the travel for supplies coming from UK. Hence Green proposes Geographical consolidation based on location of suppliers and site.

- TH Store

Transport Costs:

The PM procures materials from Germany (Flooring), Netherlands (Signage, Fixtures, Wall tiling, Audio System, Curtains) and Austria (Lighting) and gets them delivered just in time to UK. Considering geographical consolidation, the shipments need to be consolidated in one location before shipping out. The warehouse in Netherlands is a good consolidation point given the proximity to Germany and Austria. The sum of direct shipments from Germany, Austria and Netherlands amount to 19575 Euro. In case of delivery to Seacon the costs would be 4545 Euro (breakdown mentioned in the table below); these shipments will then have to be delivered from Seacon to UK. Initial shipment from Seacon the costs were 1200 for 4 pallets which is 300 Euro per pallet. With consolidating the other items in Seacon, the additional number of pallets would be 14 and if 300 was charged for each of these pallets the costs would be 4200 Euro. So, the total costs from supplier to warehouse and warehouse to UK is 8745 Euro, which is a saving of a little over 10.000 Euro compared to 19575 Euro. The stark difference substantiates the fact that most suppliers charge high for delivery as they are not logistics providers and delivery to the UK also needs custom clearance which is additional costs. Seacon is a logistic provider and is experienced in preparing documents which is why they charge comparatively lesser.

Flooring	Buenker GmbH & Co. KG	WEST GERMANY	1800 Euro to UK	800 euro to NL
Internal Signage	De goede.com B.V.	NETHERLANDS	2000 Euro to UK	220 Euro to NL
Signage	Everseen Lichtreklam e B.V.	NETHERLANDS	1500 Euro to UK	165 Euro to NL
Mannequins	Hans Boodt Mannequin s B.V.	NET HERLANDS	1500 Euro to UK	165 Euro to NL
Fixtures	Image Builders B.V.	NETHERLNDS	7705 Euro to UK	950 Euro to NL
Audio System	Mood Media Netherland s B.V.	NETHERLANDS	500 Euro to UK	240 Euro to NL
Wall Tiling	Tegeldeal.nl	NETHERLANDS	790 Euro to UK	300 Euro to NL
External Signage	The Set Company B.V.	NETHERLANDS	2340 Euro to UK	850 Euro to NL
Lighting	XAL GmbH	AUS TRIA	1440 Euro to UK	1020 Euro to NL

Table 19: TH Delivery Consolidation

Inventory Costs

Cross docking at the warehouse will incur inventory costs, a total of 9 shipments and 14 Pallets will be sent to Seacon. Each shipment 65 Euro will be charged and each coli 5 euro will be charged. But a pallet consists of more than one Coli, there were no record of number of coli's per pallet and hence this estimation will be left out. The costs per truck is 65*9 which equal to 585 Euro, the charge per coli is hard to estimate due to lack of data but the costs will not exceed the 10000 Euro saving made on transport. Hence the total costs of inventory and transport together is lesser than the initial costs.

GHG emissions

The additional 14 pallets to the initial 4 pallets from Seacon will fully occupy one truck thereby reducing the Emission factor drastically from 65 g/ton.km. Hence a huge saving on GHG emissions can be made when consolidating the shipments.

- CK store

Transport costs

The PM procures materials from Czech Republic, Netherlands and Austria. The total costs of shipment that were sent directly to store from these suppliers apart from Seacon were 10480 Euro. The costs of delivery from supplier to warehouse would amount to 6185 Euro, the warehouse initially charged 10800 Euro for 3 pallets which makes it 360 per pallet. Consolidating shipments will add another 9 pallets to the shipment, which results in additional costs of 3240 Euro(360*9). The total costs then become 9425 Euro (6185+3240 Euro) which less than 10480Euro.

Fixtures	Eyelevel	Czech Republic	7020 Euro to UK	4800 Euro to NL
Audio System	MoodMedia	Netherlands	420 Euro to UK	225 Euro to NL
Curtains	Eyelevel	Czech Republic	240 Euro to UK	90 Euro to NL
External Signage	Eyelevel	Czech Republic	800 Euro to UK	220 Euro to NL
Lighting	XAL GmbH	Austria	2000 Euro to UK	850 Euro to NL

Table 20: CK Delivery Consolidation

Inventory Costs

Four additional shipments will be sent to the warehouse and 65 euro will be charged per truck, this will amount to 260 Euro (65*4) and the coli costs will be left out due to inadequate data. But the savings on transport and inventory is very less in the CK case compared to the TH case as the fixture supplier for CK is from Czech Republic who charge higher for delivery outside their country, the difference in delivery to UK and NL is not much to make a substantial saving in terms of costs.

GHG emission

The distance between Prague, Czech Republic and Leeds, UK is 1580 km and the distance between Prague and Born, NL is 797 KM. Born is located en route Prague to Leeds. The direct shipment from Prague to Leeds the estimated GHG emission was: W1(Weight) * 1580(Distance)* 75(Emission factor) * 0.0011(converting to g/ton) = W1*130.35 g/ton.km

If it was sent via Seacon then: Prague to Born
W1 (Weight) * 797(Distance)* 75(Emission factor) * 0.0011 = W1*65 g/ton.km

Born to Leeds

W1(Weight) * 796(Distance)* 65(Emission factor, lower as Seacon uses larger truck and ensures greater occupancy as they are sending more number of pallets) * 0.0011 = W1*57 g/ton.km

Total emissions = W1(65+57) = W1*122 g/ton.km which is around 6% less than the original emission.

Intermodal Transport

Intermodal transport is the use of two or more modes of transport to deliver goods. Not all remote locations can be accessed by rail or sea; hence truck will have to be used. Netherlands and UK are well connected through sea; sea freight is cheaper and has a lower GHG emission factor than truck. Travelling more than half the distance by sea can reduce GHG emission drastically. The emission factor for sea freight ranges from as low as 8 g/ton-km to 50 g/ton km (Anten, Van Amstel, & Verweij, 2014), on the other hand the emission factor for a truck ranges from 50 g/ton km to 95 g/ton km (McKinnon & Piecyk, 2010). As it can be noted from the above the use of sea freight helps reduce 16 – 52% of GHG emissions.
The transport costs are also cheaper than the use of road and air, but additional costs will be incurred at modal junctions but is negligent compared to the savings made on transport.

4.7.3 Lean SCM and Green SCM

The above analyzed the effect of implementing Lean SCM and Green SCM strategies on costs and GHG emissions independently. It can be noted that both Lean SCM and Green SCM principles have a positive impact on cost and GHG emission reduction. The figure 16 below depicts the influence of Lean and Green practices on costs and GHG emissions.

		Lean							Green								
		Increased Information Sharing	Third Party Logistics	Merge Warehouses	Just In time	Interdepartmental Coordination	Vendor Managed Inventory	Use Local Suppliers	Supplier ISO certification	Circuit Delivery	Consolidation	Truck Pooling	Appoint additional Person	Intermodal Transport	Electric Vehicles	Pack Cartons in Truck Eficiently	Protective Reusable pallets
Costs	Transport Costs	↓	↓	↓	↑	↓	↓	↓		↓	↓	↓	↓	↓		↓	
	Invenotry Costs	↓		↓	↓	↓		↓		↓	↑		↓	↑			
	Initial Costs			↑					↑				↑				↑
Emissions	GHG Emissions	↓	↓	↓	↑	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓	↓

Figure 16:Effect of Lean and Green Practices on Costs and GHG emissions

The only aspect where Lean SCM negatively impacts GHG emission reduction is JIT delivery, global deliveries JIT increases GHG emissions as goods are travelling long distances separately when consolidation is possible. But what needs to be noted is that Lean SCM was developed in the Japanese car manufacturing industry in the 1930's, it was just after world war two when industrialization had emerged and business operation were very local, suppliers delivering parts and manufacturing units were in one geographical location. In that given scenario, Just in Time delivery saved on inventory costs as consolidating for short distance delivery was non-value adding. But with globalization and suppliers from other countries being procured to deliver materials, JIT falls short of adding value, and Lean SCM is based on eliminating non-value adding activities. With the current trend of Global Supply chain, JIT principle of Lean SCM is non-value adding and needs to be replaced with value-adding practices like geographical consolidation where ever possible. This doesn't mean to say JIT must be eliminated

completely, as mentioned in the analysis, JIT still holds good for Local deliveries. This is where a synergistic implementation strategy for Lean and Green SCM is to consolidate global shipments and JIT deliver local goods. When implementing the Lean and Green SCM framework together JIT for global deliveries will be replaced with consolidation which will reduce overall costs and GHG emissions, and retaining JIT instead of Green SCM practice of consolidation for local deliveries will reduce inventory costs.

Lean also helps save resources that can be used to achieve Green Principles. The Lean strategy of Single Inventory of merging warehouse will bring employees from both warehouses under one roof. In that case not all employees will be needed to carry out the works, as per the analysis made by Seacon there will be an additional 1.5 person which is 1 person who can be appointed to only overlook consolidation and green reporting.

Lean SCM practice of third party logistics help achieve Green SCM practice of consolidation and truck pooling. Lean SCM practice of Increased information sharing and interdepartmental coordination through EDI helps achieve Green SCM goals. The above-mentioned Lean and Green SCM practices when implemented simultaneously complement each other to further reduce costs and GHG emissions, reinstating the synergy between both practices. The other practices there are no points of digression which gives potential for simultaneous implementation, this will help achieve cumulative reduction of costs and GHG emissions of both paradigms.

To analyze the interdependency between the Lean SCM and Green SCM practices an interpretive structural model(ISM) was developed of the all the mentioned practices. An interpretive structural model helps establish hierarchical relationship between variables (Attri, Dev, & Sharma, 2013). The model is used to identify the relationship between variables and develop a comprehensive systematic model (Dube & Gawande, 2016). With the help of an ISM it can be brought to fore the Lean SCM and Green SCM practices that enable one another. The interpretive structural model was developed through the focus group sessions held with a member of the procurement team, member from Seacon, Project Manager and Project Coordinator. The stepwise breakdown of developing the ISM model can be found in Appendix C. Below is the final ISM model which represents the inter-relationship between all variables.

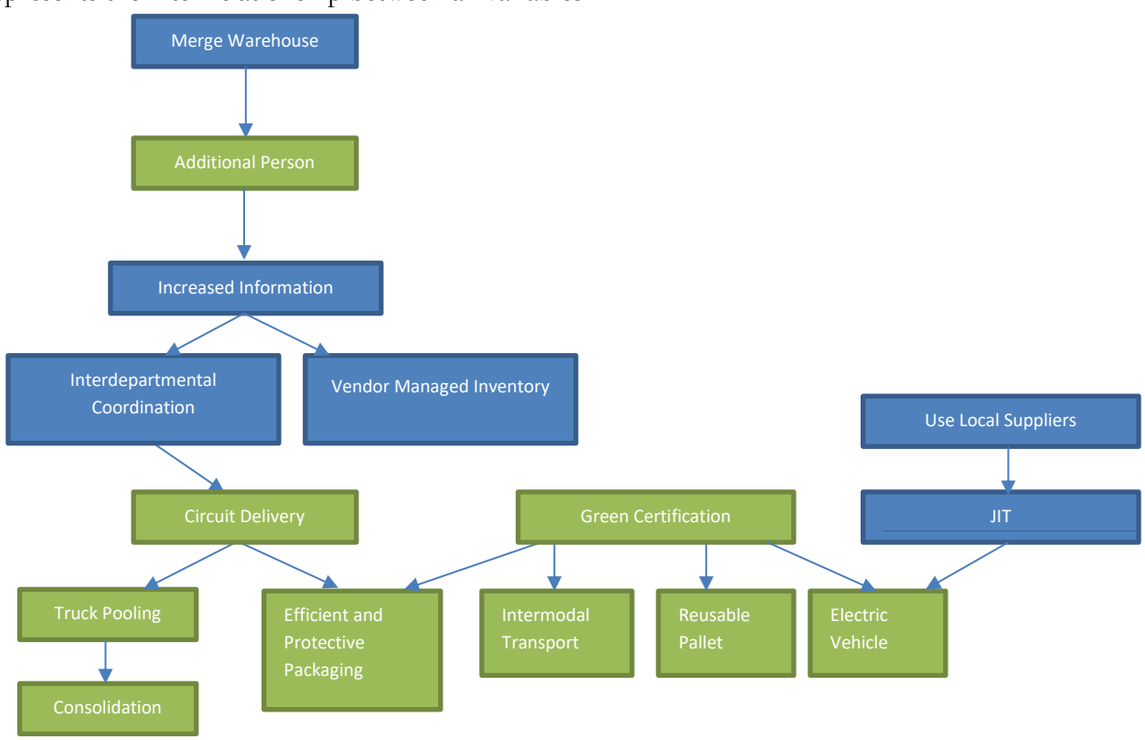

Figure 17: ISM Model of Lean and Green Practices

The above ISM model the blue boxes indicate Lean practices and Green boxes indicate Green practices. It is evident from the drawing that certain Lean practices enable Green practices and certain Green practices enable Lean. From the diagram, it can be inferred that, Merge warehouse, Green certification and JIT are level one ISM variables that do not have enablers. Implementing these strategies will help enable the other practices in the hierarchical order as mentioned in the diagram. Merge warehouse a Lean variable to eliminate non-value adding activity will enable achieve an additional person who can help in increasing the information flow within the various departments and maintaining transparency in terms of Logistics. Increased information flow will enable better collaboration which will in turn help achieve circuit delivery of picking up and delivering using truck pooling to ensure consolidation of shipments. Green certification of suppliers and the logistics provider will help achieve other Green practices such as, efficient packaging, intermodal transport, re-usable pallet and electric vehicle. The third, level one ISM variable which is the use of local suppliers will increase the use of JIT deliveries which can be done through electric trucks.

The analysis brings to fore that Lean and Green are not that divergent and one enables achieve the other thereby making it synergistic when implemented parallelly. Lean and Green help achieve costs and GHG reduction and together they have synergistic benefits as certain Lean practices help achieve Green goals with lower costs and Vice-Versa.

Chapter 5

This chapter the Limitations of the report, Conclusion and Further Research will elaborated upon.

5.1 Conclusion

The aim of the thesis was to bring about a harmonious and synergistic implementation strategy of Lean and Green practices in an organisation to reduce costs and GHG emissions of the logistics department. To achieve the aim a main research question and four research question were formulated which will be answered individually in this section.

The research focused on chalking out the key elements of a logistics department and evaluating each department against Lean and Green principles to see the effect on costs and GHG emissions. Extensive literature review of Lean and Green in the department of logistics was carried out to delineate the practices to optimise the logistics process. The data helped analyse the points of digression and convergence to develop a synergistic implementation framework. The developed framework was then tested in a case PVH Company across two supply flow of logistics operation. Data for flow one analysis was done using Pivot tables to create a trend analysis and chalk out the existing Lean and Green waste, data for flow two analysis was retrieved from company SharePoint to delineate the existing Lean and Green wastes. Then Lean and Green practices that tackle these wastes was analysed flow wise to see the benefit in terms of costs and GHG emissions. After which using ISM methodology an interdependent relationship between both paradigm was established to bring fore the synergy between both paradigms.

Answers to Research Questions

The main research question formulated is mentioned below:

Do Lean and Green principles have synergy when implemented simultaneously to reduce costs and GHG emissions across Logistics?

1. How do Lean SCM practices affect costs and GHG emissions of supply chain?

The answer to this research question was derived from literature review and the case study. According to the literature survey Lean was broadly considered to have negative impact on the environment. Breaking down Lean practices in relation to the key elements of logistics, the only aspect where Lean had a negative impact on GHG emissions according literature was in JIT delivery. JIT increases the frequency of shipments and reduces consolidation which in turn increases Green House Gas emissions. When JIT was tested in the case company PVH it was evident that JIT is eco-efficient whilst considering a local supply chain when deliveries are made by local suppliers for a short distance. The other aspects of Lean are Green friendly where elimination of non-value adding activities tend to achieve a Green initiative.
In relation to costs, both theoretically and as per the case study Lean through elimination of non-value adding activities reduce overall costs of the process.

2. How do Green SCM practices affect costs and GHG emissions of a supply chain?

As in Lean, the answer to this question was derived from literature review and the case study conducted. According to literature review Green has higher initial costs but turn out to be cheaper in the long run. Green practices require an initial investment such as getting certification, investing in ecofriendly appliances and using ecofriendly materials, but in the long run the eco-friendly material and appliance will use less electricity and require less maintenance and hence turn out to be cheaper. When tested in the case company, it was evident that Green does tend to be more expensive. The two projects chosen out which one was a BREEAM certified store had higher per/sqm costs than the traditionally managed project reinstating the fact that Green is expensive initially. The other Green Practices such as consolidation and intermodal transport

tend have higher inventory and handling costs at modal junctions but in comparison to the saving made on transport charges the inventory and handling costs are negligible.
In relation to GHG emissions, Green initiatives reduce GHG emissions from every phase of a logistics supply chain.

3. What are the aspects wherein Lean SCM and Green SCM diverge and converge?

From the literature review carried on Lean and Green it was evident that they both diverge on a principal level. Lean is to eliminate non-value adding activities and Green is to incorporate environmental friendly practices in an organization by reducing the discharge of harmful waste. Both paradigms converge at the point of waste reduction, wherein Lean is process related waste and Green is final Waste. The analysis on Lean and Green Practices in relation to logistics brought to light that the aspects wherein both diverge is Transport and Inventory. Lean proposes zero inventory and JIT delivery whereas Green proposes consolidation and minimum inventory. Lean practice of JIT delivery in today's global supply chain turns out to be non-value adding, Lean was developed in an era when supplies were procured locally and JIT was more efficient but with growing globalization this practice of Lean is not value adding and hence needs to be replaced with practices such as consolidation to reduce costs and GHG emissions. The Second point of divergence is Inventory, Lean practice of Zero Inventory is not feasible given the lead time of materials and demand for materials, hence materials need to be stocked to respond to immediate demand without delay. Hence minimum inventory should be available to service the sites that are on the roll out.

4. Does Lean SCM lend itself to Green SCM and Vice-versa?

The answer to this research question literature review and case study analysis will be used. As per literature authors have suggested that incorporation of Lean SCM makes incorporating Green SCM easier. Literature suggest that Lean principles lays the platform for Green principles and that organizations who have implemented Lean principles find implementing Green principles easier as Green is an extension of Lean. Hence in literature the synergy and the absolute necessity of implementing both parallelly has been referred to and confirmed. In the case study analysis, it was shown that individually Lean practices reduce costs and reduce GHG emissions apart from JIT delivery, Green practice on the other hand reduce GHG emissions and reduce costs apart from inventory costs. When implemented together according the proposed framework of replacing JIT of global deliveries with consolidation and retaining JIT for local deliveries saving on inventory costs help achieve synergy through collective reduced costs and GHG emissions, the savings and GHG reduction is greater than the sum of individual benefits given the trade-offs made in JIT and consolidation. Further to derive the interdependency between the Lean and Green practices an ISM model was developed in the context of the case company. The ISM model brought to fore the interdependency and independency of the different Lean and Green variables. From the ISM model, Lean practices enable certain Green practices and Vice-Versa. Merging warehouse, Green certification and procuring local suppliers are level one ISM practices which hierarchically help enable the other Lean and Green practices. Merging warehouse which a Lean practice to use single inventory helps save on resources such as man power who can then be employed for Increasing the information flow between various parties which will then increase the level of integration which in turn help achieve practices such as vendor managed inventory, consolidation and Circuit delivery. Green Certification on the other hand help achieve mostly Green practices such as efficient packaging, intermodal transport and electric transport. Use of Local suppliers though not a feasible practices will enable the use of JIT deliveries that can be done through electric vehicles. For further details, the ISM model can be referred to in section 4.6.3.

Lean and Green are two different paradigm that emerged in two different eras when the needs were totally different. But both paradigms work toward optimising a given process by reducing the emergence of waste. They have fundamental differences but work synergistically when implemented parallel. Through literature review and case study analysis it is evident that both paradigms when implemented together enable one another thereby helping in achieving synergy. The combination of both paradigms is greater than the individual sums given the level of interdependency and tendency to help achieve one another.

5.2 Recommendations

- The current process in the organization has multiple waste emerging which also reinstates the fact that logistics management is not given importance in the company. There is potential for improvement and it is high time the company embrace Lean and Green to make their Logistics Eco-Efficient. To bring about a change process in the company a few recommendations is proposed mentioned below.
- While making the stakeholder analysis it was evident that every member is aware of the current inefficiency in the logistics process, but everyone is busy with their own projects yearlong that they do not pay attention to this aspect. But with the need to reduce GHG emissions due to pressure from the EU union it is high time that employees take time out to incorporate the proposed Lean and Green aspects. Any strategy is only successful when the employees embrace it and implement it in their day to day activities. Conducting workshops is one such way to teach and educate the members to incorporate Leanness and Greenness.
- Once the change process is in motion it is important to track the performance of the implemented strategies and continuously improve. A dashboard will need to be set up to track the inbound the outbound and compare it to previous years to see the improvements and pitfalls of the current process to make the necessary changes. All suppliers will have to be encouraged to keep track of total shipments for reporting and improving.
- The starting point for implementing this Lean and Green Logistics would be to follow the ISM model and implement the Warehouse merger and Green certification. Once these are implemented with the resources that become available the other practices will gradually fall into place.
- Lack of Interdepartmental coordination was a major reason for inefficiency in the current process. There needs to be more integration and transparency between all departments to achieve the full benefits of the proposed strategy. Deploying software and apps is not the only way to increase transparency but the employees need to communicate more with each other to reach goals efficiently.
- The implementation of the proposed strategy will take time and money. Support from upper management will be required for funding purposes and the strategies must be weighed to know the economic feasibility. Below existing tools and methods that can be used to implement the proposed strategy will be recommended.

5.2.1 Existing Tools and Methods to implement Lean SCM and Green SCM

The most important lean principle is increased collaboration and information sharing. Information sharing helps achieve other lean practices such as just in time and vendor Managed Inventory, and the common method adopted by companies whilst going lean to improve information sharing is Electronic Data Interchange. Electronic Data Sharing is computer to computer sharing of information and automatic data processing, it eliminates the need of person to receive and process data

thereby eliminating any errors arising due to human negligence. Amazon web services platform can be used to run EDI between organizations.

Merging warehouses takes time, planning and money. Space from one warehouse needs to be cleared out and moved into another for which place needs to be created in the warehouse were goods are going to be moved into, this would mean relocating other customer goods and liaising with them or buying a new warehouse. The decision regarding moving both stocks to a third warehouse or making space in one of the warehouses for other stock is a strategic upper management and warehouse decision that requires consent from multiple stakeholders and long-term planning.

Ensuring fuller trucks, truck pooling is a method to ensure fuller trucks. A person appointed to ensure fuller trucks and manage green reporting needs a platform to have an overview all shipments that need to be sent to the respective locations at given times. Many transport organizations such as Uber have introduced pooling system to lower money for customers, they use real time ride sharing which uses GPS and customer data to match the driver route to customer pickup and destination. With the emergence of technology 4.0 there many such real-time apps and web services provides real-time collaboration and mapping.

Ye Li & Yuewu Yu, in their article *The use of freight apps in road freight transport for CO2 reduction*, discuss the existing apps and technology that are present that can be used to efficiently load a truck, choosing the right size truck for delivery and choosing the right route. Technology plays an important role and needs to be exploited to the maximum to reap the benefits.

5.3 Limitations of the Research

The above case study analyzed the as is situation of a project and then applied lean and green principles to see what the changes in costs and GHG would be. To make the calculations, the agility and uncertainties involved in construction process were not accounted for.

Assumptions related to GHG emission factor was made depending on the loading factor of truck, this info was from the warehouse transport account manager and process coordinator. The expertise of the warehouse professionals was used to estimate the occupancy percentage on trucks.

Certain Green principles such as intermodal transport and electric vehicle use, concrete data on costs was hard to gather and hence have been left out of the calculation process.

Certain lean principles such as warehouse merger requires initial investment of moving stock from one warehouse to another, making space in the warehouse for new stock, filling up emptied space on old warehouse and communicating with other clients to move goods to other warehouse to make space.

To develop the ISM model theoretical knowledge and experience was used to derive the interdependency, the accuracy of the interdependency in real life is unknown.

The two paradigms tested were Lean and Green. There are various other supply chain paradigms that are important whilst considering a supply chain like agile project management and resilient project management. Agility and resilience are crucial factors whilst considering the uncertainties and urgency involved in construction project management, and further research into the implementation of all four paradigms and its benefits need to be chalked out.

5.4 Further Research

The report focused on strategies to implement lean and green simultaneously to achieve synergistic benefits. But a supply chain also needs to be adaptable and responsive to changes in the environment and dynamics of construction industry, to achieve these, strategies to implement Lean, Green, Agile and resilient supply chain paradigm synergistically needs to be reviewed and tested.

Research needs to be carried out in the technological aspects that can be used to successfully implement strategies. Big data analytics is a system were trends can be analyzed; this would help in understanding the inbound and outbound trends of a construction process. There is a plethora of new and emerging technology, deeper analysis needs to be carried out see which one of them benefit the lean and green goals of the company.

The impact of the proposed changes on employee work load and ability to accept and adapt must be studied. If employees do not embrace the change, then the full potential cannot be reaped. Change management processes needs to be employed. Workshops and methods of getting employees enthusiastic and involved in the entire process needs to be studied upon.

The company deals with suppliers from all over the world; different countries have different perspectives and goals when it comes to going Green. From example, Germany as country are more enthusiastic when it to comes to implementing green changes in contrast to the Middle Eastern Countries, further research into bridging this cultural gap needs to be considered and all suppliers must be brought on board to be successful in the chosen endeavor.

The goal of a company will have to be to operate on zero emissions. Research into strategies to achieve zero emissions will have to follow to avoid stagnation.

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Appendix

Appendix A

Below mentioned is the list of suppliers and delivery details for the TH project.

Items	Suppliers	Number of Shipments	Country of Origin	Number of Pallets	Cost of Shipment	Distance	Mode	Direct or cross dock
1. GC	Prodrive Joinery & Shopfitting Ltd.	2	UK	NR	NR	NR	Truck	Direct
2.Electrical Contractor	BMB	1	UK	NR	NR	NR	Truck	Direct
3.Electrical Fittings	FMS	1	UK	NR	NR	NR	Truck	Direct
4. Fire Safety Fittings	JJ Sprinklers	1	UK	NR	NR	NR	Truck	Direct
5. IT Installation	ARC	1	UK	NR	NR	NR	Truck	Direct
6. Alarm system Installation	Universal Security Group	1	UK	NR	NR	NR	Truck	Direct
7. Ceiling Works	OMESBY	1	UK	NR	NR	NR	Truck	Direct
8.Decorations	SCP	1	UK	NR	NR	NR	Truck	Direct
9. Windows and Doors	Steeltak	1	UK	NR	NR	NR	Truck	Direct

10.Security System Contractor	Maxtag (UK) Ltd.	1	UK	2	90	16 km	Truck	Direct
11.Flooring	Buenker GmbH & Co. KG	2	WEST GERMANY	2,1	1800	850 Km	Truck	Via DC
12.Presenters	Arno GB Ltd.	1	UK	2	65	165 Km	Truck	Via DC
13. Internal Signage	De goede.com B.V.	3	NETHERLANDS	1	2000	520 Km	Truck	Direct
14.Signage	Everseen Lichtreklam e B.V.	1	NETHERLANDS	1	1500	844 Km	Truck	Direct
15. Visuals	Gehring Projects	2	NETHERLANDS	1	40	62 km	Truck	Cross dock
16.Mannequins	Hans Boodt Mannequins B.V.	1	NETHERLANDS	2	1500	765.4 Km	Truck	Direct
17. Fixtures	Image Builders B.V.	4	NETHERLANDS	3,1,1,1	7705+ 1786+ 2250+ 52	870 Km	Truck	Via DC
18. Back of House Flooring	Walkers	1	UK	2	65	70 km	Truck	Via DC
19. Back	Link 51	1	UK	1	100	150 km	Truck	Via DC
20. Audio	Mood	1	NET	1	500	850	Truck	Direct
21. Curtains	Roos Gordijnen Service	1	NETHERLANDS	1	50	66 km	Truck	Cross dock

22. Wall Tiling	Tegeldeal .nl	1	NET HER LAN DS	1	790	801 Km	Truck	Via DC
23. Ware House	TH Europe	5	NET HER	4,1,1, 1,1	1200+ 456+4	800 Km	Truck	Direct
24. External Signage	The Set Compan y B.V.	2	NET HER LAN DS	1	2340	850 Km	Truck	Direct
25. Rugs	Hagros	1	NET HER	1	40	117 Km	Truck	Cross dock
26. Lighting	XAL GmbH	2	AUS TRIA	2	1440	1780 Km	Truck	Via DC

Appendix B

Below mentioned is the list of projects and delivery details for the CK store.

Items	Suppliers	Number of Shipments	Country Of Origin	Number of Pallets	Cost of Shipment	Distance	Mode	Direct or Cross Dock
1. GC	Prodrive Joinery & Shopfitting Ltd.	2	UK	NR	NR	NR	Truck	Direct
2.Electrical Contract or	BM/.B	1	UK	NR	NR	NR	Truck	Direct
3.Electrical Fittings	FMS	1	UK	NR	NR	NR	Truck	Direct
4. Fire Safety Fittings	JJ Sprinklers	1	UK	NR	NR	NR	Truck	Direct
5. IT Installati on	ARC	1	UK	NR	NR	NR	Truck	Direct
6. Alarm system Installati on	Universal Security group	1	UK	NR	NR	NR	Truck	Direct

7. Ceiling g Work s	Ormesby	1	UK	NR	NR	NR	Truck	Direct
8.Decoration s	SCP	1	UK	NR	NR	NR	Truck	Direct
9. Windows and Door s	Steeltak	1	UK	NR	NR	NR	Truck	Direct
10. Security System	Maxtag	2	UK	2,1	90	16 km	Truck	Direct
11. Flooring	Florspec	1	UK	2	100	265 Km	Truck	Direct
12. Internal Signage	Studio Xag	1	UK	1	85	280 Km	Truck	Direct
13. Signage	Studio Xag	1	UK	1	85	280 Km	Truck	Direct
14. Visuals	Mediamome nts	4	Netherlands	1,1,1, 1	180,85, 150,75	150 Km	Truck	Direct
15. Fixtures	Eyelevel	2	Czech Republic	3,1	7020,1 500	1580 Km	Truck	Via DC
16. Back of House Flooring	Walkers	1	UK	2	65	70 km	Truck	Via DC
17. Back Of House storage system m	Link 51	3	UK	2,1,1	100	150 Km	Truck	Via DC

18. Audio System	MoodMedia	1	Netherlands	2	420	850 Km	Truck	Direct
19. Curtains	Eyelevel	1	Czech Republic	1	240	1580 Km	Truck	Via DC
20. Ware House	Seacon	2	Netherlands	3,2,1	1080,800,600	850 Km	Truck	Direct
21. External Signage	Eyelevel	1	Czech Republic	1	800	1580 Km	Truck	Direct
22. Rugs	Hagros	1	Netherlands	1	40	117 Km	Truck	Cross dock
23. Lighting	XAL GmbH	3	Austria	2,1,1	2000,800,800	1780 Km	Truck	Via DC

Appendix C

Interpretive Structural modelling is a method to establish a relationship between certain variables. The variables are connected through subordinate relations to form a structural self-interaction matrix, this is then translated to a reachability matrix after which the transitivity is accounted for. Then a ISM is developed based on the inter relationships.

It is a 6-step process which will be explained below.

Step 1: Structural Self-Interaction Matrix

To develop the structural-interaction matrix through discussions in the focus group, interviews and feedback the interdependency between variables was established. the focus group consisted of members from the procurement team and the warehouse Seacon who have knowledge of how one variable will influence the other.
A matrix is developed wherein it is divided into rows and columns. Wherein the rows are denoted by "i" and columns are denoted by "j". Four variables are denoted to represent the nature of relationship;

If "i" influences "j" then it is denoted by "V"
If "i" is influenced by "j" then it is denoted by "A"
If "i" and "j" influence each other then it is denoted by "X"
If "i" and "j" are not related then it is denoted by "O"

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Increased Information Sharing: EDI	X	V	O	O	V	O	O	V	V	V	A	O	O	V	O
2	Interdepartmental Coordination		X	A	O	O	O	O	V	V	V	A	O	O	O	O
3	Merge Warehouses			X	O	O	O	O	V	V	V	V	O	O	O	O
4	JIT				X	O	A	O	O	O	O	O	O	V	O	O
5	VMI					X	O	O	O	V	O	A	O	O	O	O
6	Use Local Supplier						X	O	O	O	O	O	O	V	O	O
7	ISO Certification							X	O	O	O	O	O	V	V	V
8	Circuit Delivery								X	V	A	O	O	O	V	O
9	Consolidate Shipments									X	A	A	O	O	O	O
10	Truck Pooling										X	A	O	O	O	O
11	Additional Person											X	O	O	V	O
12	Intermodal Transport												X	O	O	O
13	Electric Vehicle Delivery													X	O	O
14	Optimal Packaging														X	O
15	Reusable Pallets															X

Step 2: This step is to establish a reachability matrix wherein the values are replaced with binary digits "1" and "0".

If (i,j) is "V" then 1 and (j,i) becomes 0
If (i,j) is "A" then 0 and (j,i) becomes 1
If (i,j) is "X" then 1 and (j,i) becomes 1
If (i,j) is "O" then 0 and (j,i) becomes 0

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Increased Information Sharing : EDI	1	1	O	O	1	O	O	1	1	1	O	O	O	1	O
2	Interdepartmental Coordination	O	1	O	O	O	O	O	1	1	1	O	O	O	O	O
3	Merge Warehouses	O	1	1	O	O	O	O	1	1	1	O	O	O	O	O
4	JIT	O	O	O	1	O	O	O	O	O	O	O	O	1	O	O
5	VMI	O	O	O	O	1	O	O	O	1	O	O	O	O	O	O
6	Use Local Supplier	O	O	O	1	O	1	O	O	O	O	O	O	1	O	O
7	ISO Certification	O	O	O	O	O	O	1	O	O	O	O	O	1	1	1
8	Circuit Delivery	O	O	O	O	O	O	O	1	1	O	O	O	O	1	O
9	Consolidate Shipments	O	O	O	O	O	O	O	O	1	1	1	O	O	O	O
10	Truck Pooling	O	O	O	O	O	O	O	1	1	1	O	O	O	O	O
11	Additional Person	1	1	O	O	1	O	O	O	1	1	1	O	O	1	O
12	Intermodal Transport	O	O	O	O	O	O	O	O	O	O	O	1	O	O	O
13	Electric Vehicle Delivery	O	O	O	O	O	O	O	O	O	O	O	O	1	O	O
14	Optimal Packaging	O	O	O	O	O	O	O	O	O	O	O	O	O	1	O
15	Reusable Pallets	O	O	O	O	O	O	O	O	O	O	O	O	O	O	1

The next part of step 2 is to establish transitivity with 1*. Transitivity is when A=B and B=C then A=C.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Power
1	Increased Information Sharing : EDI	1	1	O	O	1	O	O	1	1	1	O	O	O	1	O	7
2	Interdepartmental Coordination	O	1	O	O	O	O	O	1	1	1	O	O	O	1*	O	5
3	Merge Warehouses	O	1	1	O	O	O	O	1	1	1	O	O	O	1*	O	6
4	JIT	O	O	O	1	O	O	O	O	O	O	O	O	1	O	O	2
5	VMI	O	O	O	O	1	O	O	O	1	O	O	O	O	O	O	2
6	Use Local Supplier	O	O	O	1	O	1	O	O	O	O	O	O	1	O	O	3
7	ISO Certification	O	O	O	O	O	O	1	O	O	O	O	O	1	1	1	4
8	Circuit Delivery	O	O	O	O	O	O	O	1	1	O	O	O	O	1	O	3
9	Consolidate Shipments	O	O	O	O	O	O	O	O	1	1	1	O	O	O	O	3
10	Truck Pooling	O	O	O	O	O	O	O	1	1	1	O	O	O	1*	O	4
11	Additional Person	1	1	O	O	1	O	O	O	1	1	1	O	O	1	O	7
12	Intermodal Transport	O	O	O	O	O	O	O	O	O	O	O	1	O	O	O	1
13	Electric Vehicle Delivery	O	O	O	O	O	O	O	O	O	O	O	O	1	O	O	1
14	Optimal Packaging	O	O	O	O	O	O	O	O	O	O	O	O	O	1	O	1
15	Reusable Pallets	O	O	O	O	O	O	O	O	O	O	O	O	O	O	1	1
	Power	2	4	1	2	3	1	1	5	8	6	2	1	4	8	2	

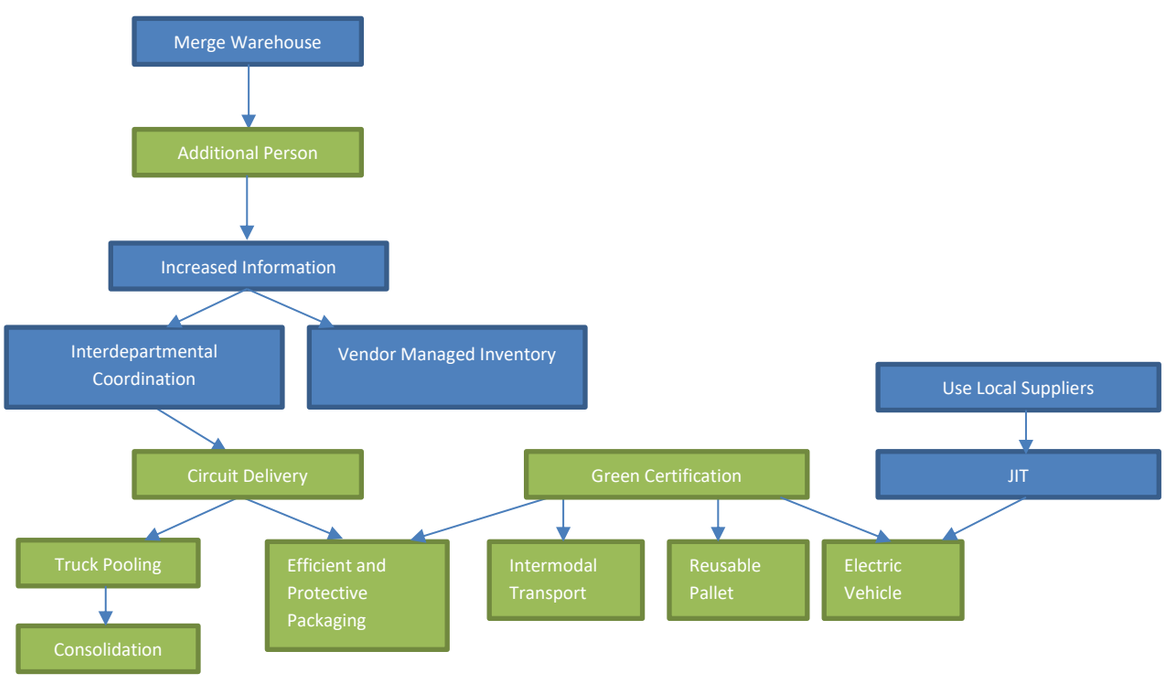
Step 3: This step the reachability matrix is established where the reachability set and antecedent set are stablised. The former is the set where all the variables that "i" enables are grouped and the latter is the set where aa variables that enable "i" are grouped.

		Reachability Matrix	Antecedent Set
1	Increased Information Sharing : EDI	1,2,5,8,9,10,14	1,11
2	Interdepartmental Coordination	2,8,9,10,14	1,2,3,11
3	Merge Warehouses	2,3,8,9,10,14	3
4	JIT	4,13	4,6
5	VMI	5,9	1,5,11
6	Use Local Supplier	4,6,13	6
7	ISO Certification	7,13,14,15	7
8	Circuit Delivery	8,9,14	1,2,3,8,10
9	Consolidate Shipments	9,10,11	1,2,3,5,8,9,10,11
10	Truck Pooling	8,9,10	1,2,3,9,10,11
11	Additional Person	1,2,5,9,10,11,14	9,11
12	Intermodal Transport	12	12
13	Electric Vehicle Delivery	13	4,6,7,13
14	Optimal Packaging	14	1,3,7,8,11,14
15	Reusable Pallets	15	7,1,5

Step 4: the drive power is established for each variable and based on the drive power the variables are ranked on the ISM level.

		Reachability Matrix	Antecedent Set	Level
1	Increased Information Sharing : EDI	1,2,5,8,9,10,14	1,11	VI
2	Interdepartmental Coordination	2,8,9,10,14	1,2,3,11	IV
3	Merge Warehouses	2,3,8,9,10,14	3	VII
4	JIT	4,13	4,6	VI
5	VMI	5,9	1,5,11	V
6	Use Local Supplier	4,6,13	6	VII
7	ISO Certification	7,13,14,15	7	VII
8	Circuit Delivery	8,9,14	1,2,3,8,10	III
9	Consolidate Shipments	9,10,11	1,2,3,5,8,9,10,11	I
10	Truck Pooling	8,9,10	1,2,3,9,10,11	II
11	Additional Person	1,2,5,9,10,11,14	9,11	VI
12	Intermodal Transport	12	12	VII
13	Electric Vehicle Delivery	13	4,6,7,13	IV
14	Optimal Packaging	14	1,3,7,8,11,14	II
15	Reusable Pallets	15	7,1,5	VI

Step 5: Based on the level established in step 4 a diagraph is drawn with transitivity and after removing the transitivity the final diagraph is drawn.



Appendix D

Interview

To develop the Stakeholder Map and understand the perspective of the stakeholders on the current logistics, members from TH store development, CK store development, Procurement, TH SIS and CK SIS were interviewed. The answers to the interview were tabulated in an excel sheet. A set of broad questions were formulated and is mentioned below.

1. What is your role in procuring materials for the project?
2. The main vendors you deal with, where are they located?
3. What is the current process in relation to procurement of materials?
    - Are all items delivered JIT or consolidated?
    - Is there a conscious effort to consolidate shipments?
    - Is there an awareness regarding truck occupancy and does Seacon provide a load planning?
    - How well is stock managed?
4. How is material handling on site managed?
    - Are there any restrictions regarding delivery?
    - What are the issues related to storing items on site?
5. How efficient is Seacon with delivery?
6. Who communicates the orders with Seacon?
7. What are the frequently arising problems regarding logistics?
8. What improvements would like to see in the current process?
9. What is your view on embracing Green in the current process?

Answers to the above questions was used to develop a stakeholder map and understand the current issues faced by team members. The people interviewed were project coordinators, project managers from both store and shop in shop, procurement buyer and Warehouse representative.

Responses:

Project Manager store 1

What is your role in procuring materials for the project?

- Prepare a bill of requirement and contact company supplier based on store concept to deliver materials to site directly. The GC procures most materials but materials that need to be uniform through all stores such as furniture, lighting, flooring, wall paneling, back of house equipment's are procured by us project managers.

The main vendors you deal with, where are they located?

- For CK projects the main suppliers are in UK, Czech Republic, Austria and Netherlands.

Are all items delivered JIT or consolidated?

- I get materials delivered to store directly and this is the practice that has been followed. In certain occasions when the supplier has been unable to prepare certain custom documents then they are delivered to Seacon.

Is there a conscious effort to consolidate shipments?

- As such from my end there is no effort. We expect Seacon to do that as they are the logistics providers.

Is there an awareness regarding truck occupancy and does Seacon provide a load planning?

- Again, this is something that Seacon needs to ensure as they are logistics providers. We as such have no overview of truck occupancy.

How well is stock managed?

- Project coordinators deal with procuring items from stock. But recently there seems to have been issues with stock levels.

How is material handling on site managed?

- The GC on site is informed of the delivery of items and most times they are stored in the back of house section or where there is place, which is a bit chaotic due to which items get lost.

Are there any restrictions regarding delivery?

- Most sites have delivery restriction specially when stores are being constructed in big malls, then mall authorities have delivery restrictions that need to be abided by as the number of loading bays are limited and every store opening in the mall would want delivery to happened at the same time.

What are the issues related to storing items on site?

- As mentioned before they get lost on site and sometimes even damaged.

How efficient is Seacon with delivery?

- Seacon is very good with communication and have been doing a decent job so far.

Who communicates the orders with Seacon?

- Orders to Seacon are communicated through the project coordinator.

What are the frequently arising problems regarding logistics?

- My projects lie within mainland EU hence I haven't had any issues with logistics. The one thing that does happen very often in projects is multiple shipments to store due to poor communication, design changes and low stock.

What improvements would like to see in the current process?

- More transparency as I feel the rates are not consistent. I would like to be able to track shipments better. The stock needs to be managed well.

What is your view on embracing Green in the current process?

- There is the need to go green. The company has recently purchased electric cars for short distance employee commute and this needs to be scaled up.

Project Manager store 2

What is your role in procuring materials for the project?

- Every supplier has their own order placement form and depending on the required quantities the order placement forms are filled out and delivery details are given to supplier for delivery. Then once the supplier sends a quote the quote is checked and a PO is created for it. Once the PO is sent to supplier they start production.

The main vendors you deal with, where are they located?

- The main vendors for both brands are UK, Netherlands, Germany, Austria and Czech Republic.

Are all items delivered JIT or consolidated?

- My region is the middle east and due to heavy custom works all orders are sent to Seacon from where they are sent out in ships.

Is there a conscious effort to consolidate shipments?

- For a particular project, we try to consolidate so that all shipments leave on a single ship, but there hasn't been success lately due to varying lead times of suppliers.

Is there an awareness regarding truck occupancy and does Seacon provide a load planning?

- We have requested Seacon for truck load planning for few projects but they haven't provided us with it as it is not part of their job.

How well is stock managed?

- Not very sure about stock as the project coordinators deal with it.

How is material handling on site managed?

- My project are all franchise projects so the franchise partners have their own storage where the materials are stored and taken to site when required.

Are there any restrictions regarding delivery?

- The delivery from franchise storage to site is taken care of by the franchise partner who is aware of all the delivery restrictions.

What are the issues related to storing items on site?

- As of now there have been no complaints of items being lost or broken.

How efficient is Seacon with delivery?

- Seacon are quick with communication and are very efficient when it comes to preparing documents and sending out shipments. They have been able to deliver items in time, one just one occasion recently the shipment got delayed by month due to miscommunication.

Who communicates the orders with Seacon?

- Mostly the project coordinators, but in certain urgent cases I deal with Seacon too.

What are the frequently arising problems regarding logistics?

- Custom documents have been the biggest issue thus far with shipments getting stuck at customs. In case of low stock, it is difficult to send back orders to the middle east given the distance and costs of shipments. It is hard to control the transport management in the middle east.

What improvements would like to see in the current process?

- Reduce the number of communication loops. Better manage stock so that everything leave together and the store can open without any hassle.

What is your view on embracing Green in the current process?

- It is important with all that is going on related to it globally. Conscious efforts need to be made for which training and education in the field is required.

Project Coordinator store 1

What is your role in procuring materials for the project?

- I procure materials from stock and certain props from vendors. A project plan is prepared for Seacon where the date of delivery to site and items that are being cross docked are mentioned. Any changes in delivery the project plan needs to be altered and sent back to Seacon. The delivery restrictions are mentioned on the project plan.

The main vendors you deal with, where are they located?

- Most vendors are in Netherlands and a few in UK.

Are all items delivered JIT or consolidated?

- All items are cross docked and occasionally if the supplier is unbale to meet the deadline then they are delivered just in time to store.

Is there a conscious effort to consolidate shipments?

- As we work on multiples projects at the same time it is hard to keep track of consolidation. Per project level I personally try to consolidate but sometimes due to other factors such as design changes and low stock consolidation is not possible.

Is there an awareness regarding truck occupancy and does Seacon provide a load planning?

- That is something Seacon needs to be aware of and I do not have any knowledge of it.

How well is stock managed?

- There has been a lot of changes in the procurement team with new people coming in and other people leaving that has led to inefficient stock management. It is getting better but stock management of so many items is hard so inefficiency is always there and something needs to be done.

Are there any restrictions regarding delivery?

- There are delivery restrictions that are communicated to us by the project manager, there have been occasions when Seacon hasn't communicated the delivery restriction to delivery company due to which multiple shipments have had to be sent.

What are the issues related to storing items on site?

- Very often we receive panic calls from site regarding missing and broken items. But the missing items are normally found later site but it takes a lot of back and forth before everything falls in place.

How efficient is Seacon with delivery?

- Seacon is little inflexible with delivery but when informed well in advance they do deliver in time. They also respond quickly to queries that makes things easier.

Who communicates the orders with Seacon?

- All communications go through the project coordinator sometimes the procurement team is involved in case of items that are not on stock. The procurement team has the overview of when stock is going to be replenished.

What are the frequently arising problems regarding logistics?

- Inefficient stock management, multiple back orders being sent are the main problems with logistics. Apart from that multiple deliveries to site means multiple calls from site regarding delivery which takes up a lot of time.

What improvements would like to see in the current process?

- Make sure there is enough items on stock so that there is no back and forth on order completion. Simpler ways to track the shipment and not having to go through Seacon all time for update.

What is your view on embracing Green in the current process?

- There seems to be a lot of potential in terms of going green. The company has just started embracing it with the sustainable store program. It is the future and is here to stay so the company should take it up seriously.

Project Coordinator 2

What is your role in procuring materials for the project?

- Contact supplier for procuring props that are not ordered by the PM. Then procure materials from stock and communicate to Seacon the details of delivery. Create Purchase orders for all the materials procured and create an estimate for the PM.

The main vendors you deal with, where are they located?

- Maximum suppliers are in Netherlands, there is a supplier in Turkey and UK.

Are all items delivered JIT or consolidated?

- The practice is to consolidate in Seacon via cross dock, but occasionally due to lead times this isn't possible. This is done to make sure everything reach site on time and one shipment.

Is there a conscious effort to consolidate shipments?

- Yes, to ensure all items are delivered to store as one shipment and there is not confusion on site.

Is there an awareness regarding truck occupancy and does Seacon provide a load planning?

- As the region, I deal with is the middle east where the partner picks up shipment from Seacon, truck load planning is requested but Seacon doesn't provide us with it. Truck occupancy is something Seacon needs to deal with.

How well is stock managed?

- CK stock is better managed but TH stock there has been a lot issues. TH there is more items than CK and maybe that's why the stock management for TH is harder than that of CK.

How is material handling on site managed?

- The PM deals with material handling on site in conjunction with the GC.

Are there any restrictions regarding delivery?

- The middle east projects the franchise partner deal with delivery and hence there are no issues regarding delivery restrictions.

What are the issues related to storing items on site?

- The franchise partners have their own warehouses where materials are stored.

How efficient is Seacon with delivery?

- Seacon prepares all the documents for pickup by partner. They are very responsive and professional when it comes to preparing documents and communicating it with franchise partner.

Who communicates the orders with Seacon?

- I do most of the communication and the PM occasionally deals with Seacon due to deliveries from suppliers that the PM deals with.

What are the frequently arising problems regarding logistics?

- Most problem arising with logistics is the documentation due to which sometimes shipments have been stuck in customs. Second is the long chain of communication when direct communication is possible.

What improvements would like to see in the current process?

- Better manage stock, reduce the communication line and make sure one project there is one project plan and one shipment. This will reduce the numerous email chains.

What is your view on embracing Green in the current process?

- It has become a strategic objective and as part of the sustainable team green needs to be incorporated and small steps are being taken towards it like expecting suppliers to have green certifications. This needs to be scaled up to entire team.

Procurement 1

What is your role in procuring materials for the project?

- We procure materials to stock for all projects based on the roll out. A minimum requirement for an item for store is known based on which materials are procured. A biweekly meeting with the store team is held to discuss the items on stock. A conscious decision is made to not over order as then the stock will have to be written off in the end.

The main vendors you deal with, where are they located?

- Our primary vendors are from UK, Germany, Portugal, China, India, Netherlands and Lithuania. We have vendors in other countries as well but these countries we have maximum vendors.

What is the current process in relation to procurement of materials?

- The procurement team is divided between TH and CK. A bulk order is placed with the supplier and the orders are called off at set intervals. We have long term contracts will all these suppliers. The suppliers deliver to Seacon directly. Seacon receives the shipments then relabels the packages and stores them

Are all items delivered JIT or consolidated?

- We procure to stock and each supplier delivers their materials directly to warehouse and there is no JIT or consolidation as we do not deal with deliveries to site.

Is there a conscious effort to consolidate shipments?

- We do have more than one supplier located in one country but we do not try to consolidate shipments as suppliers make their own deliveries to Seacon. The practice thus far has been like that, Seacon does provide with the service of pick up if requested.

Is there an awareness regarding truck occupancy and does Seacon provide a load planning?

- As vendors deliver goods we are not involved with truck occupancy and loading.

How well is stock managed?

- Off late we have had issues with stock as stores are calling of more than what they normally call off for each project. There is transition phase where the concept is being changed hence certain items need to be depleted before ordering new ones.

What are the frequently arising problems regarding logistics?

- Fluctuation in stock level has been a big problem. Past quarter due to overstocking a lot of items have had to be written off. Seacon is also complaining about a lot of items lying on shop floor that is not being used.

What improvements would like to see in the current process?

- There should be a better system for stock estimation. Departments should take responsibility of stock items that are not being used as capital is being wasted. Seacon should keep track of backorders.

What is your view on embracing Green in the current process?

- It is time that we incorporated it, we have been discussing on ways to optimize the current process but due to busy schedules we haven't able to implement any. With this PGR program, hopefully we can start by taking baby steps.

Seacon 1

The questions asked to the Seacon representative Hay was different from the previous questions. He was asked questions more related to the warehouse and transport management.

How is the PVH warehouse managed currently in Seacon?

- PVH has two warehouses under Seacon. One is in Venlo and the other in Born. The company pays persqm of floorspace owned. Sometimes the warehouse is overstocked or understocked, when it is understocked the company is still paying for unused space in case of over stocking they still pay the same amount and no extra so there is always a give and take.

Are both warehouses fully occupied or not?

- The warehouse in Venlo is always over stocked but the one in Born is understocked.

Is conscious decision made to consolidate PVH shipments?

- Currently there are two teams that work for the company, one team is in Venlo and the other in Born. In each of the warehouses the teams are divided between TH and CK, so there is a total of four teams that work for PVH. Each of these teams handle orders from within the company differently and hence there is no proper consolidation on the side of the company and at our end as teams are different.

How are the items on stock stored in the warehouse?

- Each item is given a SKU code and is registered in the warehouse system and then based on TH or CK they are labelled and stocked in the location demarcated for each brand. The heavier and fast-moving stock are in the lower shelves. Every Monday a stock list is sent to the Company of all items on stock.

How are cross dock items handled in the warehouse?

- The vendor delivering or the member from within the company must book in the inbound 24 hrs in advance. The warehouse will have to make arrangements for receiving the shipment and make space in the warehouse for labelling and storing the inbound. The items are written off if they are not being called of a project.

What is the charge on crossdock items?

- For every coli that enters the warehouse we charge 5Euro and a 65 euro for every truck that enters for unloading and handling.

What are the issues you face with orders from the organization?

- We work with strict timelines but the members of PVH at times do not pay heed to the timelines, and quite often have urgent requests that make it difficult for us.
- Next, we have certain items on stock that have been there for almost 5 years which haven't been used.
- Rugs are an item that we have placed on the shelf for easy access but haven't been called off, we in return get crossdock of rugs for individual projects.
- Certain suppliers do not pack and label their inbound packages as they should have.

How empty or full are the trucks entering or leaving Seacon?

- Most trucks that enter or leave Seacon are only half full, this has been issue for many years now but nothing concrete has been done to rectify it. Even in case of inbound some suppliers deliver using their own vans or hire small vans for delivery as they are not logistics providers.