

Self transportation of goods for consumers from a retail store: A Pilot study

Shebin Thomas

DIVISION OF PACKAGING LOGISTICS | DEPARTMENT OF DESIGN SCIENCES
FACULTY OF ENGINEERING LTH | LUND UNIVERSITY
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MASTER THESIS



Self transportation of goods for consumers from a retail store: A Pilot study

Shebin Thomas



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Supervisor: Klas Hjort

Examiner: Annika Olsson

Abstract

The Last mile delivery is seen as an emerging attention due to the increased focus on e-commerce and Omni-channel retailing. Due to these and since it involves end consumers, organizations look for innovative solutions to provide customers with a service fulfillment option. This thesis present, the evaluation and understanding of Cardboard trolley solution for self transportation of goods by a consumer, from a retail store. In the reported and described action research study performed with the organization IKEA, it is shown that the identified solution is influenced by a lot of factors which needs to be addressed before implementing the solution into the market. The Cardboard trolley solution seems to be an innovative idea, but its functionality and durability aspects affects customer choices which in turn have a combined effect on the organization. The results from the thesis are based on the structured observation field tests performed and rest heavily on the analyzed results. The Cardboard trolley solution forms a key part of the self service option provided by the retailer and therefore consumer focused SCM is a strategic part of the business as such.

The Cardboard trolley solution is relatively new and needs proper understanding and evaluation on the ease of use and quality level. The proposed conclusion in the thesis addresses these issues and provides a detailed analysis on what aspects that needs to be looked into and also on the issues that could be improved to proceed into the next cycle of action plan.

Consumers come at the end of the supply chain, but considering their needs and requirements initially emphasize the strategic importance of consumers to the organization. This thesis empirically supports the conclusion that there needs to be better considerations and research on the material aspects of the box and corrugated board wheels to make it into a feasible solution for the end consumers.

Keywords: Supply chain management, consumers, last mile delivery, retail management, self-service, packaging design, packaging logistics.

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1. Introduction

This chapter presents a theoretical and practical background to the research field and justifies the purpose and the research questions addressed. After the background follows a detailed problem discussion and purpose. After discussing the purpose an outline of the sub divided research questions have been discussed and this section ends with a short outline of the delimitations.

1.1 Project Background

Consumer shopping behaviors are changing and becoming increasingly heterogeneous in the retail industry. Due to these, organizations need to adapt and align their business processes. When adapting to these changes it adds complexities but also adds new value creating opportunities to forge a deeper relationship with the consumers (Yrjölä, Spence and Saarijärvi, 2018). Buying products from online is becoming popular and seems to increase in the future (Khurana, 2018). Due to these, more researches are carried out focusing on e-commerce and Omni-channel retailing leaving the direct purchase from stores less exposed. The retail industry comprehends all the business activities relating to selling goods and services directly to the end consumers.

IKEA is a Swedish Multi National Company that plans and sells ready to assemble furniture, kitchen appliances and home accessories. There are currently 433 IKEA stores operating in 52 countries. The key business idea for IKEA is to provide a variety of designed, functional home furnishing products at low prices and affordable to as many people as possible. In order to realize this, they apply their core five dimensions: low price, function, form, quality and sustainability. IKEA extends their supply chain focus into their customers in order to provide them with better service fulfillment options after purchasing goods from their stores. IKEA's ambition is to be 100% circular by 2030 which will be achieved through usage of renewable or recycled materials from the beginning and throughout the SC (Why the future of furniture is circular, 2020). Globalization, changing consumer shopping behaviors and their awareness

regarding sustainability is making IKEA to consider possible sustainable solutions and innovations along the SC by having their focus on last mile delivery of goods.

1.2 Problem discussion

According to Sukati, Hamid, Baharun and Yusoff, 2012, a supply chain includes all the parties that involved, directly or indirectly, in fulfilling a customer request. The SC includes parties such as manufacturer, suppliers, transporters, warehouses, retailers and even customers themselves. Organizations need to orient themselves with all parties in the SC, in order to realize their individual benefits and with other parties throughout the SC till the customer. Last mile delivery refers to the activities that are carried out for physical delivery to the final destination as decided by the customer (Olsson, Hellström and Pålsson, 2019). Mangiaracina, Perego, Seghezzi and Tumino, (2019), suggest that the Last mile delivery efficiency is seen as an emerging attention within the academic community. The research could be categorized into two groups. The first group deals on how to optimize the traditional delivery mode. The second group focuses on innovative solutions to increase last-mile delivery efficiency. Olsson, Hellström and Pålsson, (2019), in their research on Last mile logistics review, have discussed considering the three pillars of the triple bottom line had mentioned that the economic sustainability is the most covered dimension followed by environmental sustainability and social sustainability. Considering all these aspects and moving forward, IKEA wants to evaluate the possibilities for what the future might look like and how it can help customers get their job done in this dynamic and uncertain business situations.

Due to the increased demand and requirements from customers, there are lot of emerging technologies and innovations arising in e-commerce and Omni channel retailing. On the global market, organizations are continuously searching for the new technologies to keep their business alive and to be competitive. Most of these are due to urbanization, the consumer consumption patterns and their requirements for the speedy delivery. IKEA

has recently launched an innovative campaign at Dubai, in which customers can pay for goods with their time. Customers can simply show their Google map timeline to prove how much time they have spent travelling to the IKEA stores (Chandler, 2020). Adding to these, IKEA would open four new and smaller stores in the Stockholm region in the next five years. This was planned considering the growth potential in the market and also the time pressure that the new stores would be more accessible and closer to where consumers live (TheLocal.se, 2020). Due to these future plans, the consumers could have the opportunity to transport goods without using a car and could connect themselves with their everyday commute either by walk or using a public transportation. The old cash and carry model by IKEA has been very successful in Sweden and in neighboring countries. But, now expanding to the Global markets and in times where everyone does not have a car or could not afford for transportation and home deliveries, retailers are shifting their focus to use self-service technologies. In this context, IKEA wants to identify a possible self-service solution that exists in the current market situation. On identifying the cardboard trolley solution as a possible candidate, IKEA wants to test and evaluate the usage before implementing it into the market for the consumers. The main reason is the fact that consumers would try to use the new idea but the ease of use and quality is unknown which might affect the reputation of the organization. The actual usage of the cardboard trolley is considered as uncontrollable for the brand owner IKEA as it is mainly used outside their retail premises. A failure in using the trolley could harm both the consumer and the IKEA brand. Considering these challenges, does the identified solution, a cardboard trolley, match the requirements from both a technical (material, etc) and consumer perspective (convenience, etc) as a suitable self-transportation option for the consumers when (self) transporting goods from retail store?

1.3 Project purpose

The aim with this thesis is to increase the understanding of the identified possible solution and analyze it on how consumers can transport goods by themselves after purchase from an IKEA retail store. The intention is to get an understanding on whether the identified solution is technically suited to be implemented as a self-transportation solution. In order to implement these solutions, there is a need to better understand and identify its feasibility and possible causes of failure as it could endure the brand image and reputation of the organization but more importantly harm the consumer.

1.4 Research questions

In order to proceed the work with a well-defined focus, the following research questions needs to be answered:

RQ1) What are the existing solutions available in the market for the consumers to transport goods by themselves form an IKEA store?

RQ2) What are the material aspects of the cardboard trolley to be considered?

RQ3) What is the maximum load that can be carried and transported?

RQ4) What are the functionality and durability impressions while using the trolley?

RQ5) What are the uncontrolled factors that needs to be considered?

1.5 Delimitations

There is some delimitation made in this research. The tests were performed using only one particular type of corrugated board wheels which delimits the possibilities of investigating the trolley solution from another perspective. Also, the research is set to a single person work with a time delimitation of 20 weeks.

1.6 Structure of the thesis

The structure of the report is divided into six individual chapters. Chapter 2 discusses the research methodology and how it is chosen. Chapter 3, presents a literature review of the theory including customer focused SCM strategies, retail management with discussions on last mile delivery, packaging introduction and functions, complexities in packaging design and packaging logistics perspective. Chapter 4 presents the discussions on the identified possible solutions with the empirical data gathered from the field tests. Chapter 5 focuses on the analysis and discussions based on the empirical data and the theoretical frame of reference by answering the research questions. Finally, chapter 6 presents the conclusions of the overall research question and suggestions for future research.

2. Methodology and Method

This chapter discusses the methods and approaches used for this thesis work. It also explains the reader for the chosen methodology and the reasons for choosing it. This is followed by the discussion about the different data collection methods and how it is performed. Also, data analysis explanation is given ending with the research quality description. The concluding section summarizes the chapter.

2.1 Research strategy

While conducting a research in a master thesis it is important to have clear structure, since there are tradeoffs in control, realism and generalizability when choosing a research strategy (Golicic and Davis, 2012).

The research conducted in this present master thesis is exploratory. Exploratory research helps to have a better understanding of the phenomena and provides the researcher to change their direction as a result of revelation of new data and insights (Saunders, M., Lewis, P. & Thornhill, A, 2012). In this thesis work, the phenomenon is the testing and observation of a self-transportation of goods solution for consumers from a retail store. It also tends to tackle new problems on which little or no previous research has been carried out (Brown, R.B.,2006).

The chosen research strategy in this master thesis is an action research considering the characteristics of action research and the current setup in which the thesis was carried out. Action research can be defined as “an approach in which the action researcher and a client collaborate in the diagnosis of the problem and in the development of a solution based on the diagnosis” (Bryman & Bell, 2011). In other words, the essential purpose of action research involves collaboration between researchers and participants/members of organization in order to solve organizational problems and consequently develop knowledge that is useful both for the researchers in academia as well as for practitioners in the industry. In the present thesis, the author plans to gain an understanding about the possible solutions in self transportation of goods from a retail store. During this

process, the author collaborated with the members of the organization in planning, taking actions ,evaluating the actions and further planning moving into the next phase (Coughlan and Coughlan ,2002).

2.2 Literature review

In the present chapter the methodology followed while conducting the literature review is explained. The author conducted two different types of literature review using academic and non academic literature review. In order to conduct a proper literature review, the objectives and research questions needs to be established. When conducting the literature review, the author gains an understanding of what research has been done and studied regarding the self-transportation for consumers from a retail store. The main motivation for conducting these two types of literature review was the fact that, the previous researches were focusing much on self-service technologies from an e-commerce perspective leaving the direct purchase from stores less exposed. The author was not able to refer any prior framework to support the findings and analysis. Hence, the literature review was done to discuss current situation focusing on self-service in last mile delivery, SCM perspectives with consumer focus and packaging concepts in order to support the findings and analysis.

2.2.1 Academic Literature review

The literature review for the academic papers was conducted using LUB search and web of science which is the digital library of Lund University. The author considered that these libraries are useful to gather information regarding the field of study. The relevant keywords used to identify the articles were: *Supply Chain Management, End Customers, Retail Management, Last mile delivery, Packaging logistics, Packaging design, Packaging materials*. After identifying the necessary articles, a review of the problem formulation and findings were carried out. As this process is iterative more keywords were used in order to find further literature. The process was stopped after reaching a point of saturation when the results were the same.

2.2.2 Non Academic Literature review

Apart from LUB search, search engine Google was used in order to identify non academic articles. By doing these searches the author had the chance to find a wider variety of articles and useful information that could support academic texts. In this present thesis, there is a need to identify the possible solutions considering self-transportation of goods which is relatively a new field of study. These searches can provide additional information as well as latest information that are prevailing in the current market. The search process included keywords such as: *Self Service in retail, IKEA's shopping bags and trolleys, IKEA's new stores and business plans*. Once the necessary articles were identified, a review was carried out.

Both these review methods helped the author to gain an initial insight in to the research topic, to identify what has been studied in the field of study and to motivate some of the statements that have been done throughout the report.

2.3 Data Collection

Data collection is the process of gathering and measuring information on variables of interest, in an established systematic way to answer the stated research questions. Observation methods are one of the most commonly used qualitative methods of data collection. Data collection in a typical qualitative study takes a lot of time in which the researcher must record any potentially useful data accurately and systematically using field notes, sketches, audio tapes, photographs and other suitable means (Kabir, 2016).

2.3.1 Field tests and Observation

The data gathering through structured observation and field tests contributes more reliability and ensures valid data that will make easier in achieving the project objectives. The consumer insight mining can be done closely and in depth by spending time to gain deeper understanding and insights about the consumers in close vicinity to the possible product use (Hellström, Olsson and Nilsson, 2017). The distance of the consumer from

the possible product use will influence the reliability of the results as shown in figure 1 below:

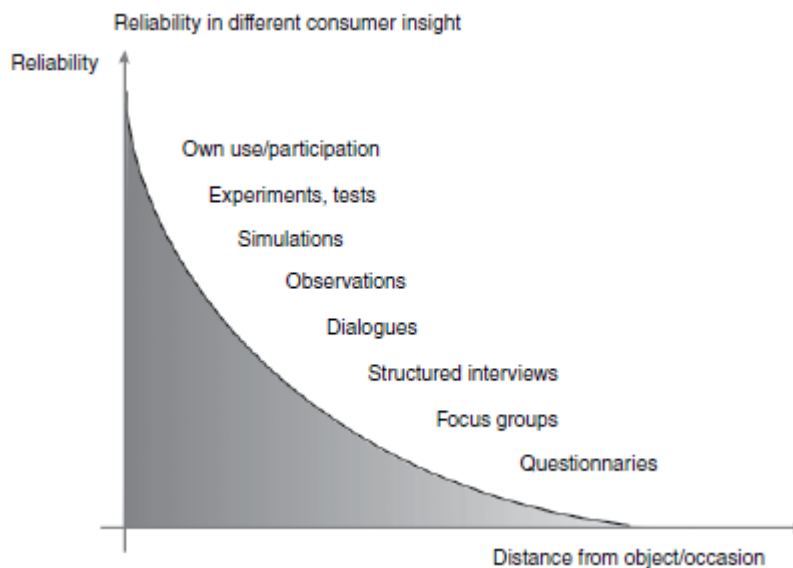


Figure 1. Reliability of different consumer insight methods (Hellström, Olsson and Nilsson, 2017)

In this master thesis, the data was collected using structured observation and through field tests. A total of 20 field tests were carried out and 12 tests were performed by the author of this report with his two classmates. The recording of data was done using field notes and photographs. The recording of data was done based on a structured plan that involved specific information of the units to be observed and also about the information to be recorded.

2.3.2 Field testing process

Initial 12 tests were carried out with the jattene box after which 4 tests were carried out in each of the two quick boxes. The tests had different requirements as mentioned below. Each test had different weights measured accordingly and then the surfaces were taped properly. The required

weights included books and were checked using an analog weighing machine. The point of origin for all the tests was from the 4th floor of Ingvar Kamprad Designcentrum (IKDC) building located at Lund University campus. The travel routes were planned priorly and the pictures were taken at different distances as well as at the point of failure. The tests were classified into three different load categories with five different requirements. These categories were created in discussion with the members of the organization. These parameters were chosen to analyze the cardboard box, handles and wheels on different weights and also on the different operating conditions such as climate, public transportation and different road surfaces. Also, by doing so, the cardboard trolley solution was evaluated on a whole or as an individual item such as box, handles, wheels and analyze their interactions and interpret the main reasons for failures. The different type of failures was closely observed and evaluated through these testing requirements using photographs. One of the categories was light load with weights less than 20kg and different parameters as shown in table 1 below:

Table 1. Testing requirements for light load

Light Load – less than 20 kg				
Public Transportation	Multiple Transportation	Road Walking in Good weather	Road Walking in bad weather	Durability test

The other categories included capacity load at 20 kg and over capacity load with weights more than 20 kg as shown in table 5 and table 2 below:

Table 2. Testing requirements for Capacity load at 20 kg

Capacity Load at 20 kg				
Public Transportation	Multiple Transportation	Road Walking in Good weather	Road Walking in bad weather	Durability test

Table 3. Testing requirements for over capacity load

Over capacity Load – More than 20 kg				
Public Transportation	Multiple Transportation	Road Walking in Good weather	Road Walking in bad weather	Durability test

The reason for not performing the tests with multiple transportation of Quick box 1 and 2 are due to the COVID-19 concerns that are prevailing currently. The detailed section about each of the individual tests is explained extensively in chapter 4.

2.4 Data Analysis

The data analysis in action research is critical since it is collaborative, both the researcher and members of the organization do it together. This collaborative approach is based on the assumption that organization best know what will work and ultimately will be the ones to implement and follow through on the next cycle of action plan (Coughlan and Coughlan, 2002).

In the present thesis, the author in collaboration with members of the organization had planned to carry out the observation field tests as a pilot study. The field tests were done to observe the performance in its natural setting in order to gain deeper insights and evaluate the identified possible solution. The initial idea was to use for different product types, furniture, accessories etc. But, after choosing the cardboard wheels and handles, IKEA wanted to use the standard jättene box to see if the box was useful. Then after conducting the first tests, the gathered data was sent for feedback, after that it was suggested to use a different box type. In addition to the field tests, data feedback through online workshop meeting with members of the organization has been done for data gathering, analysis and evaluation in order to proceed for the further steps in this research.

The setup in which the research process was carried out included an initial 8 field tests. After this, an initial data report was sent for feedback. When feedback was received, the weight setting was changed to 15 kg and less than it. Then 4 tests were carried out using this weight setting. A second feedback report was sent and then decided to test with two different cardboard boxes. Then, an online workshop meeting was conducted for data gathering, feedback and analysis. Finally after the meeting, conclusions were made regarding the further action plan. The remaining of 8 field tests was conducted in order to test and evaluate the possible outcomes.

2.5 Research Quality

The principal threat to the validity of AR is the lack of impartiality on the part of the researcher. The action researchers are engaged in shaping of a story, they need to consider the extent to which the story is a valid presentation on what has taken place and how it is understood, rather than a biased version (Argyris et al., 1985). Fisher and Tobert (1995) suggests four parts of speech as follows:

- *Framing* – clearly stating the purpose of speaking for the present occasion, defining the issue the action researcher is trying to solve and sharing expectations about the situation.

- *Advocating* – clearly stating the goal to be achieved, declare and option, recognition, feeling or proposal for action.
- *Illustrating* – telling a little of the concrete story that makes approval concrete and line up others more clearly.
- *Inquiring* – questioning participants to understand their mindset and views.

The action researchers need to combine advocacy with inquiry to communicate their inferences, attributions, opinions, viewpoints as open to testing and evaluation (Coughlan and Coughlan, 2002). In this report, the author has advocated his opinions and viewpoints to be open which needs further research.

2.6 Chapter Summary

The chapter started with the explanation about the research strategy, as well as how it is related and adapted to the present thesis. Later, the literature review methodology is explained including both the types. After, how the different data collection methods were used is explained briefly and how it is ensured that the data gathered is reliable. Also, how the data was analyzed was discussed and ending with short description about the research quality in Action research.

3. Literature review

The main purpose of this chapter is to provide the reader a theoretical frame of reference regarding a customer focused SC strategies and performances with some briefing on retail management and packaging terminologies. After, a detailed section explaining about packaging, its multiple functions, packaging design complexities, paper based packaging material and packaging logistics are discussed. The section ends with a chapter summary.

3.1 Customer- Focused Supply Chain Strategy

Globalization, shortening product lifecycles and changing consumer preferences makes the management of supply chains increasingly complex. A Supply Chain (SC) is an interconnected set of relationships from customer to supplier through various intermediate stages like sourcing, manufacturing, warehousing, distribution and may be a network of companies which has a control on one another. Customers are pivotal to any business, as without customers there are no sales and there is no revenue/profit without sales. Hence, there is a lot of key attention and focus on the end consumers as the so called ‘customer –focus’. Customer focus is described as: “... the set of beliefs that put the customers’ interest first, while not excluding those of all other stakeholders like owners, managers, and employees, so as to develop a long-term profitable enterprise” (Deshpande et al., 1993). Considering the competition at SC level, competitive advantage comes from the flexibility of SC partners to coordinate and integrate their strategies aiming in satisfying the ultimate customers. A SC strategy of the firm refers to the strategic goals and objectives of its SC and also a part of overall business strategy which is designed on the basis of innovation, low cost, service and quality. Customer focused SC strategy maximizes value to the customers in terms of both satisfaction and comparatively low cost for the product/service. SC responsiveness, resilience, reliability and realignment acts as effective capabilities which boosts customer satisfaction (Madhani, 2019).

These SC capabilities act as a dynamic capability those results in competitive advantage. The capabilities are developed and renewed in response to the changes in customer demand, market structure and economies of scale. It is necessary to interpret the needs of the ultimate consumers and not just the immediate partners along the SC. Success depends on the flexibility of all the SC partners to specialize on the ultimate consumers and reply to the changes within the demands of those consumers (Madhani, 2019).

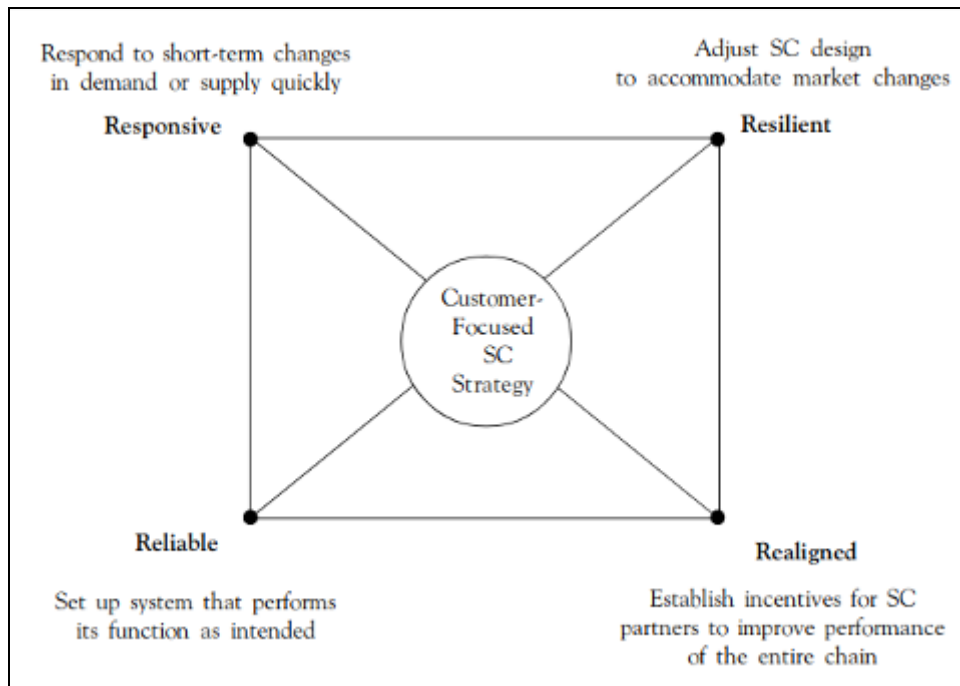


Figure 2. Customer-Focused SC strategy-4Rs Framework (Madhani, 2019)

3.2 Consumer - Based Supply Chain Management performance

The early and foundational conceptualizations of SCM generally viewed end-consumers as key supply chain entities. It is evident when considering the early literatures, scholars have considered the ultimate goal of SC was servicing and satisfying the demands of end-consumers. In spite of this fact, consumers have traditionally been neglected in SCM research by conceptualizing them as non-resistant recipients that are not vital or strategically important. This has started to change with the rapid growth of mobile technology utilization and the increasing prominence on online retail order fulfillment. As a result, there has been a shift towards more consumer- oriented SCM conversations in the academic and practitioner communities. This trend has shown that the behaviors, perceptions and point of views of consumers are strategic inputs during the design and execution of the SCM processes. The recent shift towards consumers in SCM is also reflecting the growing value being placed on logistics services and SC strategies by the consumer market. This may be seen from the proliferation of last-mile logistics services and techniques within the practitioner space (Esper and Peinkofer, 2017).

There has also been a growing specialize in SCM issues like order fulfillment, physical distribution processes further because the use of consumer insights to brief operational strategies. The link between SCM and end consumers is indicative of a growing business trend with the awareness to the vital role of SCM services to consumers and vice versa. This development further supports the need for SCM academic research on these concepts. The traditional lack of focus on end consumers within the literature has accelerated by the conceptual gap between servicing them through SCM and also measuring the performances of these services. The most extensively researched area in terms of downstream SCM operations is retail. The key subthemes of this research area involved forecasting, inventory management and retail operations. The recent focus on online

retail and Omni-channel fulfillment have emerged has a major focus in recent years. Scholars are now expanding on what it means to be effective in retail SCM from a consumer’s perspective. The figure 3 below summarizes the three emerging categories under the Consumer-Based SCM Performance (CBSP) framework (Esper and Peinkofer, 2017).

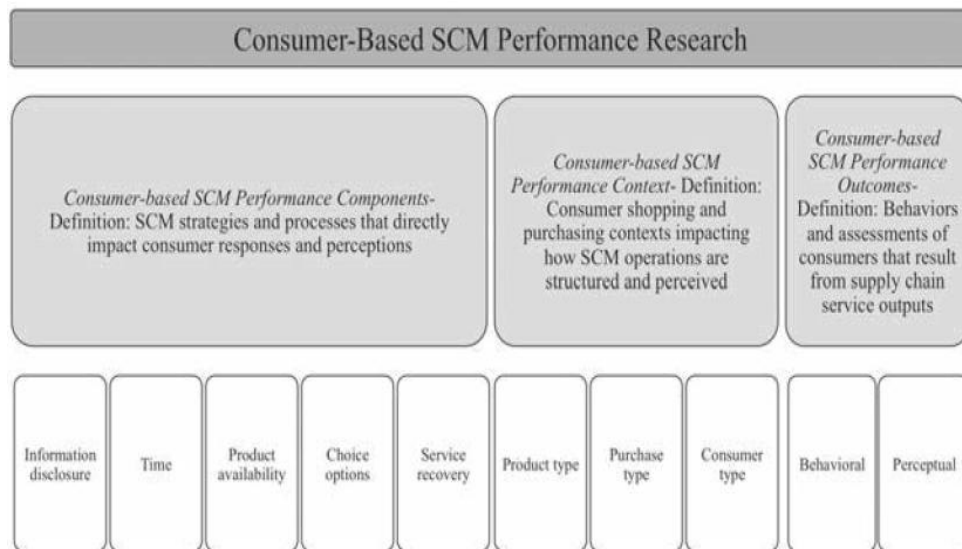


Figure 3. Consumer-Based SCM performance research (Esper and Peinkofer, 2017)

3.3 Last Mile Delivery

Last mile delivery refers to the activities necessary for physical delivery to the final destination chosen by the receiver (Olsson, J., Hellström, D. and Pålsson, H., 2019). It has become a critical source for market differentiation, motivating retailers to invest in a multitude of consumer delivery innovations such as buy-online-pickup-in-store, autonomous delivery solutions and lockers. Consumers care about last mile delivery because it offers convenience and flexibility (Lim, Jin and Srail, 2018).

Olsson, Hellström and Pålsson, (2019), proposed a framework to address the many different facets and aspects of last mile logistics as shown in figure 4. The framework is based on five interrelated components namely

last mile logistics, last mile distribution and the three central components: last mile fulfillment, last mile transport and last mile delivery. The framework can be viewed from back-end and front-end perspectives with the back-end facing the sender while the front-end faces the receiver.

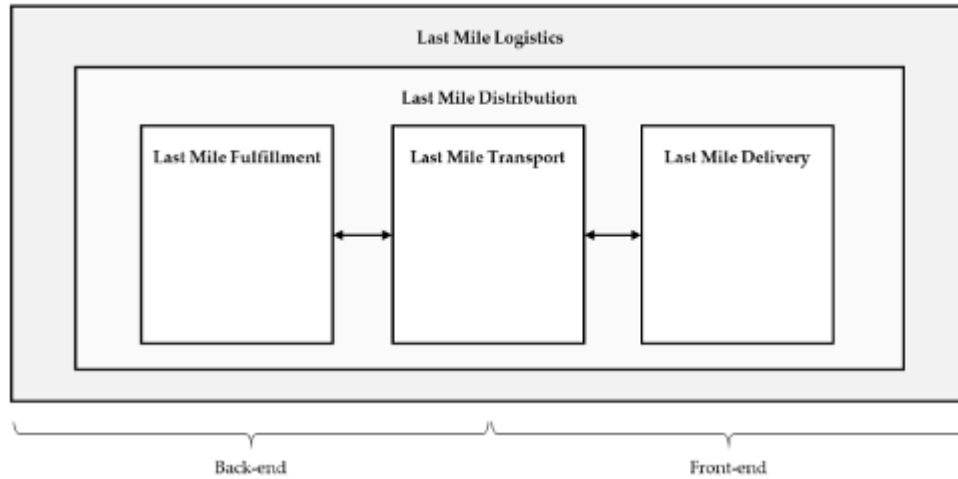


Figure 4. Last Mile Logistics framework (Olsson, J., Hellström, D. and Pålsson, H., 2019).

Digitalization has transformed the retail industry and their processes by the creation of new forms of exchange places or retailer-customer links and the combination of existing channels (Hagberg et al. 2016). Dennis et al. (2014) outlined three typical channels for making purchases: traditional or physical, web based computer integration and mobile devices. Customers are increasingly engaging with retailers across multiple channels during the same shopping experience. The click and collect functionality gives an option for the customer to purchase online and pick up product at a physical store (Sit et al., 2018). The process of customers to shop seamless across different channels and achieving integration is described as the Omni-channel retailing model. In Omni-channels, customers can place the order in one channel (e.g. smart phone), pick up or receive through another channel (e.g. home delivery), and return items in a third channel which is a physical store (Kembro and Norrman, 2019).

The majority of the last mile delivery articles focus on emerging technologies and innovations, especially on goods reception solutions. The existing literatures indicate a major focus on the growing online retailing

i.e. e-commerce and Omni channel retailing. These indicate the need for future research to be carried out in understanding and analyzing the consumer experiences from direct shopping in retail stores in order to provide them with possible solutions that offer convenience and flexibility.

3.4 Self - service or Self-transportation for consumers

The consumer purchasing behaviors paved way for the self-serve business model with a fully developed foundation to serve this new generation of retail. For retailers to consider the self service technologies is critical and gain deeper insights to determine which one could meet their business needs in order to bring new opportunities to connect and engage with consumers (Duska, 2020).

The introduction of self-service solutions has marked a revolution in the retail industry. The retailers need to focus on the consumer perceptions of what makes an ideal shopping experience: right value, tailored offerings, etc. The best approach is to design the customer experiences involving an organized cross-functional management, so that the products and services are built around the customer rather than the supply chain. Once the elements of the customer experiences have been defined they must be translated into the practical design of the self-service components. These components later should be deployed through carefully controlled pilot tests, so that the organization can understand the impact of each element on the customer. Understanding the end-to-end customer journey and developing a holistic view of their customer experiences are the new challenges for the retailers. Customers will continue to discover new needs and press retailers for more choice, better quality, value for money and more enjoyable experiences (Taylor, 2008).

The previous literatures suggested that the most typical Self-service Technology (SST) is interactive kiosks that refer to the computer workstations for public access. The current focus is more on the technological aspects in the retail sectors than on self-service aspects such as self-transportation of goods for consumers. The literature review

indicated that there has been no prior research carried out regarding the self-transportation aspects from a retail store.

3.5 Packaging Technology and development

3.5.1 Introduction to Packaging

The definition of packaging can be expressed in the following three statements according to Paine (1981) as follows:

- An interrelated system made up of materials of any nature, to be used for arranging goods for containment, protection, transport, handling, distribution, delivery and presentation.
- It is the means of verifying a safe delivery from the producer (source) to the end consumer in sound and safe conditions.
- It is a techno-economic function which is aimed at making delivery systematic while maximizing the usefulness.

Packaging has many different facets apart from its material and physical properties, especially in logistics and marketing. It is also considered as an essential link between the producer and consumer. The packaging design could be developed as a set of choices regarding the form, the function of packaging system and also the activities that support these choices (Hellström, Olsson and Nilsson, 2017).

3.5.2 Packaging Functions:

Lockamy (1995) has referred to the most commonly used multiple functions of packaging as follows:

Containment

The key purpose of containment is to hold the content and keep it or by securing the surroundings. This function highlights the need for existence of packages in making products available to the end consumers.

Protection

The protection function involves safeguarding the contents of the package from external sources and vice versa. Damages could be caused from physical, chemical, microbiological and climatic sources. It also provides physical protection against many different forces such as vibration, compression and mechanical shock.

Apportionment

This function enables a given amount of content to control and support the suitable usage. Apportionment in packaging eases the output from the large scale industries by dividing them into manageable portions and sizes.

Unitization

This function involves combining or reconciliation of units. Similar to apportionment, this function makes the handling of packaging suitable for different stakeholders in different situations and locations.

Convenience

The primary purpose of this function is to make it easy and convenient to use the package and its contents. This function relates to unitization and apportionment. The key aspect of this function in packaging throughout all handling stages includes:

- the ability to use products at any time and place;
- the recognition of the packages by considering features such as easy to open, carry and empty;
- providing correct and safe dispensing;
- ease of discarding.

Information

Information function forms a fundamental function of packaging as it is the interface between the product and the logistics, and between the product and the consumer or other users. The two major roles of this function are to

help users in identifying the content, and to provide them with instructions on how to use it.

Communication

The package is considered as a medium of communication between the brand owner and the consumer. Packaging is a sales and commercial tools, as it influences market position and consumer behavior by triggering buying and creating loyalty and identity.

3.5.3 The complexity of packaging design

Packaging design involves the consideration of numerous needs, requirements and conditions which goes beyond the packaging itself. The complexity in this process could be better understood by using the layers of the onion as a metaphor as shown in figure 5 below. Each layer may not be complex but when considered as a whole with their specific requirements and interrelations, creates the complexity of packaging design. When considering the layer five with end consumers at the end of the SC, has dynamic diversity of requirements and forms a layer on its own. There is no particular design that fits for all users and often packaging needs to be designed for different end consumers/users. The consumers may come late in the supply chain but identifying their needs is the key strategic input to start the design process (Hellström, Olsson and Nilsson, 2017).

Adding to these complexities, the sixth layer depicts the needs and requirements of various distribution channels. The channel preferences vary between customers, and consumers increasingly prefer multi channels at different times and occasions. Thus, packaging needs to comply with the needs from a multi channel perspective. The layer seven highlights the fact that packaging can have numerous lives where its lifecycle is extended beyond its use. It also involves closing the loop which forms the circular systems. Circular systems can be achieved by transforming the packaging into a completely different object which could be considered as a secondary raw material. All these layers are interrelated and needs an iterative approach in order to have a balance between the different layers (Hellström, Olsson and Nilsson, 2017).

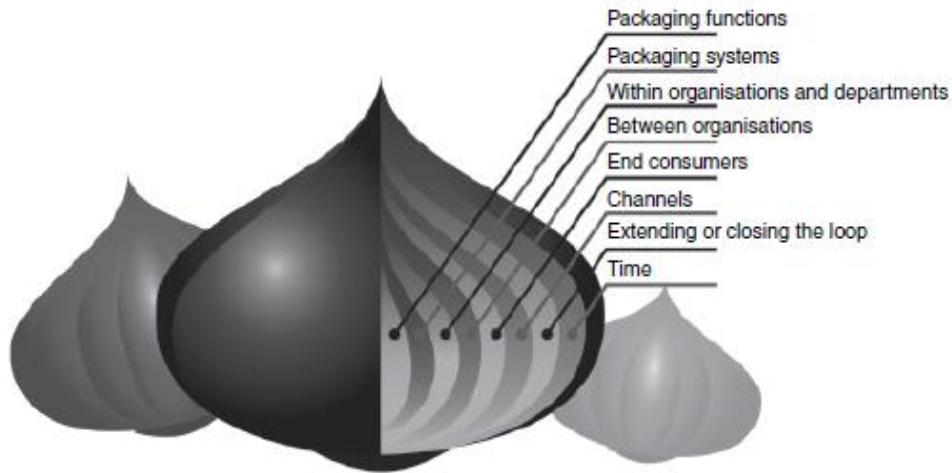


Figure 5. The interrelated packaging design layers of needs and requirements (Hellström, Olsson and Nilsson, 2017)

3.5.4 Paper-based packaging materials

3.5.4.1 Introduction:

Packaging paper materials are made up of cellulose fibers produced either from virgin-wood or recycled fibers or both. The surface of the paper is typically coated so as to strengthen printability (Niskanen et al., 2012). This section describes the structure of the corrugated board in order to gain an understanding.

3.5.4.2 Corrugated board:

Corrugated board may be a sandwich construction with a web core and face sheets made of paper. Container board is the most common name for the paper materials which are used to manufacture corrugated board. This includes linerboard, used for the facings and fluting, which is used in the core. The face sheets and core are glued together with a starch based adhesive. The most important function of the core is to separate the face sheets to develop a structure with high bending stiffness. Corrugated board is created from several layers depending on the packaging requirements. The single-faced corrugated board is made of two layers: one linerboard and a corrugated fluting layer. The single wall corrugated board is a true

sandwich consisting of three layers: two linerboard and the corrugated fluting layer. About 80% of the corrugated board is produced as single-wall board (Niskanen et al., 2012). The different types of corrugated board are presented in the figure 6 below:

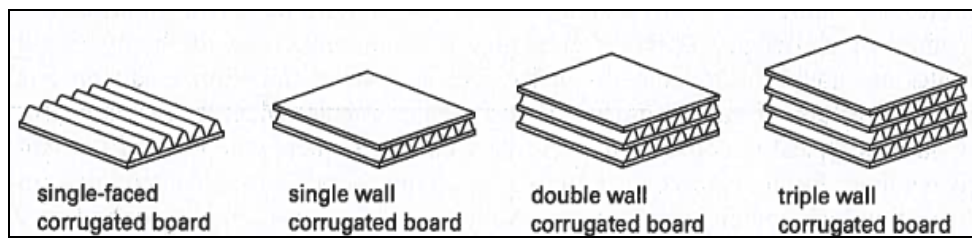


Figure 6. Single wall, double wall, triple wall corrugated board (Niskanen et al., 2012)

The converting of the corrugated board has a sequence of process that transform the corrugated board into the final corrugated container. One of the most common boxes referred as the Regular Slotted Container (RSC), is manufactured from a single sheet of corrugated board which is scored and slotted to permit folding as shown in figure 7. The boxes are subjected to different loading conditions in the filling, stacking, and transportation and storage operations. The way in which a corrugated box fails in compression is dependent on the board configurations and the box dimensions. The main failure modes of a corrugated board box are due to buckling and compression failure. There are various parameters that are used in order to characterize the mechanical performance of the corrugated board material. The most important are the Edge Crush Test (ECT) and the bending stiffness. The relatively long time usage and stress on the stiffness behavior of the packages is difficult to study and there are relatively little work published regarding it (Niskanen et al., 2012).

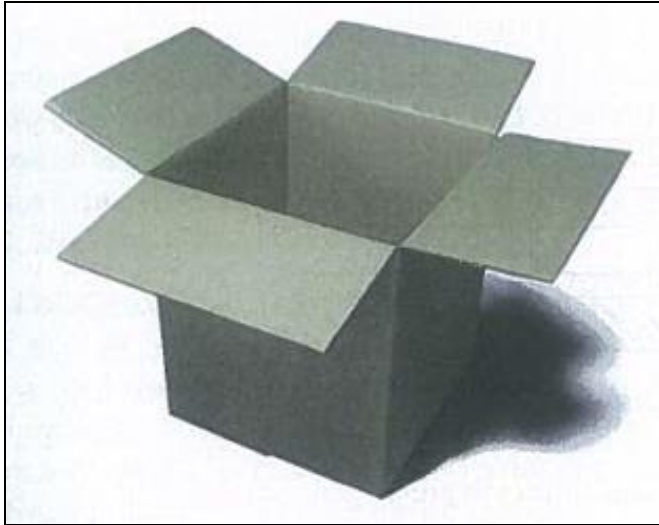


Figure 7. Regular Slotted Container(RSC) (Niskanen et al., 2012)

3.6 Packaging Logistics

Packaging logistics primarily brings together different packaging areas with logistics and SCM disciplines to support one another. It focuses on the interactions achieved by consolidating the systems of these combined disciplines with an objective of adding value to the overall system. The fundamental of this concept covers the design of the packaging system throughout the whole SC from raw product, via various actors, to the end users and to recycling and recovery. It is difficult to develop a sustainable logistics system without a packaging system that supports it or vice versa in order to create a sustainable packaging system (Hellström, Olsson and Nilsson, 2017).

Packaging is included in logistics and SCM in different ways but is recognized as having a significant contribution on logistics costs and performance. It also affects the performance of every logistical activity throughout the SC, either directly through material handling and transportation or indirectly as information carrier, product protection. The role of packaging in logistics is a long neglected but fundamental part of

activities which adds as a source of profit, but also has an effect on the environment (Hellström, Olsson and Nilsson, 2017). From a systems perspective, there are three areas where packaging related improvements can be made: in the logistics processes; in the packaging system. The third area accounts for the interface between different packaging levels and logistics processes along SC as shown in figure 8. These interactions forces the practitioners to understand where and how logistics and packaging decisions can impact the SC (Hellström and Saghir, 2007).

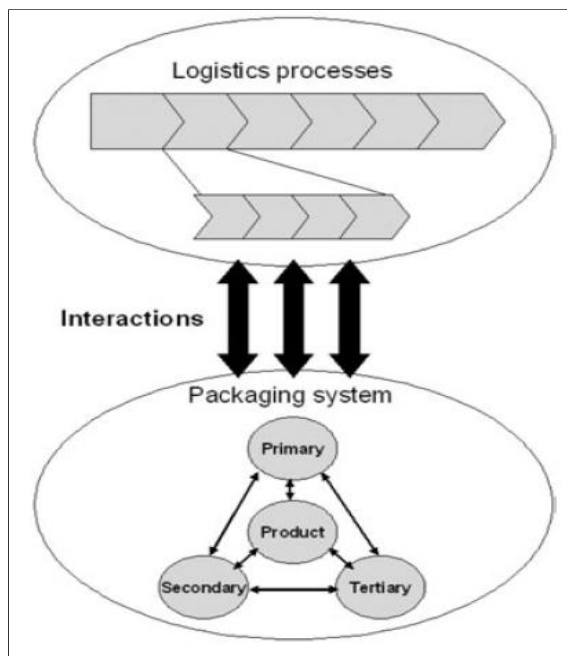


Figure 8. Systems perspective with areas of packaging related improvements (Hellström and Saghir, 2007)

3.7 Chapter Summary

The chapter starts with a section on customer focused SC strategies to discuss about the importance of focusing on the end consumers. Later, a section is discussed about measuring the performance of SCM which is consumer based. In the next section, Last mile delivery with retail

management aspects is discussed to gain an understanding and differentiating it with the other terminologies. The next section discusses the self-service aspects for the consumers from a retail store. The next section deals with the detailed description about packaging definition and its multiple functions. Also the complexities in packaging design, paper based packaging material are discussed. This section ends with the discussion about the multidisciplinary aspect of packaging. The main idea is to follow the link from SCM with focus on Consumers- Last mile delivery- Self-service- Packaging design and logistics.

4. Empirical Study

In the present chapter, first a description about the possible solution is given. It is followed by the extensive description about the different tests performed. Then, a summary of the results in a table is presented in order to answer the research questions posted relating to it. To finish, a chapter summary ends the chapter.

4.1 RQ1) What are the existing solutions available in the market for the consumers to transport goods by themselves from an IKEA store?

This section presents the results and discussion of RQ1), since it contributes to the data collected. The main requirements from the organization in order to identify the existing solution considering self transportation of goods included:

- Sustainable solution
- No return flow

The current possibilities included the following solutions:

IKEA yellow and blue shopping bags as shown in figure 9 are best suited for self delivery of goods by the consumers. Both are made from polypropylene and have 60% minimum possibility for recycling (cleaning, bags and FRAKTA Shopping bag, 2020). In spite of being a recyclable material, it has the plastic usage in it which reduces the sustainability aspects. Also, it could be used for multipurpose and can possibly be used again for shopping. The main disadvantage of using it is the fact that the convenience function for the customers may not be fulfilled. It would be difficult to carry loads for a prolonged time and might not suit all customer groups. Also, the stability of the items placed inside adds to the difficulty in handling them.



Figure 9. IKEA yellow and blue bag (cleaning, bags and FRAKTA Shopping bag, 2020)

The shopping trolley bag as shown in figure 10 could also be considered for the self delivery of goods. The bag and trolley are easy to store since they fold flat. The handle could be adjusted to two different lengths and lock it in place. The frame is made of steel and the handle and wheels are made of plastics (KNALLA black, Shopping bag on wheels - IKEA, 2020). The trolley bag on wheels could be used by leaving the car at home when shopping which contributes lesser carbon footprint to the environment. It also could be for multiple purposes and brought for shopping again. Considering the requirements, it is not a sustainable solution but offers good convenience and flexibility functions to the end user.



Figure 10. Shopping trolley bag (KNALLA black, Shopping bag on wheels - IKEA, 2020)

The cardboard trolley solution as shown in figure 11 seems to be a more efficient solution considering the previous solutions. The box, handle and wheels are corrugated board materials which are basically paper based and offer 100% recyclability. The cardboard trolley provides convenience, flexibility and proper stability for placing and handling the goods. It also provides better containment and protection functions than the other solutions and even can handle bulkier and fragile goods. This could possibly be used leaving the car at home for shopping and contributes lesser carbon footprint to the environment. The cardboard trolley solution also provides the consumers with a good feel and emotion of using a sustainable product. Considering the above requirements, this solution seems more convincing and could be tested and evaluated in order to gain better understanding.



Figure 11. Cardboard trolley solution

After market screening and discussion with the company, it was decided to test the cardboard trolley as a possible solution considering the self transportation of goods by the consumers. This solution was tested on field in order to replicate and use the trolley as a consumer performs it. The tests

were carried out using IKEA conventional Jattene boxes and with two different boxes referred as Quick box 1 and Quick box 2. To each of the boxes a handle and a pair of wheels were glued according to the instructions provided by its supplier.

Jattene Box had the openings at the sideways so that the goods can be handled easily. The top and bottom surfaces were taped in order to avoid collapsing during transportation. The details of the box are summarized below in table 1:

Table 4. Details of Jattene Box

Material	Corrugated Cardboard
Width	56 cm
Depth	33 cm
Height	41 cm
Max. Load	30 Kg

Quick Box 1 had the openings at the top side of the handle and was a heavy duty box with the same dimensions as jattene box. The details are summarized in table 2 below:

Table 5: Details of Quick Box 1

Material	Corrugated Cardboard (Heavy duty double wall)
Width	56 cm
Depth	33 cm
Height	41 cm

Max. Load	30 Kg
------------------	-------

Quick Box 2 had the openings at the top side of the handle and was a heavy duty box with a less depth than the previous boxes. The details are summarized below:

Table 6. Details of Quick Box 2

Material	Corrugated Cardboard (Heavy duty double wall)
Width	56 cm
Depth	22 cm
Height	41 cm
Max. Load	30 Kg

The data collection method mainly used is field tests with the recording of distances travelled and also with pictures indicating the type of failure. The field testing process is further explained in the next section. The author maintained conversations with the representatives of the company in order to report the findings and discussing the steps moving forward with the tests.

4.2 Field Tests:

The detailed description about each individual test with their particular testing requirements and test results are summarized in the following sections:

4.2.1 Test 4: Light load – Less than 20 kg with road walking in bad weather (preferably rain)

The test had the requirements of road walking in a bad weather with a load less than 20 kg. The walking route was chosen around the IKDC premises. A weight of 15 kg was chosen for the tests and it was decided to take pictures for every half km of travel. The box was assembled and then the weights were checked and placed inside the box. The top and bottom surfaces of the box were taped. The handle and wheels (02 No's) were glued to the respective sides of the cardboard box. The walking route was initially checked for the distance using Google maps and then proceeded for the tests. The travel was smooth initially but due to the wetness of the surfaces the wheels were getting soggy and layers of the wheels started to peel off. The results of the tests are summarized in table 7 and figure 12 below:

Table 7: Outcomes of test 4

Weather conditions	Bad Weather - Rain
Distance pulled	1.8 km
Type of Box	IKEA Jattene
Weight	15 Kg
Road surfaces	Cement blocks, Tar road
Nature of failure	Wheel peeled off from surface at 1.8km



a) Types of surfaces used



b) At 0.5 km



c) At 1 km



d) Wheels got damaged at 1.8 km

Figure 12. Pictures describing the tests at different surfaces, distances and the point of failure

4.2.2 Test 5: Light load – Less than 20 kg with Durability test:

The test had the requirement of transition over as many barriers as possible. The weight was chosen as 10 kg with the usage of different surfaces as possible. The initial preparations were carried out as mentioned in the previous test. Before and during the test the handle was not sticking to the surface properly. After a certain distance of travel the layers of the wheel were peeling off from the surface. The results of the tests are summarized in table 8 and figure 13 below:

Table 8. Outcome of Test 5

Weather conditions	Bad Weather - Rain
Distance pulled	1.7 km
Type of Box	IKEA Jattene
Weight	10 Kg
Road surfaces	Cement blocks, Tar road, Cobble stones
Barriers	Curb sides
Nature of failure	Handle peeling off at one side before and during the test, layers of the Wheel peeling off at 1.7 km.



a) Types of surfaces used for the test for different transitions



b) At 1 km



c) At 1.5 km



c) Wheels after the test



d) Handles during the test

Figure 13. Pictures describing the test 5 at different surfaces, distances and the point of failure.

4.2.3 Test 9: Capacity load at 20kg with road walking in bad weather:

The test had the requirements of load with 20 kg with road walking in bad weather (preferably rain). The initial preparations were carried out as mentioned in the previous test. During the test it was performing well for a certain distance after which the wheels started to get soggy. Due to this it was difficult to operate and wheels move unevenly on the surfaces. The results of the tests are summarized in table 9 and figure 14 below:

Table 9. Outcome of Test 9

Weather conditions	Bad Weather - Rain
Distance pulled	1.5 km
Type of Box	IKEA Jattene
Weight	20 Kg
Road surfaces	Cement blocks, Tar road.
Nature of failure	Wheels get soggy at a distance of 1.7 km.



a) At 0.5 km



b) At 1 km



c) At the end of the test after completing 1.5 km



Figure 14. Pictures describing the test 9 with different distances.

4.2.4 Test 3: Light load – Less than 20 kg with road walking in good weather:

The test had the requirement of load less than 20 kg and road walking in good weather. The initial preparations were carried out as mentioned in the previous test. The test failed at 3.5 km with wheel coming off from the

surface. It worked well for about 3.5 km after which one side wheel peeled off. It was a difficult task to bring back the trolley to the starting point. But overall, the performance was good for low weights. The results of the tests are summarized in table 10 and figure 15 below:

Table 10. Outcome of Test 3

Weather conditions	Good Weather - Sunny
Distance pulled	3.5 km
Type of Box	IKEA Jattene
Weight	5 Kg
Road surfaces	Cement blocks, Tar road.
Nature of failure	One of the Wheels go peeled off at a distance of 3.5 km.



a) At 1 km



b) At 2 km



c) At 3 km



d) Failure at 3.5

Figure 15. Pictures describing the test 3 with different distances and the point of failure.

4.2.5 Test 8: Capacity load at 20kg with road walking in good weather

The test had the requirement of a load with 20 kg and road walking in good weather. The initial preparations were carried out as mentioned in the previous test. The test performed well for a distance of 1 km, after that the layers of one of the wheels started peeling off and the entire wheel got peeled off at a distance of 1.5 km. The results of the tests are summarized in table 11 and figure 16 below:

Table 11. Outcome of Test 8

Weather conditions	Good Weather - Sunny
Distance pulled	1.5 km
Type of Box	IKEA Jattene
Weight	20 Kg
Road surfaces	Cement blocks, Tar road.
Nature of failure	Layers of the wheel got peeled off, One of the Wheels got peeled off at a distance of 1.5 km.

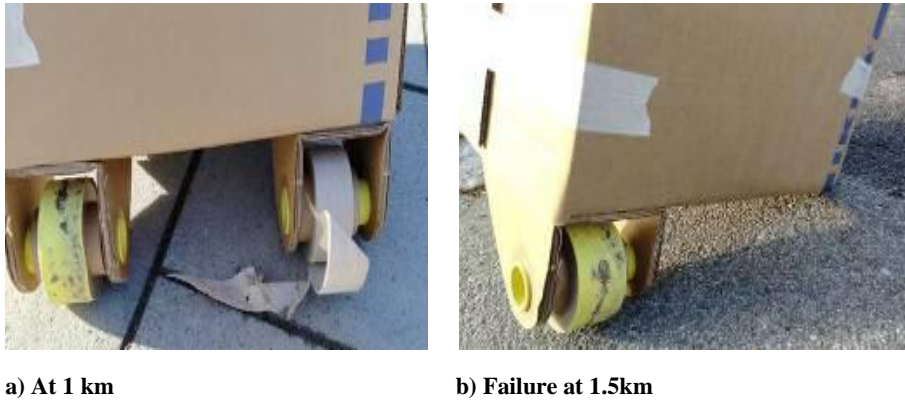


Figure 16. Pictures describing the test 8 with different distances and the point of failure.

4.2.6 Test 13: Over Capacity load – Over 20kg with road walking in good weather

The test had the requirement of load over 20 kg with road walking in good weather conditions. A load of 22kg was chosen for the test. It was fine pulling it for a distance of 1 km but after that it was difficult to handle. One side of the handle peeled off from its surface after operating for a distance of 1.7 km. With this load, after failure it was difficult to bring it back to the starting point. The results of the tests are summarized in table 12 and figure 17 below:

Table 12. Outcome of Test 13

Weather conditions	Good Weather - Sunny
Distance pulled	1.7 km
Type of Box	IKEA Jattene
Weight	22 Kg
Road surfaces	Cement blocks, Tar road.
Nature of failure	One side of the handle got peeled off at a distance of 1.7 km.



a) At 1 km



b) At 1.5 km



c) Failure at 1.5 km

Figure 17. Pictures describing the test 13 with different distances and the point of failure.

4.2.7 Test 10: Capacity load at 20 kg with Durability test

The test had the requirement of a 20 kg load with as many transitions as possible. The test failed at a distance of 500m with one of the wheel peeling from its surface. The results of the tests are summarized in table 13 and figure 18 below:

Table 13. Outcome of Test 10

Weather conditions	Good Weather - Sunny
Distance pulled	500m
Type of Box	IKEA Jattene
Weight	20 Kg
Road surfaces	Cement blocks, Cobble stones.
Nature of failure	One of the wheels got peeled off at a distance of 500m.



a) At 500 m



b) Failure at 500 m

Figure 18. Pictures describing the test 10 with different distances and the point of failure.

4.2.8 Test 15: Over Capacity load - over 20 kg with Durability test

The test had the requirement of a load more than 20 kg load with as many transitions as possible. A load of 22kg was chosen for the test. The test failed at a distance of 350m with one side handle peeling off from its surface. The results of the tests are summarized in table 14 and figure 19 below:

Table 14. Outcome of Test 15

Weather conditions	Good Weather - Sunny
Distance pulled	350m
Type of Box	IKEA Jattene
Weight	22 Kg
Road surfaces	Cement blocks.
Nature of failure	One side handle got peeled off at a distance of 350m.



a) Failure at a distance of 350 m

Figure 19. Pictures describing the test 15 with the point of failure.

4.2.9 Test 1: Light load – Less than 15 kg with public transport

The test had the requirement of load less than 20 kg with public transportation. The travel mode was bus and route was from Lund LTH bus stop to Lund Univ-sjukhuset bus stop and return via the same route. This test also had road walking with the weights from the point of origin

to the bus stop and vice versa. A weight of 10kg was chosen for the test. The trolley could only be kept in the space provided for the strollers inside bus. It was not fitting in the aisle space near the seats. The results of the tests are summarized in table 15 and figure 20 below:

Table 15. Outcome of Test 1

Type of Public Transportation	Bus
Weather conditions	Bad Weather – Rain and Windy
Distance pulled	1.5 km
Type of Box	IKEA Jattene
Weight	10 Kg
Road surfaces	Cement blocks, Tar road
Barriers	Curb sides



a) Before transportation



b) During the transportation



c) After transportation

Figure 20. Pictures describing the test 15 with public transportation mode.

4.2.10 Test 2: Light load – Less than 15 kg with multiple public transportation

The test had the requirement of load less than 15 kg with multiple mode of transportation. The mode of travel was bus and train with route from Lund LTH bus stop – Lund C station – Lund Gunnesbo station and return via the same route. This test also had road walking with the weights from

the point of origin to the bus stop and vice versa. A weight of 10kg was chosen for the test. The trolley could only be kept in the space provided for the strollers inside bus. It was not fitting in the aisle space near the seats. The transition was good through stairways and escalators. While travelling inside the train it was difficult to fit into seats, so it was kept where there were sufficient amount of space. It performed well for about 2 km after which one side handle peeled off. It was difficult to bring back the trolley to the starting point. The results of the tests are summarized in table 16 and figure 21 below:

Table 16. Outcome of Test 2

Type of Public Transportation	Bus and Train
Weather conditions	Bad Weather – Rain and Windy
Distance pulled	2.5 km
Type of Box	IKEA Jattene
Weight	10 Kg
Road surfaces	Cement blocks, Tar road, Cobble stones.
Barriers	Stair ways, Escalator.
Nature of Failure	One side handle got peeled off at a distance of 2.5 km, Lower portion of the box near the wheels go damaged.



a) Before transportation



b) During multiple transportation



c) After transportation

Figure 21. Pictures describing the test 15 with different transportation modes.

4.2.11 Test 6: Capacity load at 15 kg with public transportation

The test has the requirement of 15kg load with public transportation. The travel mode was bus and route was from Lund LTH bus stop to Lund Univ-sjukhuset bus stop and return via the same route. This test also had road walking with the weights from the point of origin to the bus stop and vice versa. The trolley could only be kept in the space provided for the strollers inside bus. It was not fitting in the aisle space near the seats. The results of the tests are summarized in table 17 and figure 22 below:

Table 17. Outcome of Test 6

Type of Public Transportation	Bus
Weather conditions	Bad Weather – Rain and Windy
Distance pulled	1.5 km
Type of Box	IKEA Jattene
Weight	15 Kg

Road surfaces	Cement blocks, Tar road
Barriers	Curb sides



a) Before transportation



b) During transportation



c) After transportation

Figure 22. Pictures describing the test 6 with public transportation.

4.2.12 Test 7: Capacity load at 15 kg with multiple public transportation

The test had the requirement of 15 kg load with multiple mode of transportation. The mode of travel was bus and train with route from Lund LTH bus stop – Lund C station – Lund Gunnesbo station and return via the same route. This test also had road walking with the weights from the point of origin to the bus stop and vice versa. The test got failed after a road walking of 50 m with one of wheel peeling off from its surface. The results of the tests are summarized in table 18 and figure 23 below:

Table 18. Outcome of Test 7

Type of Public Transportation	Bus and Train
Weather conditions	Bad Weather – Rain and Windy
Distance pulled	50 m
Type of Box	IKEA Jattene
Weight	15 Kg
Road surfaces	Cement blocks, Tar road.
Nature of Failure	One of the wheel got peeled off at a distance of 50 m



a) Failure at a distance of 50

Figure 23. Pictures describing the test 15 with the point of failure.

4.2.13: Test 13: Capacity load at 20 kg with road walking in bad weather:

The test had the requirement of load at 20 kg and road walking in bad weather. The test got failed at a distance of 50 m with one of the wheels peeling off from its surface. The results are summarized in table 19 and figure 24 below:

Table 19. Outcome of Test 13

Weather conditions	Bad Weather – Rain
Distance pulled	50 m
Type of Box	Quick Box 1
Weight	20 Kg
Road surfaces	Cement blocks, Tar road.
Nature of Failure	One of the wheel got peeled off

	at a distance of 50 m
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a) Failure at 50 m

Figure 24. Pictures describing the test 13 with the point of failure.

4.2.14 Test 14: Capacity load at 15 kg with Durability test

The test had the requirement of load at 15 kg with as much transition as possible. The test failed at a distance of 600m with one of the wheel peeling off from is surface. The results are summarized in table 20 and figure 25 below:

Table 20. Outcome of Test 14

Weather conditions	Bad Weather – Rain
Distance pulled	600 m
Type of Box	Quick Box 1
Weight	15 Kg
Road surfaces	Cement blocks, Tar road, Cobble stones.
Nature of Failure	One of the wheel got peeled off at a distance of 600 m



a) Failure at 600 m

Figure 25. Pictures describing the test 14 with the point of failure.

4.2.15 Test 15: Capacity load at 15 kg with road walking in good weather

The test had the requirement of a load at 15 kg with road walking in good weather. The test failed at a distance of 1.5km with one of the wheel peeling off from its surface. The results are summarized in table 21 and figure 26 below:

Table 21. Outcome of Test 15

Weather conditions	Good Weather – Sunny
Distance pulled	1.5 km
Type of Box	Quick Box 2
Weight	15 Kg
Road surfaces	Cement blocks, Tar road, Cobble stones.

Nature of Failure	Both the wheels got peeled off at a distance of 1.5 Km
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a) At 1 km



b) At 1.2 km



c) Failure at 1.5 km

Figure 26. Pictures describing the test 15 with different distances and the point of failure.

4.2.16 Test 16: Capacity load at 15 kg with road walking in good weather

The test had the requirement of a load at 15 kg with road walking in good weather. The test performed well covering a distance of 2.2km. The results are summarized in table 22 and figure 27 below:

Table 22. Outcome of Test 16

Weather conditions	Good Weather – Sunny
Distance pulled	2.2 km
Type of Box	Quick Box 1
Weight	15 Kg
Road surfaces	Cement blocks, Tar road, Cobble stones.
Nature of Failure	N/A



a) At 1 km



b) At 2.2 km

Figure 27. Pictures describing the test 16 with different distances

4.2.17 Test 17: Capacity load at 15 kg with Durability test

The test had the requirement of load at 15 kg with as much transition as possible. The test failed at a distance of 700m with one of the wheel peeling

off from its surface. The results are summarized in table 23 and figure 28 below:

Table 23. Outcome of Test 17

Weather conditions	Good Weather – Sunny
Distance pulled	700 m
Type of Box	Quick Box 2
Weight	15 Kg
Road surfaces	Cement blocks, Tar road, Cobble stones.
Nature of Failure	One of the wheels got peeled off at a distance of 700 m



a) Types of surfaces used



b) Failed at a distance of 700m

Figure 28. Pictures describing the test 17 with different surfaces and the point of failure.

4.2.18 Test 18: Capacity load at 15 kg with public transportation

The test has the requirement of 15kg load with public transportation. The travel mode was bus and route was from Lund LTH bus stop to Lund Univ-sjukhuset bus stop and return via the same route. This test also had road walking with the weights from the point of origin to the bus stop and vice versa. The trolley could only be kept in the space provided for the strollers inside bus. The results of the tests are summarized in table 24 and figure 29 below:

Table 24. Outcome of Test 18

Type of Public Transportation	Bus
Weather conditions	Good Weather – Sunny and Windy
Distance pulled	1.5 km
Type of Box	Quick Box 1
Weight	15 Kg
Road surfaces	Cement blocks, Tar

	road
Barriers	Curb sides



a) Before transportation



b) During the transportation



c) After transportation

Figure 29. Pictures describing the test 18 with public transportation

4.2.19 Test 19: Capacity load at 15 kg with public transportation

The test has the requirement of 15kg load with public transportation. The travel mode was bus and route was from Lund LTH bus stop to Lund Univ-sjukhuset bus stop and return via the same route. The test failed at a distance of 10 m with both the wheels peeling off from its surface. The results of the tests are summarized in table 25 and figure 30 below:

Table 25. Outcome of Test 19

Type of Public Transportation	Bus
Weather conditions	Good Weather – Sunny and Windy
Distance pulled	10 m

Type of Box	Quick Box 2
Weight	15 Kg
Road surfaces	Cement blocks
Nature of Failure	Both the wheels got peeled off at a distance of 10 m



a) Failure at a distance of 10 m

Figure 30. Picture describing test 19 with the point of failure.

4.2.20 Test 20: Capacity load at 15 kg with road walking in bad weather

The test had the requirement of load at 15 kg and road walking in bad weather. The test got failed at a distance of 15 m with one of the wheels peeling off from its surface. The results are summarized in table 26 and figure 31 below:

Table 26. Outcome of Test 20

Weather conditions	Bad Weather – Rain and windy
Distance pulled	15 m
Type of Box	Quick Box 2
Weight	15 Kg
Road surfaces	Cement blocks, Tar road.
Nature of Failure	One of the wheel got peeled from its surface



a) Failure at a distance of 15 m

Figure 31. Picture describing test 20 with the point of failure.

4.3 Summary of the test results

The summary of the test results is presented in the table below in order to proceed with the findings from the empirical study.

Table 27. Overview of the 20 tests with collected data and the reason for failure

Test No.	Testing parameters	Weight	Distance	Type of surfaces used	Weather	Reason for failure
		(kg)	(km)			
4	Road walking in bad weather with jattene box	15	1.8	Concrete, Asphalt	Rain	Wheels
5	Durability test with jattene box	10	1.7	Concrete, Asphalt, Cobble stones	Rain	Handle and Wheels
9	Road walking in bad weather with jattene box	20	1.5	Concrete, Asphalt	Rain	Wheels
3	Road walking in good weather with jattene box	5	3.5	Concrete, Asphalt	Sunny	Wheels
8	Road walking in good	20	1.5	Concrete, Asphalt	Sunny	Wheels

	weather with jattene box					
13	Road walking in good weather with jattene box	22	1.7	Concrete, Asphalt	Sunny	Handle
10	Durability test with jattene box	20	0.5	Concrete, Cobble stones	Sunny	Wheels
15	Durability test with jattene box	22	0.35	Concrete	Sunny	Handle
1	Public transportation with jattene box	10	1.5	Concrete, Asphalt,	Rain and windy	N/A
2	Multiple public transportation with jattene box	10	2.5	Concrete, Asphalt, Cobble stones	Rain and windy	Handle, Box
6	Public transportation with jattene box	15	1.5	Concrete, Asphalt,	Rain and Windy	N/A
7	Multiple public	15	0.05	Concrete, Asphalt,	Rain and	Wheels

	transportation with jattene box				Windy	
13	Road walking in bad weather with QB1	20	0.05	Concrete, Asphalt	Rain	Wheels
14	Durability test with QB1	15	0.6	Concrete, Asphalt, Cobble stones	Rain	Wheels
15	Road walking in bad weather with QB2	15	1.5	Concrete, Asphalt, Cobble stones	Sunny	Wheels
16	Road walking in good weather with QB2	15	2.2	Concrete, Asphalt, Cobble stones	Sunny	N/A
17	Durability test with QB2	15	0.7	Concrete, Asphalt, Cobble stones	Sunny	Wheels
18	Public transportation with QB1	15	1.5	Concrete, Asphalt	Sunny and windy	N/A
19	Public transportation with QB2	15	0.01	Concrete	Sunny and windy	Wheels

20	Road walking in bad weather with QB2	15	0.015	Concrete, Asphalt	Rain and windy	Wheels
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The test result with a reason of failure indicates the contribution of the item that caused the failure of that particular test. It is to be noted that all the tests have certain testing requirements which are indicated in the above table 27. Among the 20 tests conducted there were only 4 tests without a failure and the remaining tests had some item that has contributed to the failure. It is also evident from the table that the majority of the tests have wheels has the reason for failure. The nature of failure had the wheels peeling off from the surfaces of the box and getting wet while operating under raining conditions. Also, the surface area of the glue that is in contact with the box is less when compared to the handle. The wheels are glued to a single point of contact with the box surface. These issues made the author of this report to motivate that the wheels are critical and contributes significantly in deciding the feasibility of the solution. In order to support and motivate these statements, the following research questions are answered below with reference to the empirical data.

4.4 RQ2) What are the material aspects of the cardboard trolley to be considered?

The material aspects of the trolley could be categorized into three different ways such as box, wheels and handle. The analysis of these three items would be discussed on an individual entity as follows:

Box:

There are three different box types used for the tests namely IKEA jattene box, Quick box 1(QB1) and Quick box 2 (QB2) as shown in figure 32. Among the 20 tests that were carried out, 12 tests were performed using

IKEA jattene box and 4 tests were performed using QB1 and QB2 respectively. The below analysis are based on the visual and operational view that the author had encountered while performing the tests with these above mentioned boxes.

The IKEA jattene box was a single wall corrugated board type. When performing the multiple transportation tests (refer test 2 in table), the bottom surface got damaged and had a hole at the corner. This particular test was carried out in a bad climatic condition with rain and heavy winds. As a single entity, there were not many complications when using this box for the tests.

The QB1 and QB 2 are a heavy duty double wall corrugated board type. When considering these boxes as an individual entity there were not many issues while performing the tests.



a) IKEA Jattene box



b) Quick Box 1



c) Quick box 2

Figure 32. The three different corrugated board boxes used for the tests

Handle:

The handle is made up of a corrugated board material and has three areas with glue in order to glue it to the box surface as shown in figure 33. It has a front and back portion indicated for gluing it on the respective sides. Among the 20 tests carried out with different loads as mentioned in chapter 3, there were 4 tests (refer tests 2, _5, _13, _15 in table 27) that had the nature of failure with one side of the handle getting peeled off from its surface. The rest of the tests were carried out smoothly without much complication.



Figure 33. Corrugated board handles used for the tests

Wheels:

The wheels are also made of corrugated board material and have a single glue layer for each wheel in order to glue it to the box surface as shown in figure 34. A trolley comprises of two wheels that were aligned and glued to the respective sides of the box. There is also an indication on the handle to show the correct placing of the wheels. From the 20 tests that were carried out, there were 12 tests (refer tests 3, _4, _5, _7, _8, _10, _13, _14, _15, _17, _19, _20 in table) that had the nature of failure with one or both the wheels getting peeled off from the box surface. Also, under bad weather conditions (rain) the wheels are getting soggy and difficult to operate since the layers of the wheel starts to peel off. These wheels have only a single contact side with the box which is glued together - More than 50% of the failure during the tests was due to the wheels, which adds itself as the critical part.



Figure 34. Corrugated board wheels used for the tests

4.5 RQ3) What is the maximum load that can be carried and transported using the cardboard trolley?

The load carrying capacity of the trolley contributes to the ergonomics aspect which in turn justifies the overall satisfaction for the end user. The initial 8 tests were carried out with a weight of less than 20 kg, at 20 kg and over 20 kg using jattene box. The distance covered using these loads determines the efficiency of the trolley. After analyzing the results, test 3 with a load of 5kg covered a distance of 3.5 km (refer table 27) whereas tests 10 and 15 with 20 and 22 kg were able to cover only a distance of 500m and 350 m (refer table 27) respectively. When performing the tests with weights 20kg and more, it was difficult to operate after reaching a distance of 1 km. It should be noted that all these tests were performed based on their requirements as mentioned in chapter 4.

After a data feedback session with the members of the organization, the weight limit was set to 15kg, less than 15 kg and performed the tests. The jattene box was used for 4 tests using loads 10 and 15 kg, with test 7 failing at 50 m using a weight of 15 kg (refer table 27). The QB1 was tested with 15 kg; test 16 reached a maximum distance of 2.2 km (refer table 27). The

QB2 was tested with 15kg; test 18 reached a maximum distance of 1.5 km (refer table 27).

4.6 RQ4) What are the functionality and durability impressions while using the trolley?

The functionality and durability impressions of the trolley contribute to the quality aspect which in turn justifies the overall satisfaction for the end user. The results would be analyzed on an individual item basis and then summed together as follows:

Box:

The IKEA jattene box was spacious and its stability was good while operating it throughout the tests. The only issue with the box was that the openings were at the sides and excessive taping was required to hold the things inside (see figure 32). Considering the box alone with respect to functionality and durability, the basic functions such as containment, protection, apportionment as mentioned in section 3.4.2 were satisfactory. Also, when performing the public and multiple transportation tests, it was not convenient to use and place the box inside bus and train due to their sizes.

The QB1 was similar in size to the IKEA jattene box with difference in the quality of the material. The box was spacious and the items could be loaded from the top positions. It required some amount of taping at the top and bottom sides. The difficulty was experienced in unloading the items from the box due to the placing of handle (see fig 32). Also, it was not convenient to place it near the seat inside the bus while performing the public transportation tests.

The QB2 depth was less when compared to the previous boxes and it was not so spacious. Also adding to this, the stability was not satisfactory since it tends to slide when loaded. The items were loaded from the top position and also required taping at the top and bottom positions. The difficulty was

experienced in unloading the items from the box due to the placing of handle (see figure 32).

Handle:

The handle functionality was good when holding it at the dedicated slots for it. A total of 5 durability tests were carried out and there were two failures due to handle peeling off when conducting test 5 and test 15 (refer table 27).

Wheels:

The wheels were the critical part of the trolley and contributed significantly toward the failure of the tests. Among the 5 durability tests conducted, 4 of the tests (refer test 5, _10, _14, _7 in table 27) had the nature of failure with the wheels peeling off from the surface.

4.7 Chapter Summary

The chapter started by answering the research question regarding the possible solution and the motivation behind choosing the cardboard trolley solution. After, a section describing extensively about the 20 tests conducted with the summary of results and pictures were explained. Then, an overview of the results was presented in table 27 following the answering of research question 2, 3 and 4. The following chapter analyzes and discusses the overall results made throughout the thesis.

5. Analysis and discussion

This section discusses about the analysis and findings of the thesis done from the empirical and supporting the theoretical reference.

5.1 Analysis regarding the material aspects of cardboard trolley solution

Considering the entire trolley solution, it was operated and tested at different conditions covering a distance of 25km (approx.) including all the 20 tests - The material aspect to be considered from the results would be on the contact surface and quality of the glue where it is glued to the wheel and box. Since, in most of the cases the wheels are peeling from the box surfaces and the material properties of the box could affect the adhesive of the corrugated board wheels. Also, the handle glue surface area is contributing to the reasons of failure. The literature suggests that the boxes are subjected to different loads during various operations (Niskanen et al., 2012), and the trolley solution is a relatively new concept in order to compare with the existing literature. But, seeing the load developed on the boxes from photographs it could be visually related to compression loads at the point of contact with the wheels. The only possible way is to analyze the key parameters characterizing the mechanical performance using ECT and bending stiffness (Niskanen et al., 2012), which is beyond the scope of this master thesis.

Also the different boxes used in the tests are not intended for these purposes of handling them as a trolley. The boxes configurations are different and when the wheels peel off from the box surfaces, the wheels are treated as the reason for failure. The main reason could be due to the box dimensions and configurations (Niskanen et al., 2012). This information could be beneficial for the supplier of the wheels and handles as well as to the organization in order to proceed further into the next cycle of research. These aspects could be researched in the future in order to analyze the material properties of the box and also with the use of special coatings such as water proof on the box surfaces.

Areas of concern: material properties of the box such as buckling and compression, surface area of the glue applied and quality of the glue.

5.2 Analysis of the maximum load carrying capacity for the card board trolley

The maximum load that can be carried and transported using the trolley is uncertain, since the summarized results (see table 27) were varying and not conclusive. But, considering the ergonomics aspects, it could be safe to operate a load of 15kg and less than that. These are based on the operational evidence (see table 27) of the conducted tests from authors' perspective. When the trolley is operated with weights more than 20 kg, the stress on the wheels are more which makes the handling of the trolley difficult. The initial movement would be easier but after reaching a particular distance, the pulling becomes tougher which causes pain on shoulders while operating. This long time behavior of the load on the box and wheels are difficult to study since there is only a little published theories regarding it (Niskanen et al., 2012).

The natural tendency of the consumers is to fill the boxes, since the individual boxes has the specified load carrying capacity. The future research could be performed on different weights and then analyzing the box and wheels, would provide the information regarding the optimal weight usage for the consumers.

Areas of concern: Climate, distance, type of road surfaces, surface area of the glue applied and quality of the glue.

5.3 Analysis of the functionality and durability aspects of the cardboard trolley solution

When analyzing together as a solution, the test results were varying and not consistent enough to conclude as a proper solution. The test 3 had covered a distance of 3.5km whereas test 19 had covered only 10 m. Considering all

these aspects and the total distance covered, the functionality aspects was satisfactory with respect to functions such as convenience, information and communication (Hellström, Olsson and Nilsson, 2017) but the durability of the trolley was not satisfactory. The trolley was convenient to carry, open and use the contents considering a single flow i.e. without a need to use it again. The information on the handles, wheels and boxes helped to identify the items with proper instructions on how to use it. While performing the field tests, some individuals were eager to know about this solution which indicates the trolley solution as an effective communication tool to trigger a purchase. The dissatisfaction was mainly due to the durability aspects with major contribution of failures from the wheels (refer table 27). Due to this critical item, the quality of the trolley as a whole is affected and contributes significantly to the overall satisfaction of the solution.

The functionality and durability aspects have contributed as the elements of the customer experiences which are translated practically into the self-service components as the trolley solution. By performing this controlled pilot study, the organization understands the impact of each element such as quality aspects for the end customer (Taylor, 2008). This information is also useful for the supplier of cardboard wheels to get an initial understanding of the ease of use and quality level.

The packaging design is a complex process and there is no particular solution that fits to all users (Hellström, Olsson and Nilsson, 2017). In this regard, the cardboard wheels design could be redesigned by having two or more contact surfaces with the box. Also, another material type such as ocean plastics could be used in order to obtain a different perspective and to visualize the operational behaviors.

Areas of concern: Climate, distance, weight, type of road surfaces, quality must be good enough to limit the surface.

5.4 RQ5) What are the uncontrollable factors that needs to be considered?

The main reason to consider the uncontrollable factors is that, the packaging design decision is complex and involves the consideration of numerous needs, requirements and conditions (Hellström, Olsson and Nilsson, 2017). When considering the end consumers, their requirements and conditions differ, especially with this cardboard trolley solution.

The tests had separate requirements and categories of weight in order to evaluate its use under these circumstances (refer table 27). This is a way of controlled actions and analyzes of the results. When considering a customer's perspective, he can adopt all these controlled actions at the same time. All these actions might work for the end user or end up in failure, which contributes significantly to the overall satisfaction of the product.

The uncontrollable factors that contribute significantly are climate, distance travelled, maximum weight that could be handled and transported, type of road surfaces (asphalt, sand, concrete). If these aspects are considered beforehand there are possibilities to control the occurrence of failure. As mentioned in Chapter 4, the author had experienced a lot of difficulties when the test fails, in order to bring it back to the point of origin.

In order to avoid these complexities, if there is a consideration on these uncontrollable factors it could benefit the end user. Consumers come at the end of the chain, but focusing on their needs and requirements highlights the organization SCM strategies to be consumer focused and prioritize customer interests (Ketchen and Hult, 2007). The customers expect different options when using these solutions and could measure their performances too. These perceptions and attitudes could serve as a key input during the design and execution of the supply chain management processes (Esper and Peinkofer, 2017).

6. Conclusion

This chapter presents the conclusions of this thesis followed by a section with future research

6.1 Does the identified solution, a cardboard trolley, match the requirements from both a technical (material, etc) and consumer perspective (convenience, etc) as a suitable self-transportation option for the consumers when (self) transporting goods from retail store?

The overall purpose of this thesis was to gain an understanding, identify possible solutions and evaluate the feasibility on how consumers can self-transport goods from a retail store. An initial understanding through this pilot study has paved the way to the next phase of evaluation at IKEA warehouse in UK. This prior knowledge was vital before implementing this solution, since it endures the brand image and reputation of the organization.

The field tests and the analysis carried out in this thesis have made the author to discuss some critical aspects of the cardboard trolley solution. When providing a customer with a self-transportation solution, the ease of use and quality is important aspects to be taken into consideration. The field tests were performed to simulate the customer behavior and to voice out the opinion after using it. The material properties of the box, quality and surface area of the glue needs to be explored further. The ergonomics aspects such as the movements when loaded and unloading were satisfactory but with some weight restrictions as mentioned in the analysis section. The main issue was with the durability aspects which in turn affects the overall satisfaction of the cardboard trolley solution for the consumer. The critical part that contributes significantly to the durability aspects is the corrugated board wheels. The reason is that, as self-service option consumers prefer a last mile delivery solution that offers more convenience

and flexibility with different choices considering the uncontrollable factors such as climate, distance, weight and type of road surfaces.

To conclude, the cardboard trolley solution seems innovative as an idea that is relatively new considering previous researches in last mile delivery and self-service aspects. Understanding the end consumers and developing a holistic view of their shopping experience is the new challenge for the retailers, since they continue to discover new needs and better quality of services. In order to roll this solution out on to the market, there needs to be better considerations and research on the technical aspects such as material properties of the box, surface area of the glue on the wheels and the quality of the glue to make it into a feasible solution for the end consumers.

6.2 Future Research

The suggested conclusions are only based on the field tests conducted on the three different box materials. For future research, it is recommended to perform studies by increasing the contact area of the glue between the wheels and the box. It could also be studied with wheels having two points of contacts with the box. Also, the quality of the corrugated board material of the box could be studied and tested for better adhesiveness to the surface of wheels.

As mentioned in this report, regarding the next phase of action plan to test at IKEA warehouse in UK, the wheels should only be attached to the boxed items at IKEA which is not using a box to fill the items. Instead, attach the wheels to the already packaged goods given certain requirements considering the uncontrollable factors. These studies could be carried out from a packaging logistics perspective. It should include mapping of the current packaging system with their interactions along the logistics processes, evaluating and visualizing the packaging system performance in order to understand and manage the economic and environmental impacts of packaging in supply chains.

The future research could also consider ocean plastics as a substitute material for the wheels. The plastic material offers more strength and could be used on all different conditions that restrict the corrugated board wheels

usage. The plastic materials reduce the sustainability aspects, but considering the current environmental issues regarding the plastic pollution in the ocean, these materials could be used thereby reducing the marine pollution.

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