The Current State and Future Trends in The Use of Pallets in Distribution Systems

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This thesis comprises 30 ECTS credits and is a compulsory part in the Master of Science with a Major in Industrial Engineering – Logistics Management, 60/120 ECTS credits No. 19/2009
The Current State and Future Trends in The Use of Pallets in Distribution Systems

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Master thesis

Subject Category: Technology Management

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Date: October 2009

Keywords: Euro Pallets, Pallets Costs, Pallets Status, Pallets Trends, Third Party Logistics (3PL), Pallet Pools.
Acknowledgement

We would like to take this opportunity to dedicate our deepest unrestrained gratitude to all those who their generosities gave us the ability and possibility of taking this significant over.

It would be a pleasure for us to express our reverential appreciation to our parents who have the attitude and the substance of a genius: they continually and convincingly conveyed a spirit of adventure in regard to our research and studies, and an excitement in regard to our future. Without their guidance and persistent help, the creation of this dissertation would not have been possible.

We gratefully wish to convey our thanks to Department of Industrial Engineering and Logistics in School of Engineering at University of Borås simultaneously, Department of Design Sciences and Packaging Logistics in Faculty of Engineering at Lund University for giving us the permission to commence this thesis in the first instance.

We are genuinely indebted to our supervisors, Assistant prof. Daniel Hellström from Lund University and Agnes Andersson from University of Borås whose aids, stimulating suggestions, and encouragements guided us through research for and writing of this thesis. Especially we are obliged to Agnes Andersson for all her additional assistance.

Our interviewees efforts & corporation were really appreciated; Mr. Mikael Lindmark, Supply Chain and Packaging Development Manager, IKEA Sweden, Mr. Bo Filhage, Borås branch Operations Manager, COOP Forum Sweden and Mr. Per Dalheim, Global Logistics Manager, VOLVO Logistics Sweden, for all their applicative helps, benevolent supports, and interesting and valuable hints.

Furthermore, we would like to give our extraordinary recognition to our examiner, Prof. Goran Stjernman, whose patient help and kindness enabled us to complete this work.

Javad Mokhlesi
Saman Lohrasebi                                                                 October 2009
Abstract

Pallets play a very important role in whole distribution systems through the supply chain. Such a fact alone shows the importance of pallets in today’s fast growing global logistics. Due to the increasing number of regulations and policies regarding natural resource conservations and also sustainable development, the issue of pallet utilization, reuse and recycling matters became the core concern in most of the researches performed in this field.

As a consequence, the presented report discusses the current problems, requirements and debates around pallets utilization in distribution systems in depth along with the other affecting factors such as Cost, Environment, Materials, Sustainability, Information Technology and so forth. To achieve such goals, the first step is recognizing the mass Industrial production factors and global market requirements for the current and future of pallet utilization in order to achieve the desired efficiency and effectiveness in practice with focus on standardized pallets utilization in specific regions like European Union.

The second step is the considering of various pallet types compatibility in different environments with respect to unit load assignments both at present and future. The third step is to challenge the obtained data and observed results and also, to verify them according to the foreseen future requirements, tendencies and demands of pallets and unit loads assignments through the international logistics providers. The last step which is as well the most important part of this thesis report is, to put the information together in order to clarify and specify the encountered difficulties regarding usage of pallets with concentration on cost, environment and ergonomic issues.

Keywords: Euro Pallets, Pallets Costs, Pallets Status, Pallets Trends, Third Party Logistics (3PL), Pallet Pools.
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1. Introduction

This chapter is provided with a general overview of what are going to be done in this thesis report. It starts with a brief explanation regarding the purpose and objective of this report at first level and then followed by a thorough description of problems and likely issues of concerns in pallet and associated industries. At the second stage of this chapter the delimitations and scopes will be discussed. At the last section of this chapter a brief outline for the discussed chapters is presented.

1.1. Purpose

The main idea behind developing such a research is to demonstrate the situation of pallet utilization in industries and related affecting factors. Pallet plays a very important role in Logistics chains or Distribution systems. Regardless of the application purposes of pallets there are a lot of other factors in pallet usage that draw a great attention for the users and also producers of pallet. These factors can be considered from so many different aspects.

Pallet is a part of a cargo carrier concept. This concept is broadly taken into account since individual transportation and handling of materials is costly. It can also reduce the speed of handling process to a very low level. It also decreases the efficiency of the desired logistics chain (Stjernman & Torstensson, 2006).

To overcome the stated obstacles creating a desired large unit configuration is of interest. When it comes to larger scales then mechanical handling becomes vital (Stjernman & Torstensson, 2006).

One of the most important aspects that brought a lot of heat on pallet industries in the recent years is Environmental issues along with the strict associated policies and regulations. Due to the limited number of natural resources for instance Forrest and water there have been a lot of debate around roles and regulations regarding resource conservation and so forth.

These factors directly or indirectly affect the pallet utilization in any kinds of business sectors which leads this industry to a new futuristic trends and changes. These trends can be classified in many different ways and from several points of views. Many experts believe that, these likely changes and trends have been started quite a while ago and they are just in the process of evolving for the predicted needs of the future.

Some of the argued trends are about the recycling, repairing and also the re-using of pallets. As mentioned earlier these facts demonstrate the importance of the pallet in distribution systems and related industries. Such characteristics of this device talk for the other dimensions of importance. This attitude is widely discussed in this report and will be explained in details in the provided chapters.

The focus in this thesis report is mostly around the current situation of pallets and the used raw materials for producing them also create a guideline for possible future trends and changes both in structure, design and used materials.
1.2. Problem Description

As the final fallout of our thesis work both theoretically and practically, our main focus is to find some applicable answers to the following questions of our report which can play a very much so important role in our recommendations and latter conclusions. Basically in our work we try to get along with answers to the questions;

‘‘What are the current state and future trends in pallet utilization?’’

Such an objective will lead the problem to a broader point of view which embraces the following sub-questions in order to achieve the desired answer to the main question of concern;

1. What are the current trends in using pallets?

2. What will be the trends of pallets usage in the next ten years with respect to design issues, economical issues like direct and indirect costs as well as sustainability issues?

3. Will be any reasons for considering some substitutes for pallets in the future?

Finding the answer to the above questions is the substantial basis for further research and also recommendations. It contributes to the facts that most of the companies engaged with pallet utilization are dealing with.

1.3. Scope

In this thesis report the main idea is dealing with basics in terms of pallet utilization. Pallet issue or let’s say material handling is a very broad topic of science discussion and bringing all those aspects into such a summarized report is not of interest. The highlights in this thesis report are environment, risk issues, ergonomic issues, cost perspective and sustainability. As per the problem description section the aim is to achieve possible patterns in which the current state and likely trends and changes in raw materials, structure, handling methods and so forth can be justified. As a matter of fact what have been done in the field of pallets and materials handling recently haven’t added much values and views to the upcoming trends and associated problems in the use of pallets, therefore the best effort of this thesis will be mainly focusing on creation and demonstration of such patterns based upon which likely changes and problems can be described.

1.4. Outline of the Thesis

The outline if the thesis is presented in this chapter to provide the reviewer with a better picture of what have been done in writing this report.

Chapter 1 describes the aim of this thesis and defines the problem that this thesis has addressed along with the desired research questions.

Chapter 2 contains a brief background of pallet such as a general overview, the history of pallet, the development of pallet, pallets and transportation chains and some related issues.
Chapter 3 presents the recent literature and empirical studies in pallet and material handling industries done by the other researches. This chapter also includes the terms that are being widely used in packaging and material handling studies. In this chapter, lots of aspects have been brought into consideration. Aspects such as sustainable development issues and the influences on the use of pallet in logistics chains and also the possible substitutes and alternative materials for current raw materials used in pallet construction, the current treatments for pallets in order to be reused for further usage in distribution systems, the prevalent facts regarding ergonomic, safety issues and risks associated with pallet utilization, the related environmental issues regarding reusing and also recycling patterns and the recent development in computer-aided applications regarding pallet designs and laying out.

Chapter 4 explains some general terms adopted in this research along with the associated methods.

Chapter 5 demonstrates the current development and application in real-time practices are presented.

Chapter 6 describes the practical analysis and the discovered results from on-site observation (visits) in accordance with the research method adopted in the current thesis project based upon the literature studies along with the empirical observations. This chapter presents the main idea behind this research.

Chapter 7 embraces the final conclusion, results, futuristic horizon in the use of pallets. The likely patterns from which the trends will be derived and also the recommendations for further research based on the interests of the current thesis project are discussed in this chapter. It will come up with a general conclusion, the likely impacts of the researched areas and finally the answers to some of the most crucial research questions of this work.

1.5. Research Validity

Validity of any research work is totally dependent on the criteria which are defined to measure the authenticity of a research. In this research, apart from the latest literature review the basic practical observations have been brought into effect in order to achieve the desired quality and authenticity. The main idea was to establish possible criteria based on which theoretical concepts and studies along with practical measurements are evaluated.

In order to cover the research validity, we had tried to protect the external validity of our thesis by using numerous library and internet-based sources of evidence and different methods of data gathering through literature study and case studies by research questionnaire which being answered by different companies expert’s and academic literatures.

1.6. Research Reliability

Since most of the cited and stated expressions and information are based upon previous researches and findings then the reliability issue regarding this thesis is absolutely justifiable. The other fact that demonstrates the reliability of this thesis work is the methodology adopted which is based on ideas and alignments presented by related experts. In Delphi method the
reliability of information is correlated to the experts’ knowledge and information authenticity which in this case is a reliable source.

This research was performed in both theoretical and practical perspectives and we tried to use more scientific literatures also more case studies and Questionnaires, therefore an acceptable level of reliability could be verified.

The main focus of the third chapter is to cover the literature review and theoretical parts of our research to answer the validity requirements of our subject. In the sixth chapter, the implementation of reliable experiments through the practical parts of our research by finding the answers to different issues which are categorized into particular questionnaire panels in wide areas of usage have been verified.
2. Background and Overview

In this chapter some basic overview and definitions regarding pallet utilization and its influence on the transportation chains performance in different stages are discussed. A brief background and history of pallet from the development perspective are also taken into account. The last part of this chapter is mostly about the common pallet types and affiliated standards and regulations for pallet utilizations in Physical distribution systems worldwide.

2.1. Definitions

In this part some of the most related definitions to the interest of this report are given. The purpose of providing such definitions is to create clear view on what is going to be discussed here to give readers a better understanding of the scopes of this thesis. Since Logistics and related issues are very broad topics to be taken into account therefore the rest of the terms and techniques are disregarded.

There are a lot of concepts behind the meaning of the term Packaging. This term can be considered from so many different aspects. Packaging cab refer to the action of covering or wrapping up the cargo carrier in order to be protected and safely handled. The other way of looking at it may also be the process of covering up a container along with to be handled goods in order to be transported or better say carried (Stjernman & Torstensson, 2006).

To be able to understand the underlying meanings beneath the packaging logistics concept, there will be some definitions as below to make what have been stated earlier more transparent.

2.1.1. Packaging

There can be considered a considerable number of definitions for packaging. It is sometime defined as the organized processes of goods preparation for specific logistical purposes for instance distribution, storage, handling and so forth (Paine, 1981). On the other hand sometimes it is considered as all range of goods for any purpose and made from any materials in order to be utilized for the purpose of protecting, handling, delivering from the producers to the consumers (Johansson, 1997).

From a different point of view according to Stjernamn and Torstensson (2006) packaging or packing could be described in such a manner as below:

“The activities of supplying goods with covering, in order to fulfill the requirements of the material handling process in the logistics chain”.

2.1.2. Packing Up

As mentioned earlier in this chapter, there are several explanations and definitions regarding the packaging per se which may lead to a little bit of confusion due to the simple but broad nature of such a thing. One of the easiest ways to explain such a substantial activity is to consider it as an activity that provides goods or transported materials with an appropriate
covering in order to assure safety and security regardless of transport mode (Stjernman & Torstensson, 2006).

### 2.1.3. Cargo Unit

Cargo unit is a very general term when it comes to explanation. Depending on the type of the business and also the surrounding environment, cargo units can be defined in so many different but possible forms. But moreover as Stjernamn and Torstensson (2006) pointed out:

"Cover plus goods, however loose covers and empty containers are also defined as cargo unit for instance returned products”.

### 2.1.4. Covering

Covering can demonstrate a general functionality in logistics terms. It embraces most of the important fact and issues concerning the safety and reliability of the mode of transport. Understanding such an indispensable part of packaging would lead to a better functionality. For this purpose Stjernamn and Torstensson (2006) defined covering in a through way as:

"Covering holding goods together for a better and easier handling and protection, it sometimes also used for information about content, handling, manufacturer, sender and destination. It can also be used for exposure by retailers”.

### 2.1.5. Packaging in Logistics

As Hellstrom (2007) stated in his earlier research, there are many possibilities to consider the interactions between logistics and packaging. It can be demonstrated on a basis of some derived and detected aspects. Furthermore He describes the term in a more professional point of view as:

"From a packaging point of view, the physical interactions between packaging and logistics can be identified and described as packaging aspects related to logistics”.

At the other side, Twede and Parson (1997) identified another perspective on the substantiality of packaging in logistical activities in their earlier work. Substantiality as such has been explained as:

"Logistical packaging affects the cost of every logistical activity, and has a significant impact on the productivity of logistical systems. Transport and storage costs are directly related to the size and density of packages. Handling cost depends on unit loading techniques. Inventory control depends on the accuracy of manual or automatic identification systems. Customer service depends on the protection afforded to products as well as the cost to unpack and discard packaging materials. Furthermore, the characteristics of logistics system determine the requirements and costs for packaging”.

Packaging takes on several effects on the logistics performance point of view. It has been defined in so many different ways in order to picture the importance of such activity in
logistics chains. Sometimes, it is more beneficial to take the performance and functionality of packaging and related actions into account to be able to create such a picture. However depending on what is important, there will be different expectations on the fashion of the stated picture.

The obvious fact to deal with when it comes to packaging influence on logistics chain is that there should be some certain criteria to evaluate the effect of packaging activities on logistics chains. There are three aspects to consider while assessing the packaging activities functionality. The first one could be the aspect on the issue of security and reliability functionality. The second aspect is the correlating functionality. What meant by correlating functionality is that such a function provides possibilities to establish a linkage between different components of a logistics chain. The other aspect is mostly dealing with moving and handling concerns in the chain (Stjernman & Torstensson, 2006).

One of the best ways to understand to importance of packaging in any logistics chain is to consider the packaging systems in different levels. The level breakdown facilitates the roles of each component of any designated packaging systems in logistics chains. The following figure presents different levels of a packaging system in the logistics chains:

![Diagram of packaging system levels](image_url)

**The levels of the packaging system**

- **Primary Packaging**
- **Secondary Packaging**
- **Tertiary Packaging**

**Figure 1** Several components of a packaging system. (Saghir, 2004)
2.1.6. Modular Design

In this section of this report the focus will mostly be on the optimization of the capacity utilization while using cargo carrier in order to handle unit loads. The best way to put such a fact into practice is to optimally evaluate the maximum output of volume utilization in packaging terms. The story behind this matter is to create a frame for all kinds of packages and their cargo carrier to be able to fit into any related environments or systems. Example of such environments will be logistics chains, handling equipment, storage areas and so forth. (Stjernman & Torstensson, 2006)

As the matter of fact, the objective is to optimize the utilization of packages and turn the requirements into flexible capabilities of different sizing and capacities. They will all lead to soar up the efficiency and to facilitate the process steps in the logistics chains. Without considering all the dimensions and possibilities of such a design, it will be so hard to create balance among the playing components in the transportation chains. The above explanation was a brief description about the importance of layout optimization and related issues. A desired design outcome should meet all the matching and fitting requirements due to the diversity of the available sizes and also materials. It should cover all the likely dimensions and maybe weights to some extent. That was just a recap of a very substantial concern in packaging and cargo carrier fields. A Through explanation will be discussed in Chapter 3 of this report. (Lumsden, 2006)

2.1.7. Unit Load

When it comes to material handling and transportation, the concern will be the best unitized load that flows at the least cost. This perspective is important since in such manner increasing the efficiency and more importantly the uncalled-for costs. The term Unit load, is normally referred to as an optimized, wrapped article that carries the package along with the content in the biggest scale possible. This is, as mentioned earlier, because of the aiming on the efficiency improvement. However, such an achievement is totally dependent on the type of packaging, the mode of transportation and also the environment in which the unit load flows along. (McVenes & McReynolds, n.d.)

2.2. Pallet at a Glance

A pallet or so called skid can be considered as flat transport structure which handles product batches so that they can be lifted by a forklift, pallet jack, or other jacking devices. A pallet is the basic requirement of a unit load aimed at being loaded, unloaded or even transported from the point of origin to the others. The basic materials used in a pallet construction can be of wood, plastics, composite and other carbon based materials.

From the industrial perspective pallets can be described as a Piece of equipment that facilitates mechanical handling of palletized goods which made usually of undressed wood and commonly 4 x 4 feet (1.2 x 1 meter in Europe) in dimensions. it can carry a typical load of one metric ton (1,000 kilograms or about 2,200 pounds), and serves as a base for assembling, handling, sorting, storing, and transporting goods as a unit load. Pallets come in
different designs, dimensions, and materials; such as a two-way entry pallet, four-way entry pallet, box pallet, post pallet, steel pallet, etc. (Stjernman & Torstensson, 2006)

In the United States, the most common pallet size is 48 inches by 40 inches. In giving the dimensions of a pallet, the first number is the length of the stringer or stringer board, which is perpendicular to the duckboards, whose length is the second number given. Pallets may be either 4-way, meaning a forklift can lift them from any side, or 2-way, in which case two sides of the pallet are solid and the tines can only be inserted from two sides. The world is moving toward adoption of the Euro pallet system. The standard Euro pallet (ISO 1) is 800 millimeters by 1200 millimeters. (National Wood Pallet and Container Association (NWPCA), Pallet Market Assessment (1998))

In Europe the Euro Pallet is sometimes also called a CEN pallet. To manufacture Euro Pallets you have to be sanctioned by EPAL. The pallet is easily recognized by the marking of EUR somewhere on it. The most common size is the “Pallet EUR” its 800 x 1200mm. It’s sometimes called a “whole pallet”. (European Pallet Association (EPAL), Pallet pools, The European market place, Euro Pallets: Good or Bad for Business (2002))

2.3. History of Pallet

Pallets had an enormous impact on logistics packaging and also on the transportation systems. Pallets have been the basic substantial component of the new streak material handling system since 1940s. However the new palletization system has been evolved in the recent decades but the palletization has quite an old background. Somewhere about over 100 years. That’s what it makes it such a vital part of a transportation chain particularly from a material handling perspective. (LeBlanc, 2002)

The use of modern pallets in industries returns to the World War II. Pallet was use before that time but back in 1940s the presence of pallets in practice was totally tangible. It was making the supply of military equipments and related goods much easier. Even before that time, there were some forms of unitization in order to carry a huge amount of load for a certain purpose but the emergence of pallet had a tremendous impact on the style of material handling. Pallets were introduced in Europe after the WWII. The dimensions of those pallets back then were 813 x 1219 mm (32 x 48 inches). (LeBlanc, 2002)

The evolution of pallet was in conjunction with the introduction of lift trucks back in late 1900s. The sparkling of the industrial revolution was an important landmark in transportation packaging forms and also standards. Before palletization there were several kinds of cargo carriers used for handling and also protection of goods. Such packaging was developed in order to obviate the needs of the transportation chains back then (Stjernman & Torstensson, 2006).

As mentioned earlier, pallets or palletization have been developed in various stages. It just didn’t occur all at once. The reason for such a claim is that crude pallets were emerging in conjunction with the primary material handling equipments. The best example for such equipments is the primary lift trucks that used to be utilized in the U.S. manufacturing firms at
that time. Some experts believe that pallets have been evolved based on the crude skids that used be the main cargo carrier for moving heavy unit loads. Skids were generally built with a basic deck and stringers in order to strap the cargo down on the deck (Stjernman & Torstensson, 2006).

Another considerable milestone in the history of pallet was the involvement of the newly developed lifting machine like Fork lift truck. After introducing a more modified handler in 1915, the pallet utilization in material handling environment was scuffling with different challenges. Challenges such as the required standards and compatibility to the equipments used and so forth. These factors played a very vital role in forming the today’s pallet along with the related regulations and standards. There were a lot improvement both in machineries and also the mechanism of handling. The improvement era was coursing a very quick emergence so that the pallet became one of the indispensible components of the modern material handling. The improvements both in lifting equipments and the cargo carriers place pallets among the factors that increase the logistics chain efficiency, effectiveness and also reliability. (LeBlanc 2002, A HISTORY OF EUROPEAN PALLET REUSE REPAIR & RECYCLING-National Association of Pallet Distributors (2003))

2.4. Pallet Development

As mentioned earlier, pallet was emerged in diverse phases. The phases that have been established due to the growing needs of the material handling in logistics chains. At first the spacers for an easier loading by lift trucks and then placement of a board at the bottom of the skid to create pallet. It was developed to be adapted to the requirements of better stacking while loading by lift truck specially fork lift trucks and also because of the necessity of an efficient lay outing while storing. The development was mostly concentrated on facilitating the handling by the equipments. (Anderson, 2002)

2.5. Common Pallet Classes and Materials

There are various types of pallets with different structures and materials depending on where they are about to be used. It is very substantial to understand the current pallet types that are being used in the distribution systems in order to have a broad picture of the state of such cargo carriers. In this part of this report the most prevalent pallet kinds are being presented. Material handling experts divide pallets into 2 main categories of structures:

Stringer Pallet: Stinger pallet is constructed from three parallel parts and a duckboard that is attached to these stringers. They are mostly from timber and they most often referred to as stringers. These types of pallet are also considered as two-way pallet since it can only be handled from two directions. (Clark, 2004)

Block Pallet: Block pallet structure consists of the two parallel timbers that are also called stringers along with perpendicular stringers. Such a structure makes Block pallet easier to handle and more stable and stronger in terms of structure resistance. These types of pallets are also referred to as four-way pallets due to capability of being handled from any of four sides. (Clark, 2004)
In some cases of pallet structures the orientation of the lower board turns out to be an important issue. The playing factor in such a fact is the ability of being handled easily from any directions of sides. Being unidirectional can save lots of effort while being stored or transported from one point to the other. It can also influence system efficiency considerably. In material handling, most of the concerns regarding pallets are derived from the safety and easiness in handling perspective, meaning that if it is safe to rack them up or easy to be moved. Therefore, these factors determined the needs of the efficient pallet structures.

The following figures demonstrate a clear picture of what have been discussed here:

Figure 2 Different components of a Block pallet. (Clark, 2004)

Figure 3 Different components of a Stringer pallet. (Clark, 2004)

Depending on the intended use of a pallet, there are different materials used. Materials such as softwood, hardwood, plastic, paper based materials and also steel. The type of the wood being sued in the construction also plays a determinative role is this case. Pallets can be used in storage, export, FDA, handling of chemical products and so forth. As mentioned earlier one the substantial issues in pallet utilization is the cost involved. It is so important to designate a
right pallet type with certain materials used to a proper application. For instance pallets with less durable materials are no use for applications that require the maximum durability of cargo carriers that are being used.

Solid wood is the widely used material for pallet construction for more than over 60 years. Since these types of pallets are the prevalent ones in the market. It is notable that pallet consumers or let’s say pallet users are facing a diverse materials and designs selections. These factors along with upcoming trends specify the material usage in the pallet industries. Some of the affecting trends such as new standardization, sustainability, resource conservation, new technologies and so on not only challenge the pallet manufacturers but also the pallet users and related side industries. This section will be discussed entirely in chapter 3.

2.6. Standardization

There are various organizations active in setting up specific standards for pallets and the associated issues in terms of utilization and performance. Some of these organizations are entitled to establish rules and regulations regarding pallet standards such as globally recognized dimensions, types of materials used designs, performance and also testing methods;

**ISO Technical Committee 51:** ISO TC 51 declares the standardization of pallets in general use in the form of platforms or trays on which goods may be packed to form unit loads for handling by mechanical devices. TC 51 is responsible for developing the ISO 6780 which states the standards for flat pallets designated for intercontinental material handling purposes. There are several other technical committees along with the mentioned ones in collaboration in order to set the standards. (ISO Standard 6780: Flat pallets for intercontinental materials handling)

**National Wood Pallet and Container Association:** National Wood Pallet and Container Association (NWPCA) is mostly dealing with the commercial issues of pallets in favor of pallet and container manufacturers. NWPCA represents solutions with respect to cost, environment and customer cares. (National Wood Pallet and Container Association (NWPCA), Pallet Market Assessment (1998))

**European Committee for Standardization (Comité Européen de Normalisation):** The European Committee for Standardization also referred to as CEN declares standards for pallets. The ICS 55.180.20 General purpose pallets are one the mentioned standards set by CEN. (ICS: 55.180.20 General purpose pallets, European Committee for Standardization (CEN))

There are some others along with the ones mentioned above which have their own criteria. For instance MIL-STD-1660, the military standard for pallets set by US DOD (Department of Defense). (Design Criteria for Ammunition Unit Loads Department of Defense (DOD) (2008))
Regarding the environmental concerns, there are also some sanctioned regulations and criteria such as the Phytosanitary measures that set regulations around the pests and insects spread by wooden packaging including wooden pallets. It is in accordance with the ISMP 15 regulation imposed by the International Planet Protection Convention (IPPC) which is a subsidiary of the Food and agriculture Organization of the United Nation (FAO). There is a certain stamp set to approve the designated packaging as shown below. (International Planet Protection Convention (IPPC) (1997))

Figure 4 Stamp authorizations for wooden packaging to be used, [www.cmpallet.com/html_eng/about.htm](http://www.cmpallet.com/html_eng/about.htm), (Date accessed 2009.08.15, Copyright 2002).
3. Frame of Reference

In this section of this report, some of the most important literature studies and researches done in the fields of pallet utilization and related issues will be discussed. There are some business reports presenting the status and recent developments along with some academic based observations.

3.1. Definitions & Terminology

Since familiarity with common terms and definitions plays a vital role in recognizing the basic concepts of pallets and associated parts, therefore some of the mostly used expressions are described here based on NWPCA criteria.

As per Industry Standards & Specifications, Glossary of Terms, National Wooden Pallet & Container Association (NWPCA) following terms associated with pallets have been set:

**Block Pallet:** a type of pallet which is formed with a couple of blocks between the pallet decks or beneath the upper (top) deck.

**Double-Face Pallet:** is a kind of pallet that embraces upper and lower decks.

**Economic Life:** is a term used for demonstration of number of trips that the pallet is performing, repairing details and the economic benefits associated with that.

**Exchange Pallet:** is described as a pallet which is used among a certain number of users. In such a case, the possession of the pallet will move along to the next user with the handled product (Unit load).

**Expendable Pallet:** a pallet that is designated for a certain number of handlings. After the numbers are reached it can be disposed.

**Fork Entry:** is defined as an entrance in pallet structure in order to help fit the fork for an easier handling or placement.

**Four-Way Block Pallet:** is a pallet type with fork entries in both sides.

**Two-Way Entry Pallet:** is a pallet type with possibility of being handled just from the end entrances.

**Unit Load:** is the set of products placed on a pallet for the purpose of transportation, storage and so forth

3.2. The Impact of Pallet on Different Components of a Logistics Chain

As mentioned earlier, pallets are very vital components in material handling and its related issues. It turns into a more transparent deal when it comes to the distribution concepts. Pallets have a great impact on the performance measurements in any logistics Chains, particularly from Distribution perspectives. There are the pallets which move the products, keep them tied
together and protect them against the possible risks and incidents during handling or storage. As the result, getting familiar with the impacts of pallets on different components of Logistics Chains can be lead to a more efficient and effective process. What meant by the impact is the influence of pallet utilization on different parties in a designated Logistics chain such as Distribution Centers, Manufacturers, 3PLs and so forth. (Anderson, 1991, Pallet Trends (2009))

3.2.1. Pallet Utilization in Distribution Centers (DC)

In today’s logistics world, material handling has a substantial standing among all the other parts. It is important since most of the problems with products such as defectiveness and damage, safety and also the other concerns can be originated from the material handling stage. Such a viewpoint raised a lot of questions regarding the role of pallet utilizations in Distribution Centers (DC). The questions were basically asked upon the percentage of pallet utilization in the whole distribution chain. On other hand, how useful pallets are in easing and speeding up the distribution process. The answers to these questions can be understood by defining a procedure for pallet movements, the utilization circumstances and also the nature of the business. What is meant by the nature of business is if it is a manufacturing firm, a retailing form or a wholesaler. The other way of observing is to define the material flow outline for the designated Distribution Center and its different components and parts and then highlight the pallet utilization and associated circumstance in that confined map. (Sandoval, 2003, Tsujimoto, 2003, Recommendations on Grocery Industry Pallet Systems (1992), White & Hamner, 2005)

Following figures demonstrate precise examples of pallet utilization in a designated Distribution Center along with the utilization level (percentage) in different stages.

Figure 5 Method of Pallet utilization in a manufacturing environment. (Tsujimoto, 2003)
As seen in above figure, most of pallet usage load is on the way from factory to the Distribution Center and also from the Distribution Center to the Shipping destination. In the other figure, there is a little bit different scenario regarding pallet usage in inbound and outbound flows.

![Figure 6](image)

*Figure 6 Different configuration of pallet utilization in a retail environment. (Tsujimoto, 2003)*

There can be a lot of different configurations regarding pallet usage in any Distribution Centers but the clear thing about it is that the utilization level is totally dependent on the availability of some playing factors such as equipments, storage room and etc.

### 3.2.2. Problems with Using Pallets in DC

Despite the inevitable role of pallet utilization in an efficient logistics chain, using pallets can draw some troubles too. Most of these troubles have been detected in the DCs. To be able to create a more effective and efficient process, identifying these difficulties is the first priority. From DC perspectives, troubles with using pallets can be described as below (Tsujimoto, 2003):

1. Most of the received products are from different locations with different standards and sizing policies. It has been one of the major challenges ahead of distributors and pallet users.

2. The other problem is considered in receiving of pallets. It is quite a challenge to reuse pallets with different standards. In this case, unification of pallets is the main obstacle.
3. Loading pallets while shipping is another issue of concerns in pallets utilization. There are a lot of concerns raised from loading pallets into different containers and different vehicles.

4. Pallet standardization is required internationally since any company uses a pallet matching its requirements especially from pallets shipped from Asia.

5. Reusing a pallet is more efficient than the single-way ones from a sustainable point of view but from technical perspective it could cause some difficulties.

6. There could be a lot troubles detected while using pallets but they can be beneficial on the other hands.

3.2.3. Impact on Manufacturers

After lots of observations have been done regarding the different impact of pallets on the several components of a logistics chain, the impact of pallet utilization on manufacturers drew some results. These results help manufacturers to adapt their requirements to the existing pallet standardization system.

As the fallout, manufacturers of different products have to find the best options of pallets for their specific usage. Such an achievement will provide them with a more reliable and time efficient process. It can also pare a notable amount from the manufacturers’ operating costs. For some manufacturers with pallet-less system, new pallet technologies compatible with their requirements are the best way to reduce the total operating costs and system defectiveness. (Recommendations on Grocery Industry Pallet Systems (1992))

The other aspect of the pallet impact on manufacturers is to try to identify trends in the usage of pallets by manufacturers. Studies show that, apart from bulk handling of raw materials which are carried by other carriers than pallets, most of the finished products are carried on pallets. In fact, this matter itself can be speculated in using more pallets by manufacturers in the coming futures as the development of economy stimulates the establishment of new and more manufacturing firms.

The direct movement of palletized products from manufacturers to the distribution centers without even being unloaded is the other fact that complies with the increase in the use of palletized handling by manufacturers and their belonging distribution centers and warehouses. The reason for such a claim is that in general, the same number of pallets used to handle finished products from manufacturers is also used in distribution centers and warehouses. Since as mentioned earlier, they are not unloaded during the transfer. (Anderson, 1991)

The following figure helps to understand the movement pattern that supports the stated claim.
The above figure demonstrates a possible designated relationship between Pallet manufacturers (Suppliers) and the assigned distribution centers. The figure presents the pallet movement from two different perspectives and the associated impact or influence on the palletized chain. The first point of view is from a pallet supplier perspective and the other one is from a retailer’s point of view. In order to fulfill the pallet demands of a retailer or a manufacturer certain number of pallet manufacturers should be involved in order to keep the balance in the logistics chains. The retail manufacturer receives raw materials from a single manufacturer but the pallet supply and the product movement are from different suppliers to distributors. As a consequence, as it is obvious, the discussed chain (pattern) is quite simple in comparison with a pallet less manufacturing pattern. It means that without assigned pallet suppliers, the manufacturing process would be a way slower. (Anderson, 1991)

3.2.4. Impact on Distributors

As stated in the previous section, pallets have huge impact on the distribution part of a logistics chain. As a matter of fact, there is a great deal of pallet shipping, receiving and also storage in the designated Distribution Centers. A significant part the pallet cost is to create a possibility for an improved rack-ability in distribution warehouses. It means that warehouses
should be compatible with the new pallet designs and structures with respect to rack-ability and supporting features. (Recommendations on Grocery Industry Pallet Systems (1992), (White & Hamner, 2005))

3.2.5. Impact on Third Party Logistics Providers (3PL)

The impact of pallet utilization on 3PL firms can be taken into account from several aspects. The point that really matters here is that most of the 3PL companies spending a way too much of time on picking up, delivering and exchanging loaded and empty pallets. That itself could result in unproductive distance between the picking up and delivery points. It can also yield in causing unnecessary costs and effort. The other aspect is to consider it from the operator’s perspective who handles pallets manually. It is one the challenges that most of the 3PL service providers are scuffling with. Such challenges can be in the form of workers’ injuries or similar risk concerns. (Recommendations on Grocery Industry Pallet Systems (1992))

The other concern that 3PL service providers are dealing with is the pallet exchange. Pallet exchanging requires a great deal of effort including time and cost in order to be accomplished. Ehen considering the state of the existing pallet system in order to design an improved one, this fact should be prioritized since. The reason why that it has to be taken care of is the elimination of unproductive responsibilities and tasks. From a pallet design point of view it is considerably essential to design a pallet that fit into the most prevalent transportation and handling equipments. Such an approach can help all the parties involved in a specific logistics chain to save and improve with respect to time, cost and also sustainability. (White & Hamner, 2005)

3.2.6. Automation

Recent development in pallet production systems has created a great tendency toward the efficient use of resources, time saving approaches, and cost saving tasks along with sustainable developments and also low risk issues regarding manual handling. As a matter of fact, by emergence of automation and consecutively standardization, the pallet industry has entered a new era. This approach itself contributes to the cost cutting, time saving and also sustainable achievements. Now a day, depending on the location and purposes of utilization, there are some certain standardized pallets used in distribution channels or let’s say logistics chains. As (Pallets: Playing a vital role in PD systems (2007)) pointed out:

“Today it is reckoned that around 80% of pallets in use conform to the 1000 x 1200mm standard and that 80% of these are of four-way perimeter base, open-deck construction”.

3.2.7. The Pallet Dilemma

(Sandoval, 2003) describes The Pallet Dilemma in a perfect definition as following:

“The productivity value impact of pallets applies to two basic areas of operations: internal materials handling, and the movement of goods between trading partners. Standardization of pallet design contributes to effective materials handling between trading partners, as well as efficient application of automation throughout various supply chains. These dynamics have
led to the development and widespread use of standardized pallet designs. A pallet built according to these guidelines specifications has significant load-bearing capabilities, is rackable, reusable and repairable, resulting in a relatively long life cycle. It also comes with a substantial price tag, and as a result is a valuable asset requiring effective management and control processes. Unfortunately, trading partners in the grocery and other supply chains that have adopted these pallet standards have struggled mightily with the charge of managing this asset across company boundaries. This is the pallet dilemma.”

As perceived from the above statement, however pallets can provide so many positive impacts on the easiness and smoothness of materials handling and internal flow throughout Logistics Chains, it can also affect these processes in a negative fashion. Compatibility with several standardizations through Logistics Chains is the biggest challenge for the use of pallets. Early recognition of this dilemma can lead up to a considerable amount of saving both in costs and effort which sometimes referred to as time.

3.2.8. Pallet Asset Management

One of the most convenient methods adopted by many companies in managing pallet assets is the pallet exchange. As products are delivered, empty pallets are exchanged for the pallets carrying the products or let’s say loads. The drawback with the pallet exchange is that there is no certain administration supporting it among the trade partners and also carriers of pallets since they are all involved and subsequently get affected by each other’s operations. This policy turned into a cost-derived process for 3PL service providers. Some of the costs were because of charging a fee for pallet exchange and as the result the pallet quality suffered that caused several troubles in pallet pools. Troubles like product damage, system breakdowns and arising safety issues. There were some alternative models introduced to the market. Rental pallets model is one of them from which the pallet exchange is removed due to the problem making and costly roles. The advantage with the rental model is the quality improvement since the pallets in use are owned by 3PL providers. (Pallets: Playing a vital role in PD systems (2007))

3.2.9. Initiatives

Several studies and researches have been conducted in recent years regarding the appraisal of pallet status along with so many comments and recommendations for quality and performance improvements. What seem to be the initiatives in the pallet utilization can be described as concentration on some influencing factors and drivers. For instance, pallet design, specifications, requirements, performance characteristics as well as the adaptability with the existing and growing trends set by the 3PL service providers and the other users. (Sandoval, 2003, Martens, n.d, White & Hamner, 2005)
3.2.10. Impacts on Total Logistics Performance

The impact of pallets on the total logistics performance of any designated chains could be considered from several perspectives. The concentration here is paid to identifying the main drivers, their effects on the logistics components and the most influenced ones.

Lack of the efficient and effective management methods and also, production quality drawbacks in wooden pallet pools cause huge number of insufficient performance through the whole logistics chain. Productivity improvement in import and export docks and distribution channels, utilization and performance enhancement in production processes, material handling automation systems, safety and insurance are the key players of these areas.

Side effects of the poor quality in pallet production and other related issues are entirely apparent for management systems in whole supply chain from the suppliers and manufactures till 3PL’s (Third party Logistics Providers) or pallet pools and customers. Distribution channels and warehouses are the most defected components of this issue. (Sandoval, 2003)

3.2.11. The Impact of Pallet Design on Performance

So far there has not been a pallet design that can meet all the requirement characteristics in a satisfactory way and at a reasonable cost. However, there are prospects on developing a desired design at a logical cost. Based on recent surveys and researches it is very likely that in the coming future, wood will be the most desirable raw material for pallets.

There are some facts supporting this claim. First of all wood is a replaceable resource at some points. Secondly, it is easy to use in order to construct a pallet and finally is the cost issues which is relatively low. The other advantage of using wood as a predominant raw material for pallet is the strength and reasonable security for the loaded cargos. Some disadvantages have been considered in this matter. One the problem with using wood as a quality raw material is the weight issue. An appropriately constructed wooden pallet for a safer transport is weighing a lot more than expected. The other drawback is from the sustainable point of view which claims that use of wooden pallets can lead up to natural resource downstream due to the utilization of wood resources. On the other hand using plastic as the basic raw material for pallets can create other difficulties and concerns. Some of these problems have been identified as cost of recycling and also cost of construction that would far more expensive than the wooden based pallets.

However, the easiness with plastic usage with respect to sanitation and construction is considerable but some service providers that are mainly dealing with pallets wouldn’t take the risk of higher and more expensive prices and costs. One the possible trends is the combination of materials in order to meet certain design requirements and applications. (Recommendations on Grocery Industry Pallet Systems (1992), Pallets: Playing a vital role in PD systems (2007), White & Hamner, (2005))
3.3. Prevalent Pallet Sizes and Styles

In today’s pallet industries, anywhere in the world, classification and categorizing of different types and classes or sizes are the most essential task to take over. Getting familiar with the existing pallet pool classifications can help users to draw a better picture over pallets and associated material handling issues. (Pallet Trends (2009))

3.3.1. Pallet Characteristics

In Warehouses, Distribution Centers (DC) and Containers, storage of pallet racks needs an appropriate design, proper fundamentals, nice application and installation systems in combination with staff's skills and training in order to obtain improved processes.

This part of the research tries to provide a more applicable set of Standards, Characteristics, types and sizes for better usage, handling, warehousing and distributing of pallet through the logistics processes. (Pallets: Playing a vital role in PD systems (2007))

3.3.2. Dimension

In pallet sizing record the first digit(s) shows the stringer length and second one shows the deck board.

There are no global common standards for pallet dimensions. Firms and companies perform different types and sizes of the pallets around the world. In table below the most current pallets types and sizes is demonstrated. (Clark, 2004)

3.3.3. ISO Pallet

The following table shows the most common types of pallets recognized by International Standards Organization (ISO):

<table>
<thead>
<tr>
<th>Metric size (mm)</th>
<th>US size (inches)</th>
<th>Region</th>
</tr>
</thead>
<tbody>
<tr>
<td>1200 x 1000</td>
<td>47.24 x 39.37</td>
<td>Europe, Asia</td>
</tr>
<tr>
<td>1200 x 800</td>
<td>47.24 x 31.50</td>
<td>Europe</td>
</tr>
<tr>
<td>1219 x 1016</td>
<td>48.00 x 40.00</td>
<td>North America</td>
</tr>
<tr>
<td>1140 x 1140</td>
<td>44.88 x 44.88</td>
<td>Australia</td>
</tr>
<tr>
<td>1100 x 1100</td>
<td>43.30 x 43.30</td>
<td>Asia</td>
</tr>
<tr>
<td>1067 x 1067</td>
<td>42.00 x 42.00</td>
<td>North America, Europe, Asia</td>
</tr>
</tbody>
</table>

Table 1 Different pallet sizes (Clark, 2004)
3.3.4. Euro Pallet

The EURO pallet is one of the extremely used types of pallet in European industries. The sizes and shape of the EURO pallet and even the size and kind of accessories are recognized by European Pallet Association (EPAL) for Manufacturers. The EURO pallet does not fit efficiently within the ISO shipping container and slightly wider containers are often used for this reason. (Euro Pallets: Good or Bad for Business? (2002) Uniform Standard for Wood Pallet, NWPCA (2007))

3.3.5. North American Pallet

Some of the top used pallets in industries & logistics systems in North America regarding National Wooden Pallet & Container Association (NWPCA) are listed in the table below. The most prevalent one is the Grocery Manufacturers' Association (GMA) pallet, which accounts for 30% of all wooden pallets produced in the United States. (Pallet Market Assessment (1998), Clarke et al., 2005, Uniform Standard for Wood Pallet, NWPCA (2007))
Since the global trade between North America and Europe is relatively high in different sectors, therefore getting familiar with several pallet classes is a vital issue. In fact, according to Ray et al. (2006), most of the operational costs in logistics chains are considered to be from various standardizations specially in this case North American Pallet standardizations.

### 3.3.6. Australian Pallet

The Australian Standard Pallet is a hardwood pallet with an especial size (1165 mm by 1165 mm) and squared shape which use in Oceanic Countries but rarely found other parts of the world. This pallet size is completely suited for Australian containers and their rail way transportation system but it is a bit poor and weak to fit through the ISO or other global pallet standards around the world. (Review of domestic and international pallet standards and ongoing operational and cost Implications to Australian Domestic and International Logistics, Strategic Design + Development (2002))

![Australian Pallets](http://www.ferret.com.au/c/Pallet-Control-Australia/Pallet-Control-by-Pallet-Control-Australia-p13970)

### 3.4. Materials in Pallet

Over the years, solid wood was the main predominant raw material in pallet industries. It is interesting to mention that solid wood has been the basis for pallet construction for more than 70 years. Wooden pallets are still used widely in the world something about 90-95%. However, currently pallet consumers have a huge list of pallet choices and different materials. There can be different market shares depending on the locations and the natures of businesses. The possible choices that are common in the market are wood, composite wood, plastic, metal and corrugated papers. The following table demonstrates the market shares for different raw materials used in pallets. (Pallet Market Assessment (1998), Clarke et al., 2005, Uniform Standard for Wood Pallet, NWPCA (2007), Martens, n.d., Pallet Trends (2009))

### 3.4.1. Raw Materials

Raw materials usage in pallet construction is determined by some affecting factors such as availability of raw materials and their resources, transition of raw materials, forms of raw materials and finally the current trends and future tendency.

#### 3.4.1.1. Availability

Availability and immediate access to the basic raw materials used in pallet construction have been one of the growing challenges for the pallet industries. According to the studies
that have been conducted prior to this report stated in Martens (n.d.), Pallet Trends (2009) & Pallet Market Assessment (1998), there is a high chance that wood (Hard wood timber and other species) will be the first available resource for pallet industries in the near futures. However, in consideration of the trends and new technology that are developing so fast, any possible changes to the resource availability of pallets would not be unexpected. (Martens, n.d.)

3.4.1.2. Future Trends

It has been quite a time spent on finding appropriate answers to the questions regarding future trends and tendencies in raw materials used in pallets. Identifying a trend which is likely to occur in the future obeys specific facts and rules. It appears to be more of a forecast based on some actual data with respect to sustainable trends in different industries, resource availability, economy situations, technological developments and so forth. (White Packaging solutions, New Unit Load Design Trends (2009), Pallet Trends (2009))

3.4.2. Wood in Pallets

About 95% of pallets constructed are made of wood. Most of the wood types used in pallet manufacturing are either from hard wood or softwood. The advantages of using wood in pallet manufacturing are the stiffness, durability and endurance, immediate availability and reasonable low costs. However, there are some remarkable disadvantages with using wood in the pallet manufacturing some of which are the susceptibility of soaking up (moist) and bugs (insects). (Ray & Deomano, 2007)

3.4.3. Plastics in Pallets

Plastic pallets have been first introduced to the market about 40 years ago. Plastic pallets are mainly made of High Density Poly Ethylene (HDPE), Polypropylene (PP) and Polyvinyl Chloride (PVC). Plastic pallets costs are roughly around 3-6% more than similar wooden types. However, there are some certain benefits that are gained by using plastic pallets instead. Some of these advantages have been expressed as better durability, resistance against moist and bugs (insects) and also the matter of hygiene or let’s say cleanliness. Since there are always some disadvantages next to advantages thus, some particular problems regarding plastic pallets have been identified. Relevant higher costs, difficulties with repairing which is sometime impossible, issues regarding safety and fire concerns and also tendency to easy damaging are such disadvantages.

3.4.4. Metals in Pallets

Metal pallets are mixture of Carbon Steel, Stainless Steel and Aluminum which have just less than 1% of market share but have nice endurance through distribution systems. (Pallet Trends (2009))

Although the Carbon Steel in more expensive compared to wood and Stainless Steel and also Aluminum it still costs 3 times more than wood but however, the long term cost will be
lower than wooden pallets with respect to the negligible maintenance and service costs. (Brindly, 2002)

Benefits are mentioned as strength, endurance, bugs free and recyclability. Metal pallets could carry severely heavy products and support long and wide loads and reloads without too much mass. Metal pallets satisfy usual interstate, intrastate and also global export/ import requirements which wooden or plastic pallets could not accomplish. Metal pallets have higher resell value and are completely recyclable.

Drawbacks are considered as high production cost, weight problem through the impact on human handling and rusting occurrence. (Brindly, 2002)

Metal pallet usually used in closed loop environments where the product &cargo security have priority and also durability of the pallets is the key point. The most common use of them is in Primary industries include automotive, heavy industrial and military, pharmaceutical, lawn tractors, motorcycles, government applications and tires. (Clark, 2004)

3.4.5. Paper in Pallets

One of the other materials used in pallet manufacturing is paper. There are some different pallets types made of paper, for instance, corrugated, honeycomb and solid fiberboard pallets are the varieties of paper pallets. Paper pallets have been in used for about ten years. Due to the application constraints, paper pallets holding a market share of lower than 1% in pallet market. But recently, there has been an identified trend towards the use of some certain paper pallet type like corrugate pallets. Some of the researches reveal that such a trend is because of the weight issues, recycling matter and low pests rate. From sustainable perspectives paper pallets hold a great standing due to the energy saving, resource recovery by using the recycled-wastes in manufacturing of paper pallets. (Pallet Trends (2009))
3.4.6. Composite Wood

The other alternative that has drawn most of the pallet manufacturers’ attentions is the Composite wood. Wood composites have various types such as Plywood, OSB, LVL and some others. According to the recent surveys, Composite wood pallets have roughly 2-4% of the pallets market share. Some of the regulations regarding country to country or continental export and import handlings create some kind of trend towards using these types of materials in pallets manufacturing. The positive things about composite wood in comparison with similar metal and plastics ones are the cost and maintenance issues. They are cheaper to manufacture and easier to repair compared to the metal and plastic pallets. The most apparent disadvantage of composite pallets compared to the similar metal and plastic ones is the weather resistance issue which is far less than plastic and metal pallets. (Martens, n.d.)

3.4.7. Wood or Plastics

Due to the recent developments in Technology and material science, the issue of better raw materials for pallet industries became interesting. Based upon the conducted market researches, plastic is a more possible substitute for wood. As mentioned in previous sections, both plastic and wood have their own advantages and the disadvantages. Wood is a positive choice form cost and repairing perspectives. On the other hands, plastic is a better choice when it comes to cleanness and some certain regulations. Since there is not an authentic source regarding the environmental impact of plastic pallets in a longer period of time, therefore it is kind of tough to make a proper selection. However based on previous studies and experiments, wooden pallets are manufactured at lower costs and a far less energy level is used to manufacture them. It is interesting to note that less energy consumption can be a positive aspect regarding sustainable development and the related achievements. The other fact is the recycling issue which is quite easier for wooden pallets to be reused and recycled compared to the plastic ones. (Pallet Trends (2009))

3.5. Loading & Standardization

The positive impact of a properly loaded pallet on the economy of transport is a very much so essential that should certainly be taken into account. Because of variety in pallet types and classifications, loading pallets becomes more important than ever. In consideration of this matter, couple of factors should be taken into account in order to develop more efficient pattern or in this case module. In this report, these factors have been identified as
standardization, the module and container loading. (Uniform Standard for Containers, NWPCA (2009))

Space utilization in the use of pallets is one of the essential configuration regarding efficient spacing and also effective transportation. A pallet is designed to place one or more packages. The most efficient and the best configuration are to fully utilize the space available on a pallet. Accordingly, the sizing of the packages loaded on pallets must be compatible. Such an approach is considerable form two different aspects. One aspect is that the transported load on pallets will fit in better and the other aspect is the handling security and safety. It means that more fasteners or lockers won’t be needed in order to tighten the loads up together. (Uniform Standard for Containers, NWPCA (2009))

After pallet and packages loading is time to consider the pallet dimensions and the adaptability in a larger scale. What is meant by a larger scale is loading pallets on vehicles, containers and so forth. After this stage different pallet types and their dimensions have to fit efficiently into containers or any other carriers for optimal transportation and the available space utilization.

There are some troubles detected in practice regarding the adaptability of pallet dimensions into variable container or wagon types. As a result, these troubles can lead up to huge costs and expenditures over long periods. There are some pallet sizes that are sanctioned by ISO. (Lumsden, 2006) The following sizes are the most applicable pallets in the market (Units are mentioned in mm):

- 800 x 1200
- 1200 x 1600
- 800 x 1000
- 1000 x 1200
- 1200 x 1800
- 850 x 1100

Among which, 800 x 1200, 1200 x 1600 and 850 x 1100 are known as Euro pallet, Ship pallet and container adapted pallet respectively. There are also some pallet types which are standardized with different organizations and for different applications. Some of them are semi (600 x 800) and construction pallets (370 x 500) which are rarely used compared to the most prevalent ones mentioned above. However in some countries like the US some of the standards are not recognized for some pallet sizes and some other standardized sizes are provided instead. (Lumsden, 2006) The offered sizes are as below:

- 825 x 1100
- 880 x 1100
- 1100 x 1100
- 1100 x 1320

The following figures demonstrate current patterns of pallet loading:

![Euro pallet](image)
![ISO pallet](image)
![Container adapted](image)

(1200 x 1600)  (1000 x 1200)  (850 x 1000)

**Figure 14** Loading pattern for several pallet sizes. (Lumsden, 2006)

Different pallet sizes comparison is presented in the figure below:

![Different pallet sizes comparison](image)

**Figure 15** Different pallet sizes comparison. (Lumsden, 2006)

As a matter of fact, Loading & Standardization issue happened to be the most important aspect when it comes to the economy of transport point of view in pallet usage. Warehouse productivity and handling efficiency are the two influencing factors in this fashion. Layout design and loading configuration of different pallet types and classes are one of the obstacles ahead of effective pallet utilization particularly in distribution centers. Empty containers, half loaded containers and the pallet warehousing push pallet pooling companies and pallet users towards a more vivid picture of proper lay outing and loading. (d’Hont, 1996, Wu, 2006, Raballand & Aldaz-Carroll, 2007)

Due to the growing importance of international trade, the use of different pallet types with different standards becomes inevitable. So many international companies deal with these problems especially in loading and warehousing of different pallet sizes and standards. The
cause has been identified as the lack of certain pallet-based loading and warehousing design policies or regulations. As a consequence, realizing such an important fact can improve the quality and also increase the efficiency inside the logistics chains which leads to a smoother material flow. (d’Hont, 1996, Tsujimoto, 2003, White Packaging solutions, New Unit Load Design Trends (2009))

3.6. Distribution Control Systems (DCS) & Pallet Control

Cost reduction and value adding activities are two main key words of today international markets. Strong supporting systems which not only drive forward established expertise in operational, transport and distribution management but also add value to the services provided to customers are the most important needs in Pallet Distribution systems.

As a matter of fact, advanced information technology (IT) systems have extremely great effects and benefits on what the pallet users and their customers exactly need, through a closed loop working with the customers and integration of the information which are available by the companies and customers. These information and data which directly affect the cost reduction of the value chain are as follow; customer demands delivery speed, accuracy and transparency of the information communication stream, exact delivery of invoices, continues improvement of cash-flow, sharp flow of delays reporting and non-conformances recording and pallet control systems. (Wilson, 1995)

3.7. Pallet Pooling Systems

The main issues of the pallet pooling companies are distributing the ready-for-use pallets and containers through the distribution Control Centers (DC) to satisfy the manufactures and customers product loading needs in whole supply chain, receiving or distributing the offloads pallets from retailer and customers, inspecting and repairing the damaged ones to make sure it reached the ad equated standards quality for the next utilization loop and re-injection of pallets into markets.

In fact, the main concepts of pallet pooling systems are adding value to the supply chain and providing desire environmental conditions by which companies can focus and concentrate on their core business issues not on producing, sourcing, maintaining and recovering the pallets. These are some of untouchable and unobvious benefits of pallet pooling which are not viewable interdepartmentally. The larger pallet pools are economically more useful than the small one to response the huge demands of global industrial markets (Smyth, 2007).

According to the latest researches conducted regarding Life Cycle Analysis (LCA), although the production of multiple-use pallets consume two times more wood resources than the single-use wooden pallets but the energy resource utilization and waste creation of multiple-use pallets are nearly as the half of the single-use wooden pallets and they are more environmental friendly.

Pallet pooling systems are very common in North America, European Union (EU) and European major industrial countries. Due to the high raw material prices, environmental
issues and money saving processes which comes through the cost of repair, improvement, maintenance and recovery of pallets after intercontinental product shipping’s, pallet pooling management and pallet rental systems commonly utilized universally. (Pallet Trends (2009), Smyth, 2007, Wu, 2006)

3.8. Pallet, Information Technology (IT) Systems & RFID

Based upon the latest published surveys and studies, the use of Information Technology tools in pallets and containers is a vital issue in current and future trends of distribution systems and worldwide logistics market.

Radio Frequency Identification (RFID) Technology and its potentials, known as one of the most convenient ones to reduce pallets, containers and distribution channels costs during long-term usage and adding the value of clearance and visibility to the transportation components.

In fact, with regard to supply chain visibility and all logistics players’ needs, it is transparent that pallets and containers will need to be tracked and traced and also, products and assets need to exact follow up of, where and why they are gone and being lost. Such kinds of Information Technology (IT) tools like Tags and RFIDs for better tracking and tracing of the products and assets are useful. The main key factors in field of compatibility of the distribution systems with such Information Technology (IT) tools are; chips, tags, readers, the distribution channels environment and enterprise (software) systems. (Brindley, 2004)

Based upon a long-term view on internal benefits of RFID, it will be so exciting about the potentials which it held for improving inventory visibility, transportation resiliency and reducing labor costs and so on. By this brief history and definition, plans to offer RFID-enabled pallets and containers as a premium service through the whole supply chain and distribution systems are urgent.

Although the use of RFID utilized pallets in distribution systems impose some extra and additional costs to the whole logistics chain but these costs will be pushed down through the supply chain.

These extra costs will be shared between supplier, manufacturer, third party logistics (3PL) provider and customers or consumers. They would not all be dumped on just one player in the logistics chain because everybody’s benefits. There will be benefits for the container and pallet producer companies and also for pallet pooling systems which rent or reuse the pallets and containers in wide or closed loops. (LeBlanc, 2006)
4. Methodologies

In order to answer the research questions and fulfill the objectives of the thesis, different methods and approaches for data collecting and information gathering are conducting in our research subject. As a starting point of study, in this chapter we try to describe the foundation and definition of research methodology to give the reader an overview of it in common. The purpose of this chapter is, to sharply clear the ways of data gathering for this thesis, the scientific approaches and methods of data gathering, and especially validity and reliability of the approaches and methods in our research subject. Finally, the generalization possibilities of thesis will be discussed in conclusion to summarize our research methodology.

4.1. Methods of Data Collecting

Research method or methodology refers overall approach to the research process, from the theoretical underpinning to the collection and analysis of data (Hussey et al., 1997). Therefore, it is essential to choose appropriate methodologies and data collection procedures when doing research to work out the answers from the formulated research questions.

<table>
<thead>
<tr>
<th>Type of research</th>
<th>Basic of classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploratory, descriptive, analytical or predictive</td>
<td>Purpose of the research</td>
</tr>
<tr>
<td>Quantitative or qualitative research</td>
<td>Process of the research</td>
</tr>
<tr>
<td>Deductive or inductive research</td>
<td>Logic of the research</td>
</tr>
<tr>
<td>Applied or basic research</td>
<td>Outcome of the research</td>
</tr>
</tbody>
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Figure 16 Classification of main types of research, Hussey et al., (1997)

There are different ways for collecting data and information. The most appropriate and common one’s for data gathering in research methods are: surveys and literature reviews, talking with people and personal interviews, surveys via mail and phone, E-mail and internet surveys.

Survey and literature research is involved, review of company’s information and documents, statistical and economical annual reports, market news, national and international trade publications and magazines, books and directories, online and internet based information. Although it is a bit hard to get update information by this way but, it is one of the cheapest ways for information gathering. Web search and internet based information are the fastest ways for collecting data.

During the first steps of research plan, talking with people and personal interview is a nice way for gathering unavailable and too new information which are not public. Examples of this way are included: meetings and negotiations with prospects, manufacturers, suppliers, distributors, retailers, 3PLs (third part logistics providers), customers, all types of business and trade conversations like national and international conferences and seminars, professional association meetings and interviews. Personal interviews are used generally when the subjects could not responded by other survey methods.
Surveys via mail and phone are the fastest and cost effective methods for data collecting and information gathering. These ways are usually appropriate for huge number of samples in long distance areas and specific prepared questions.

E-mail and internet surveys are obviously the most cost effective and also the newest ways for data collecting and information gathering. There is no timely, geographical and demographical limitation for this kind of survey and research. (Walonick, David S., 1997 – 2004)

4.2. Deductive and Inductive Research Approaches

There are two different main approaches to address a problem or response to a question to receive a certain conclusion, Deductive and inductive approaches which should be used based on the volume of theories available within our title or subject of the survey.

Assumptions will be made from available theories to create a deductive approach, on which hypothesis and statements are done. Hypothesis and statements will be examined through various observations and experiments to come to clear and exact conclusions.

The inductive approach works based on reality and will be shifted from particular observations to a vast broader generalizations and theories with an empiric survey and research. In inductive approach, we try to distinguish prototypes and priorities of specific observations and measures, formulate some experimental and trail version of hypotheses which could be investigated and examined, and finally finish by developing some general conclusions or theories. (http://www.socialresearchmethods.net/kb/dedind.php, (Date accessed 2009.07.12, Last Revised: 10/20/2006))

![Figure 17 Deductive and Inductive Thinking](M.K. 2006)
The kind of research methodology approach which is taken out in our thesis can be categorized as deductive one. Based on Hussey et al. (1997, pp 13-15) “deductive research is a study in which a conceptual and theoretical structure is developed and then tested by empirical observation; thus particular instances are deduced from general inferences. For this reason, the deductive method is referred to as moving from the general to the particular.”

Base upon the main concepts of deductive approach, we start an accurate investigation amount the existing literatures and articles, available production and market theories and accepted pallet industry facts to achieve the general rules, related laws, standards, specifications, types, shapes, materials, applications, markets, costs and the other related aspects of pallet status and trend.

The processes of finding the specific results about the importance of pallet current status and tangible prediction for its’ future trend come up through implementation of the designed questionnaire based on the obtained information from deductive approach in methodology and specific analyze of the results.

4.3. Strategies of Information Gathering

Primary or secondary information are two different types of data and information which can be gathered. Primary type of information is gathered by the researcher or investigator (him/herself), usually through face to face or personal interviews, library research and surveys, internet and web based surveys or questionnaires. The second one has already been collected, existed and documented by other Scientists and researchers and are available in different sources.

To be able to assemble a strong theory base for further experiments and applications, a collection of secondary information and data is made from literature review of internet and web based logistics and distribution books, journals, logistics magazines, national and international published articles and available literatures in Lund and Borås Universities libraries’.

The primary type of information is collected through interviews and questionnaires planning by use of Delphi study method. The rounds of interviews are to be performed with a semi structured interview base with prepared questionnaires. The interviews bases and questionnaires and also the results are presented in the other chapters. (Eriksson, Lars-Torsten & Wiedersheim-Paul, 1997)

4.4. Qualitative and Quantitative Research Methods

There is large number of differences between qualitative and quantitative research measurements and methods.

In general, qualitative research creates pure, exhaustive and applicable data and information that contribute to in-depth understanding of the context. Qualitative Research is based on gathering, analyzing, and understanding data and information through observing what others do and say.
Quantitative research creates reliable population based and generalisable data and information which are well suited to establishing cause-and-effect affairs. Quantitative research method is a kind of research involves the use of organized questions where the response options are predictable and a large number of respondents are involved.

The decision of whether to choose a qualitative method or a quantitative one is a philosophical question and will depend on the nature and characters of the project or subject, the type of data and information needed the context of the study and the availability of resources such as time, money, and human(Anderson, John D.,2006).

We should keep in mind that these are two different philosophies, not necessarily polar opposites. Actually, factors of both designs can be used together in mixed-methods studies (Anderson, 2006)

4.5. Validity

Regarding to (Yin, 1994), There are three different experiments to examine the validity of a subject or research which are named as construct validity, internal validity, and external validity.

Construct validity is about establishing exact practical measures and seeks harmony between a theoretical concept and a specific measuring mechanism or process. In fact, validity means an instrument’s ability to measure what is meant to be measured (Wiedersheim, Paul and Eriksson, 1991).

According to Yin (1994, p.35), “Internal validity is the extent to which we can establish a causal relationship; whereby certain conditions are shown to lead to other conditions, as distinguished from spurious relationships”.

To understand whether a research’s finding or result can be generalized further than our subject or not, we can deal with external validity.

In order to cover the research validity, we had tried to protect the external validity of our thesis by using numerous library and internet based sources of evidence and different methods of data gathering through literature study and case studies by research questionnaire which being answered by different companies expert’s and academic literatures.

4.6. Reliability

Reliability is the extent to which a study’s operations can be repeated, with the same results (Yin 1994, p.36); also Reliability involves the accuracy of the chosen research According to Wiedersheim-Paul and Eriksson (1991). In fact, the reliability of a study is acceptable if another researcher can conduct the same research and carry out the same results. Researchers should provide the same result at different times if the conditions are identical.
This research was performed in both theoretical and practical perspectives and we tried to use more scientific literatures also more case studies and Questionnaires, therefore an acceptable level of reliability could be verified.

The main focus of the third chapter is to cover the literature review and theoretical parts of our research to answer the validity requirements of our subject. In the sixth chapter, the implementation of reliable experiments through the practical parts of our research by finding the answers to different issues which are categorized into particular questionnaire panels in wide areas of usage have been verified.

4.7. Questionnaire Design

Design phase of a thesis or research has the most consequence on Questionnaire design and analysis. Easier consideration of a well-designed questionnaire needs to have clear and well-defined goals which assist the questionnaire to better address the purpose of the research. Only the questions which directly address the thesis or research goals without any temptation or deviation should be asked. The questions have to be as short as possible to maximize the rate of effective response.

In compare with other ways of data collecting and information gathering like face to face interview or surveys via phone and e-mail, questionnaire method has more advantages. There is no timely, geographical, demographical and sample size limitation. Questionnaire analysis is easier and familiarity of people is higher than other ways.

The quality of the questionnaire will be evaluated by the quality of the questions, so good questions should have some specifications which are:

1. To receive the purpose of the survey and finding out the correct information, one dimension questions are better.

2. Questionnaire design is similar to other literature activities, thus consequence and transaction between questions should make a good level of comfortably for respondents.

3. Never make presuppose and unjustified assumption in the questionnaire. One of the most common unwarranted assumptions in the questionnaire is that, the respondent knows the correct answer.

4. Wording of a question is enormously important to reach the objectives of the survey or research, so using the questions which will be leaded to desired answers is not desired.

5. To prevent the usage of unfamiliar, uncommon and doubtable words and abbreviations in sentences.
Further information regarding what kind of Questionnaire design and interviewing techniques have been adapted in this research with a thorough explanation is provided in part 4.8.9 of this chapter under category of Interview & Implementation Phase.

4.8. Delphi Study

This more or less new method of information gathering and data analyzing is based upon collaborative estimating or forecasting technique that combines independent analysis with maximum use of feedback to achieve the reliable and creative exploration of ideas or the production of suitable information for decision making and building consensus among experts who interact anonymously.

Delphi method is structured and circulated series of processes among participating experts who comment on it and modify the opinion by means of a series of questionnaires interspersed with controlled opinion feedback. (Adler and Ziglio, 1996)

4.8.1. Delphi Method Background

Delphi method is used in Futurology. Applying the Delphi method is mainly with innovative and reliable discovery of ideas and information appropriate to the preparation of decisions. Delphi method structures process for collecting and classification in knowledge with a group of experts by the means of distributed questionnaire among these people. Based upon such principle, this path has been adopted in order to fulfill the aims which are taken along this project. As most of the literature based contexts demonstrated, the ideas and conclusions derived from this method is practically dependant on the authenticities of the experts’ knowledge involved. A Delphi-based research can be categorized into eight different steps: Design, Techniques, and Preparation, organizing the procedures, Use of Delphi, Topic formulation, Analysis of results and finally implementation. The methods adopted in this report in order to fulfill the criteria are following the same patterns.

4.8.2. Designing Step

This phase happens to be a very important stage of the Delphi method. It is because of the fact that many different and unexpected results can be obtained from the Delphi method. It could be a huge digression for the main framework. In a sense, designing an appropriate and subject-oriented process is the most important task to do in order to achieve the desired results and fulfill the criteria. Many experts believe that if the design stage be framed properly then the rest of the process will smoothly go on.

4.8.3. Techniques

Right after the designing phase of the Delphi Method procedure, the importance of the proper techniques used in order to accomplish the desired tasks becomes transparent. There is a basis for most of the techniques adopted in the Delphi Method and that is the expert’s panel. What is meant by the experts’ panel is to create a tendency towards a certain point by
consulting the experts and professionals in those specific fields. Some of these techniques in this project work are used to solicit some the experts’ ideas and opinions regarding an area of interest. Such a process can be performed in different rounds depending on the importance of the scope of the research and the reliability of the information source or it’d be better r to say, the experts’ opinions. The other aspect of such an achievement is to create possibilities to conduct researches without in person visits. The other fact is to prevent the confrontation with opposing ideas. Experience demonstrates that sometime Delphi techniques can be worth trying and relying on since there is a huge possibility of forecasting an exact tendency towards the areas of interests.

4.8.4. Preparation

This phase of the Delphi Method keeps an important level among the other factors since an appropriate selection of participants or experts can make the final results more accurate and reliable. Constructing and preparing the questionnaire should occur with an obvious picture in mind with respect to the main point and criteria. It is so clear that the accuracy of the obtained information and results is absolutely dependent on the quality of the experts’ panel. It means the more proficient the experts, the more reliable the results are. As mentioned earlier, there are the participants who help the interested project gets shaped. For this reason, a sample size of experts’ panel should be defined. It could be from couple of participants to hundreds of them. As the matter of fact, this is totally dependent on the scope of the research. For instance, in this report a set of couple of experts has been selected since their opinions do not vary from each other.

4.8.5. Organizing the Procedures

What have been done here is to make a pattern for the required procedures during this project work. In fact, organizing a process is a lot like the designing phase with some specific differences. These differences can be easily detected when it comes to the preparation stage. The main philosophy behind organization is to follow a correct lead in order to have a precise accomplishment. What have been defined as procedures can refer to the steps that have been followed by the authors of this report (Cuhls, n.d. 2003). These steps can be summarized as following:

1. Identifying the objectives, resource constraints, evaluation of choices and formulation.

2. Creation of executive team to represent the interests of the research and monitor the results.

3. Defining the participants set. It means who to be interviewed and contacted. The participants will be the basis to perform the Delphi method. They are kept posted about the purpose of the Delphi. They are most often involved in most of the phases of the Delphi.

4. At this step, the first round interview questions are sent to the participants in the form of a questionnaire.
5. In this part the data are being collected and processed.

6. The next stage is to create a database for the first round feedback.

7. In this step, second round interviews are performed.

8. Collection of the second round questionnaire results.

9. Processing of the obtained data and information.

10. Analyzing the final phase.

11. Testing the primary implementation.

12. Preparation of the final report.

13. Sending the final feedback to the participants.

The following figure demonstrates the typical Delphi process adopted to fulfill the criteria of this research thesis:

![Figure 18 Typical Delphi Processes. (Modified from Hartman, et al., (2007))]

4.8.6. Use of Delphi

Since Delphi Method is based on foundational service to create a tendency towards the research field situation in foreseen future there for use of Delphi becomes so important to take care of.

The use of Delphi comes with the futuristic point of view to asses to present information with respect to available data information obtain from the expert panels. Such an implementation should be totally relevant to the fields under which expert panels are operating. This achievement is mainly utilized when long-term accomplishments are of interest. This is a very interesting way of fulfillment since it reduces the complexity which
most of the researchers are encountering while forecasting. It can start which a simple initialization based upon to be tasted panels.

These principles have been our guidelines in achieving our goals in this report. The following figure demonstrates the research process adopted in our thesis work.

![Research Process Diagram]

4.8.7. Topic Formulation

After organizing the process and initializing the first panel, it is time to categorize the problems into different topic fields. It is really important to understand the organization of the fields that are going to be tested. In most of the cases, one or two thematic fields are enough; it totally depends on the size of the sample set. What have been done here, were the classification and division of panels into the most relevant fields of this report's interest. It embraces the prevalent criteria such as service and consumption, management, materials, risk and safety assessment, environment, energy resources, construction and production.

4.8.8. Analysis of the Results

At this stage, all the gathered information and data are processed in order to be classified based on their rankings, qualitative clustering and experimental observation and findings. It could be hard to analyze those fields of interest as a whole picture. Thus, the best way is to concentrate on the data and statistics which are the most relevant to the interest of this research thesis. This achievement was taken while using the Delphi Method. Alternative feedbacks have been used in order to increase the accuracy of the questioned panels. It makes it a lot easier to analyze the obtained results with respect to the feedbacks.
4.8.9. Interview Design & Implementation

Since the desired data gathering in this report was based on interviewing therefore a precise description for the interviewing procedure and implementation process is presented here. What have been accomplished in this research for the interview and implementation phase can be detailed as following steps:

1. Defining different panels and their related boundaries in order to highlight the desired interests of the research. In this phase several panels have been presented to create a better picture of the discussed factors such as Cost, Types, Classification, Sustainability, Design & Structure, Materials, Trends and so forth. In fact, most of these panels were created in accordance with the today’s current studies and trends. The contents of panels were determined by means of the state of the art literatures review.

2. At the second stage of developing the empirical phase, targeted companies and their operating executives have been selected. The selection criteria were based on the size of their operations, relativity and their importance in the logistics markets in their designated areas of expertise.

3. At the third stage of practical phase, the modified and supervised questions and their related panels have been submitted to the assigned experts and companies in the form of a professional questionnaire prior to the interview dates so they can elaborate their knowledge according to the interests of this thesis. Most of the interviews have been performed by phone conference and one has been performed in person as a face to face interview.

4. The last step was to put the gathered information and data together along with the observations and studies in order to develop a pattern in which this research is intended to be. The analysis, final conclusion and recommendations have been done based upon the derived results and information. The substantiality of this stage was to expand the analyzed findings to the real time applications and to consider the useful results as the basis for the future forecasting.

As the final achievement, what have been done during this process was bringing most of the recent literature studies along with experimental observations together. Linking the users’ willingness and requirements to the state of the art researches was the key to making a tendency towards the future trends, introducing a mechanism, finalizing the accurate and useful results and finally extend it to a futuristic phase.
5. Empirical Phase

Main focuses in this part of our research work are laid on the practical stage in order to achieve the desired and expected results of interests. Based upon the methodology acquired in this research, the empirical phase consists of the participating companies’ backgrounds, associated experts and finally the adopted procedures and the obtained results.

5.1. Companies Backgrounds

Here, a brief overview on the participating companies is presented. These companies are the Logistics Division of Volvo cooperation, IKEA Sweden and Coop forum which is a part of Coop hypermarkets. Most of these companies and their subsidies have imposed a lot of influences on the current state of the packaging markets and industries. They also have their own packaging standards including pallets for instance, loading ledge and Volvo’s special pallets. For a better understanding of the areas of operations that these companies are involved in, a short introduction is provided for each of them.

5.1.1. VOLVO Logistics

VOLVO Logistics is a specialized subsidiary of VOLVO Group that takes care of the logistics applications in VOLVO and affiliated groups. VOLVO Logistics provides VOLVO with unique packaging systems in order to obviate the logistical requirements of VOLVO. Such requirements are quality, cargo protection, safety, sustainability and so forth. This attitude engaged VOLVO Logistics in creating new standards and specification with respect to VOLVO’s requests. As a result, different dimensions, materials and also structures are applied to these packaging systems in order to be in accordance with the pre-determined standards.

As mentioned in the official business directory of VOLVO Logistics, the packaging systems used in VOLVO Logistics are from returnable materials and equipments which include wooden containers, Pallets and plastics bins. VOLVO’s special packaging system provides a possibility to utilize the cargo volume as efficient as it could be. This is because of combining different standards for different products. The required industrial requirements are met because of this unique standardized packaging system.

VOLVO’s wooden containers are designed to cover most of global regulations particularly those ones which are set by Europe and the U.S. they also designed with foldable walls for convenient assembly and breakdown. VOLVO’s pallets are designed to obviate the various industrial needs with capability of extra endurance. As stated in the official statement of VOLVO’s, these types of pallets are able to handle over 2000lb for different purposes. This is because of using the extra strong plastic blocks adopted in VOLVO’s handling system. Plastic bins (small boxes) are designated to the dimensionally small parts.

As a summery, VOLVO Logistics Packaging system concentrations are the customized packaging including pallets, plastic bin and flexible containers, Renting and reusing packaging, rack and layout designing, procurement of related items and stock control. One of
the special characteristics of VOLVO logistics packaging system is the possibility of combining two or more packages for more convenient and also safer handling and transportation. This increases the reliability of the transportation mode and cargo safety. Regardless of size, weight and materials, VOLVO logistics packaging system offers a broad range of packaging and handling options for different applications and expectations.

5.1.2. COOP Forum

COOP is operated and owned by the cooperative Union, KF. Within the conglomerate, there are several retail chains such as COOP Forum, COOP Extra, COOP Konsum, COOP Bygg, Dagsliv, COOP Near and Matafären. This extension alone shows the impact of such a conglomerate on the use of packaging and packaging related issues in a designated market like Sweden. From pallet utilization point of view that is some valuable assessment which can lead to useful fallouts.

One of the essential facts regarding COOP Forum inclusion in this research is the policies they follow with respect to the waste and recycling of their used materials and packaging. The main idea is to reduce the packaging waste including pallets and increase the recycling and recyclability. According to the KF’s statements, the wastes are categorized into different classes for improved recycling purposes. Those classes are fuel wood, corrugated paper, plastic and paper. That has a huge influence on the pallet pool system. Return pallets are collected and wooden pallets are used as fuel for heating and other applications.

5.1.3. IKEA Sweden

IKEA was founded in 1943 by Ingvar Kamprad. IKEA developed its furniture business in 1948. IKEA opened its exhibition center in 1953. The business philosophy behind IKEA soon turned it into a very fast growing and huge logistics chain. The packaging has become the most inevitable strategy for this chain. Due to the increasing demand for the inbound packaging and the importance of the supplied products quality IKEA has developed its own packaging and handling solutions one of which is loading ledge. Loading ledge according to the IKEA distribution experts is plastic based carrier. IKEA’s loading ledge is capable of carrying loads up to 5000lbs. Aside from loading ledge, IKEA is using a combination of cargo carriers with different standards and materials for instance Euro pallet, ISO pallet, half pallet and other types of pallets and packaging systems. IKEA has a lot of strict policies and regulations regarding sustainability concerns for instance, recyclability, resource preservation, being environmental friendly and so forth. Loading ledge has a short background regarding utilization duration. It has been introduced into IKEA’s logistics chain quite recently.

5.2. Experts Panel

At this stage, the cooperating experts are presented. They have been the basic panel for this research work due to the nature of the methodology adopted in this report. Since, the importance of packaging specially pallets has grown in the recent years so selection of the participating companies and their associated experts was performed with respect to professionalism and the expertise. Each of these companies is among the best ones in their
fields of operation. IKEA, COOP and VOLVO Logistics are the main concentration in this work in order to identify the possible patterns in pallet utilization and future trends. The following experts described their points of views in the current state and trends in the use of pallets in distribution systems:

- **Mr. Bo Filhage**: COOP Forum, Borås branch Operations Manager.
- **Mr. Milkael Lindmark**: IKEA Sweden, Supply Chain and Packaging Development Manager.
- **Mr. Per Dalheim**: VOLVO Logistics, Sweden, Global Logistics Manager.

Their perspectives and opinions have been reflected in this project for the purpose of the analyzing the existing situation and the future outcomes. The next part describes the achievements that have been reached while interviewing the mentioned experts.
6. Analysis

This section of the report is the most important part of practical phase in our thesis research. The pallet utilization and its related issues will be accurately evaluated and analyzed. The analysis will be based upon the individual considerations, expert’s experiments and experiences along with the reviewing of latest literatures and researches. The first part of this chapter is the results and achievements from the interviews with participating experts and the second part is the main body analysis done with respects to the latest literatures, studies and observations taken during the practical phase.

6.1. Interview Results & the Achievements

For the designed questionnaire, there have been defined 7 different panels with respect to several pallet utilization aspects. These panels are Pallet Classification, Pallet Treatment, Pallet Impact, Sustainability, Risk & Safety, Trends, Loading and Cost. The participating experts have almost taken same side regarding most of these panels. They are described in details in this section.

**Pallet Classification:** most of the interviewed companies were dealing with Different Euro Pallet types. The assumption is the pallet type selection is region wise at least in the EU. Apart for Euro Pallet, some companies like IKEA and VOLVO have utilized some different types with different standards according to their detected needs and requirements. For instance IKEA uses a very specific type of pallet which is called IKEA size pallet. The size for this pallet is 200 X 800 and it is made of wood. The other type which typically utilized in such businesses as IKEA is the Loading Ledge which is a plastic based carrier designed to bear loads up to 5000lbs. the rest are corrugated paper pallets, Half Pallet sizing 600 X 800 and a special metal pallet with one layer of plastic sheet over it. In VOLVO’s case, there is a VOLVO pallet standard which is similar to the Euro Pallet sizing 1225 X 820. Wooden pallets were the most used ones during this study except for special purposes and applications. Factors that encourage the users to use pallets were the cost issues, easiness, standard procedure, handling capacity and the relative safety compared to the other types of carriers. Drivers and that lead the users towards wooden, plastic, metal, corrugated paper and the other types are described as below:

1. **Wooden pallets:** For wooden pallets the main drivers were described as Standard platform, Strength, standardized size, cost, weight and also availability. There have been some back draws mentioned regarding using wooden pallets in the pallet pools. The main troubles that were detected in wooden pallets were the increase in weight in case of moisture, dust problem, stacking and warehousing and the pests and hygiene issues.

2. **Plastic pallets:** the most important drivers in using plastic pallets in pallet pools have been identified as hygiene and safety. Plastic pallets do not face the problems regarding hygienic regulations so as a result they could be cost savers at some points. However, by considering the high purchasing prices they are mainly suitable for special orders and applications. The other problem with plastic pallets that all of the experts hold the common position regarding it, was the flammability of plastic or on the other hand fire safety. IKEA’s
loading ledge (760 X 45) is a wise choice for some particular purposes. Stacking and standardization are the two main points the encouraged IKEA to create such carriers.

3. **Corrugated paper pallets:** The main reason that pallet users using the corrugated pallet type is the environmental issues from a sustainable perspective. The durability, strength and moist absorption are the transparent back draws.

4. **Metal pallets:** As mentioned earlier, metal pallets are mostly utilized for special applications and customers. Weight and cost are the main problems in using metal pallets. The metal pallets are specialized for outbound transport.

Depending on the type of application there are several options. From a retailer’s perspective plastic pallets can be a trend regardless of cost factor. On the other hand wooden pallets cause a lot of side costs and effects such as transportation cost for returning them, fuel consumption, emission, illegal wood and pests’ issues. The other types of pallets like loading ledge in IKEA and the composite ones have several back draws and benefits but surely cannot contribute to the identification of the future trends. Composite pallets can be more hygiene, lighter, more durable, and stronger. These options can be available at reasonable prices. Composite can also provide a better protective functionality.

**Pallet Treatment:** According to the experts, cost is the essential factor regarding maintenance. If the utilized pallets are repairable or fixable at a reasonable cost then they are worth fixing in order to extend their operational life somewhat. Otherwise selling them out, donation or fuel production purposes are the prioritized options. For different pallet types there are several treatments. For wooden pallet, which are the leading type, heat treatment according to IPPC sanctions regarding hygiene and pests regulations is an available option for most pallet users and pallet pools. Reusing is the option in case of possibility.

**Pallet Impact:** Sustainability of the whole engaged Logistics chain is the main idea here. Being environmental friendly and cost saving are the two objectives in this part. It means pallet users prefer to stay as sustainable as possible and at reasonable expenditures. In general, pallet utilization has a huge impact on the operational cost and expenses of a company. Most of these costs are derived from the movements of pallets, treating them like repairing and reusing and also the overall business impact. On the other hand companies gain considerable amount efficiency in their systems by using pallets for material handling or sometimes storage.

**Sustainability:** Recycling and recycling options are the main concerns under this category. The pallet users must adopt their consumption patterns to the current policies regarding environment and so forth. Still, cost of being sustainable can be an obstacle in the future. Sending the discarded pallets to fuel generating station, landfills and also recycling ports is a part of a sustainable development.

**Risk Panel:** Risks can be categorized into different classes. In the case of pallets, following the standard safety regulations are the basic moves towards safety and less risk environment.
Plastic pallets can be the exposure of fire risk more than wooden and metal ones. Stack collapse and related injuries are reported to be the main risk and safety concerns.

**Trends Panel:** From different perspectives the trends can vary. The fact behind the trend is that pallet users try to pick those pallets that are more compatible with their requirements and needs. For some plastic can be wise choice, for some metal and corrugated paper and for some composite pallets. But what is interesting here is that all of the participating experts hold a common position regarding wooden pallets because of the availability and cost. The future trend will probably be more focused on the cost, weight and the dimensions. The types of materials as well as the sustainability concerns will be placed afterward.

The following figure is the visual presentation around the interests of this thesis. The achievement that has been reached during the empirical phase based on the results from the interviews correlates the theory and realities in practice. In fact this is one the most valid and reliable source of reference when it comes to determination of results and the future tendencies which in this case are the conclusion and the pallet likely trends in the future.

![Figure 20 Affecting Factors in Pallet usage. (Authors, 2009)](image-url)
In accordance with the building components of the above visual presentation, the pallet current state and possible trends are entirely constructed upon 3 different time frames as previous state, current state and the future tendency. What meant by time frame here is the pallet development from different perspectives and aspects in certain periods of time. The mentioned pallet development has been under influence with so many drivers during the defined periods.

Some of the most affecting factors and drivers, as demonstrated in the figure, are classified as Cost, Materials, Market Demand or Aptitude, Design & Structure, Treatment and also Sustainability. These drivers with the related interactions and relationships amongst them determine the likely trends, changes and transformation to the design, structure and also the raw materials used in pallets.

The stated interactions and relationships alone can lead to the identification of the main causes of trends development. For instance, realization of the main drivers in the previous states of pallet usage can be used in identifying the cost factors which is considered to be an input for the determination of current state. In the same fashion, Raw materials prices and government regulations balance the interaction between cost and materials used. What is meant by balance is which driver has more weight in terms of essentiality in order to lead the creation of future trends. As perceived from the figure, market demand, design & Structure, treatment, sustainability and the relationships and the interactions among them are the most significant role players in the evaluation of future state.

The pallet treatment is influenced by the maintenance issues observed in current state and it is correlated to the future state by the service improvement factor. It means that if the future of treatment is desired the estimation and evaluation of likely changes have to be based on the maintenance factor in the present state. For sustainability and design drivers; quality issues, durability & reusability and recycling happened to be the key touching factors. The meaning behind this expression is that recycling is the lead in future state recognition when it comes to sustainability and similarly, durability and reusability are the leads in future state approximation when the interested driver is the design and structure.

As the bottom line, previous state of pallet utilization helps pallet pool companies and the pallet manufacturers to determine the cost and material conditions in accordance with the present situation. Market demand and treatment are the drivers that are directly influenced by the present situation of the pallet usage. However these influenced drivers exert effect on the future status of pallets along with the other drivers which are design and structure and sustainability in this scenario.

The results show that sustainability, market demand and structure issues are the most substantial key factors or drivers in identification of the future state of pallets in logistics chains especially in distribution systems. To have a better understanding of what has been presented here as analytic results, the following categories are presented in this chapter to totalize the details in different parts of the analysis.
6.2. Main Body Analysis

In this section, a thorough analysis is described. The presented analysis is the integration of results gathered from interviews and the latest literature review and studies. This part of this chapter is considered to be the basis for the conclusion of this work.

6.2.1. Pallet Demand & Market Aspects

As mentioned in the previous sections, 6% of the whole pallet consumption rate is designated to wooden pallets. Wood is the major raw material for 95% of the pallets constructed in the market. There is a ballpark figure demonstrating a decrement in the use of pallets in the developed countries although, there is been an incremental tendency observed in some other countries such as China.

When it comes to market aspect of pallet consumption there is only and only one factor that determines the demand and consumption rate of pallets in designated markets and that is the factor of raw material used in construction of pallet. There have been a lot of studies and researches conducted over this factor in order to identify a tendency towards a specific raw material usage.

Many pallet users believe that the market share for different raw materials used in pallet construction is likely to tell the true figures behind various types of pallet market share. The following table demonstrates the fact regarding market share issue in the pallet industries:

<table>
<thead>
<tr>
<th>Raw Material</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood</td>
<td>95%</td>
</tr>
<tr>
<td>Composite Wood</td>
<td>2 to 4%</td>
</tr>
<tr>
<td>Paper</td>
<td>1%</td>
</tr>
<tr>
<td>Metal</td>
<td>1%</td>
</tr>
<tr>
<td>Plastic</td>
<td>1%</td>
</tr>
</tbody>
</table>

Table 21 Pallet market shared based on raw materials used. (Anon., 2009)

What has been revealed during this research work was that the demand for pallets will be so likely to increase in the coming future. The demand issue can be described from different aspects. One the factors that determines the pallet demand the most is the pallet management including treatment, direct use and repairing for more usage or more trips. The recycling and also after life factors can be determinative regarding the pallet demand.

According to market share data the demand for wooden pallets will definitely be increasing to the possibilities of using the pallet wooden parts in order to produce other products. This fact itself demonstrates the demand for different pallet types particularly for wooden ones. As mentioned in the University of North Carolina research paper (1998), the Third Party Pallet Management companies stimulate the tendency towards pallet trends in the coming future.
As observed in the experimental phase of this research which was laid on the experts’ comments and suggestions, the demand of pallet will have an incremental growth. In this growth, the third Party Pallet operators have the lead to identify the trends.

As a recap of what have been discovered, it can be concluded that the pallet futuristic trend is following the Pallet third party operators’ tendencies towards some specific trends that could end up in possible demand growth. This is because of the conditions of operations which as stated before are the direct reuse, repairing and turning into useful products after the effective life cycle is over.

6.2.2. Pallet Trends

Pallet future trends follow some essential factors like the design, materials, the possible substitutes for them and also loading capabilities. Loading issue is sometimes considered as a design concern. Most of the pallet operators put their priorities on the cost issue as the identical factor for trends recognition. Many of the interviewed experts have stand on their opinions regarding the fact that the trend issue is basically a subsequent of a historical chart of pallet utilization. It means that the trend will most likely be specified by the raw materials, the technological development in creating new composites, substitute sources, the involved cost and the design options for pallets and unitized loads configurations.

In the latter parts of this chapter the detailed explanations for the impact of materials, unit load design and pallet structure on the future trends of pallet. What is transparent in this path is that cost reduction will be the concentration of the future trends. Since, most of such factors as unit load design and pallet structure influence the cost and subsequently affect the possible trend. The following figure demonstrates the impact of these factors on the trends identification.

![Figure 22 Pallet trend sequential impacts. (Modified from White, 2009)](image-url)
The other possible trend in pallet utilization is the quality and standardization factors. As this research and the previous studies reveal, the trend for the future can be classified into long term and short run. This classification gives a connotation to the fact that quality standards may impact the likely trends in the use of pallet. For pallet operators and consumers cost reduction is the main challenge. According to Brindley (2009), Consumers expect reasonable qualities for received pallets but on the other side pallet operators try to reduce the expenses by any possible ways. That could be by using a less quality product or materials. This policy has a huge effect on the quality in the short term run since the long term quality is more focused on the quality.

6.2.2.1. Substitute Materials

The debate of substitute materials has been raised in the recent years. In case of pallets, plastic, metal, wood, composites and paper are the practical options. Each of these materials has some advantages and also many drawbacks but what most of the experts believe that could help to identify the trend in the future substitutes are dependent on some criteria. There criteria are the cost, weight, availability, easiness of use, moist, dust and hygienic issues due to the strict regulations imposed by some regions.

Plastic happens to be a proper option due to some benefits. Advantages like elimination of maintenance cost, recycling, longer operating life, less expenses for disposal purpose and finally hygienic treatments. On the other hands there are several back draws for plastic as a raw material for pallet. One the most important one is the cost and the other one is the safety and hazard issues. Pallet stack collapse, fire risk and deformation due to the overweight storage are the known disadvantages for plastic.

Metal condition is similar to plastic to some extent. Paper and composite are the less demanded one so they most likely won’t influence that much on the trend. After all, wood is the most demanded one since it has low cost, strength and reasonable safety.

6.2.2.2. Design Trends for Pallets

Trends in pallet structure are analyzed to be based on different criteria such as Strength, stiffness, handling easiness, structure and durability. As this research work revealed, in accordance with White (2009), the trend with respect to structure will be from stringer to block and also form unidirectional to perimeter bottom. However there is a likeliness to push perimeter bottom base towards the cruciform base one.

6.2.2.3. Design Criteria

Compatibility of a pallet type to an assigned application is one the most trouble making process in the use of pallets in practice. Most of the pallet experts try to define the suitability of pallets regarding the purpose in which the pallet is utilized. There has been a huge deal of researches and studies around this matter. As a consequence, there are five factors that specify the adaptability of a pallet type for a specific application. These factors are according to Clark
(2004), *Strength, Stiffness, Durability, Functionality* and *Price*. Each of these factors has a different influence on the compatibility issue.

*Strength* is defined as the capability of pallets in handling the load. Pallets have to be designed in such a way that they are capable of carrying a desired load or in this case weight.

*Stiffness* is the term used to determine the pallet ability to resist against the pressure. Stiffness is an essential factor when it comes to the cargo security concerns. It is because of; any deformation can end up to product damage.

*Durability* is how long a pallet can stay in use. This factor is important from economical perspective. Pallets should be designed according some certain criteria so that they provide the maximum durability in practice and real time implementation.

*Functionality* is described as how adaptable pallet is to the handling environment. What meant by environment includes tools and equipments used.

*Price* is the other affecting factor in designing criteria. Many experts believe that a pallet type with an average embracement of the above factors but at a reasonable price is the best choice but providing all these factors in one collection seems to be a hard coordination. Price can be the first criterion from so many perspectives.

Since cost analysis plays a very essential role in identifying futuristic trends in pallet utilization, therefore the cost issue is discussed in details in chapter 6 based upon the experimental findings and also the recent literatures in this field.

For this reason, the pallet treatment part in Chapter 6 analyzes the dimensions of pallet maintenance and treatments in a more accurate fashion.

### 6.2.3. Pallet Treatment

The factor of pallet treatment or pallet maintenance is an issue that hasn’t been paid that much attention as it should have. For some pallet users treatment is equal to extra cost or effort. But on the other hand, from the other point of view, it can be an appropriate move in cost reduction. Depending on the application types and also general conditions of used pallets there are different treatment techniques. Some of which are stated here as the main options for most of the pallet pools that are in use. The most prevalent treatment options for most of the pallet users are refurbishing, repairing and reusing. The rest of the options are more professional and costly. After reviewing the recent researches and experts’ opinions; recovery, heat treatment, refurbishing, repairing and reusing became the main concerns of this part of the analysis phase. According to some recent research paper (Anon., 2009) more than 70% of pallets used in the pallet pools are repaired and reused. About 16% are used as parts, recovery and other sustainable actions. Approximately 8% are reused without any treatments like repairing. Around 5% are putting aside and 1% is being sent to the landfills.
6.2.3.1. Heat Treatment

As observed in so many cases along with some studies (Brindley, 2005) which are the interest of this research work, heat treatment is the main procedure to kill the pests and insects. The moisture can affect the heat treatment somehow. There are also some claims that heat treatment can end up in helping molds to grow. As a result, there are some extra procedures such as cooling and air-blowing are needed. Just 20% percent humidity is deemed to cause mold growth. After heat treatment due to some drawbacks in hears treatment, the moisture can cause mold. To avoid this mishap another procedure like drying should be included that could be costly and not time efficient. As some third party pallet companies concentrate on the quality issue then heat treatment happens to be a good option.

6.2.3.2. Repair

Pallet users bear considerable costs for repairing partly damaged pallets in order to reuse them for further trips. Form different users’ points of views it can be advantageous or disadvantageous. The repairing could be just fixing a small part or component or total replacement of main components and parts. Normally for most of the pallet users that are not involved in the repairing business, replacing damage boards, fixing a minor impairment or putting new nails or screws are some cost saving procedures. This fact reveals the importance of using qualitatively produced pallets in order to cut off the extra costs caused by repairing or refurbishing of pallets in the desired pools. However there are some certain techniques when it comes to repairing business which is not the concern of this thesis work. The evaluation of using the trained staff to perform the internal repairing or having external companies taking care for them is totally dependent on the companies’ policies and the natures of their businesses.

6.2.3.3. Reuse

As this study revealed, the reusing of pallet is some kind of issue that is laid on the quality factors. Reusing pallets for more trips or on the other hand extending the life cycle of pallets could be a saving policy in short term but in a long run it can create other negative impacts on the overall performance and costs of the involved logistics chains along with the environmental or sustainable concerns. At some points when pallet life cycle is extended, the efficiency of the system can be at risk exposure. Product damage, production downtime and concerns from these types are not the desired outcomes that pallet users are expecting. Pallet recycling is another factor that can be affected. Since recycling has been grown in recent years due the associated benefits, reusing is being faded with the pace of the time. It is more of a tricky decision whether to use new pallets or reused ones. Based on the purchasing prices of new pallets and refurbished ones, reusing pallets seems more economical. However, as mentioned earlier, from a long run perspective it may not be an appropriate option.

6.2.3.4. Pallet Maintenance

Apart from the risk and hazard factors associated with pallet utilization, there is also the maintenance factor. For so many pallet pooling systems, maintenance can be a vital procedure
when it comes to cost saving policies and tricks. As it was pointed out in so many researches, dust, moist and a phenomenon called bark occurrence were among the most frequent troubles in pallet maintenance region-wise. What meant by region-wise is the differences that are identified in several locations considering the climate and environment conditions.

In international trades, the pallet maintenance can cause lots of procedures, regulations and subsequently expenses. Countries have their own different environmental standards and regulations. Some of them are so strict about the pests spread and some others imposing regulations for moist and dust. The bark occurrence could be due to the raw material used and the type of pallet.

When the pallet is about to use in a region with high possibilities of such occurrences then it is recommended to utilize a more appropriate pallet type considering the used raw material and also structure. The other consideration is repairing, reusing and refurbishing of pallets. Some of these techniques can draw more expenses for the users.

6.2.4. Pallet Cost Analysis

According to recent researches, it is obvious that the most important driver in the use of pallet is the issue of cost. Most of the pallet users prefer to stick with the cheapest options available in their pallet pools. So many experts believe that cost will probably be the first priority in determining pallet trends in coming future.

That is why cost should be taken more into account than ever. Cost in so many scientific and financial reviews is considered as the determinative leading factor in trend identification.

The recent studies reveal that standardization of different pallet types is the most concern regarding cost issues. Since there are different pallet sizes and classifications globally, it seems kind of challenging to create a pattern in order to reduce the costs associated with pallet utilizations. In general, material handling equipments are built around certain standards and specifications due to the fulfillment of demands in specific regions. Region-wise, it sounds little a bit more convenient to achieve the policies regarding cost reduction patterns but when it comes to a universal scale it becomes a huge concern with respect to trade costs for most of the parties in a designated logistics chain.

6.2.4.1. Pallet System Cost Model

Ray et al. (2006) mentioned that most of the cost analysis is with concentration on the production costs of the pallet. Thus, demonstrating cost model that can provide a good picture of a comparison between purchased and rental pallets. The following figure demonstrates the different cost elements for several pallet practices.
6.2. Other Cost Drivers

Besides the initial fee of a pallet there are so many other affiliated costs that should be borne by the pallet users. For a rental system several cost drivers can be defined. As Mosqueda (2009) pointed out, initial costs, transportation and transferring fees, issuing fee, hiring fees are considered to be the main cost drivers in determining the final cost of a pallet operation. There exists different researches regarding identifying the real costs regarding pallets utilizations. Ray et al. (2006) define the true cost of a pallet as the following formula:

\[ \text{Disposal Cost} + \text{Associated Cost} = \text{True Cost}. \]

Disposal costs are the costs related to the disposal of the used pallets. That may include the container rental and affiliated fees to the destination for the purpose of the land filling or other purposes. Associated costs for pallets aside from the disposal cost can be described as raw material costs, staff costs, equipments and some similar costs. (Ray et al., 2006)

6.2.5. Risk & Safety

In most cases, safety procedures for pallets follow the general safety rules. It means that risks associated with using pallets, aside from particular mishaps, can be categorized in the same category with the other entities. After doing studies, experiments and recording experts’ opinions in this field, it appears that fire risk and pallet stack or rack collapse are the main concerns for pallet many users. Practically injuries, fire hazards and stack collapse can be prevented by the general safety regulations and procedures which are practical in most of the industrial applications.

Moreover, vibration during transportation, environmental based impacts can be classified as the other types of risks involved in pallet usage. As a whole picture, the risks can be divided into two main classes. Risks associated with handling and transportation and risks related to warehousing, storage. There can also be an overall class too which is broken down as some parts of the main two classes. Vibration and products damage during transportation are classified under the external class. Collapse, fire hazards, product damage during inbound handling and stacking, atmosphere conditions like humidity, temperature and racking methods.
are categorized under the internal class. As a recap, fire and stack collapse are considered to be the main concerns since the other factors are relatively easier to be taken care of.

6.2.6. Sustainability

Based upon our latest finding through the published data and statistics by The National Wooden Pallet and Container Association (NWPCA), more than 2 billion Pallets were annually manufactured round the globe which, are known as fundament of the whole intercontinental products transportation and also the same, throughout the countries.

Approximately, just 10 percent of the whole pallet production market share is belong to Plastic, Metal, Corrugated Paper and composite pallets and the rest huge part completely covered by the wooden pallets (90 percent).

With regard to the past decade information and a nice futuristic prediction view, it will be obvious that the timber and landfill prices increased year by year and so, a new modified and planed management of this market to evaluate and improve pallet production by the goal of pallet associated waste reduction and reducing the number of managed pallets by the companies seems urgent.

Through the way of this part of research, examining and investigating the current and future use of pallet, observing the pallet movement from first arrival to disposal and types of used pallets, counting the number of purchased, shipped in, shipped out, returned, maintained and disposed pallets and also their costs to reduce the number of pallets which should be produced and managed, had been done.

6.2.6.1. Reduced the Waste

By the goal of new pallets buying cost saving and promoting the reuse of pallets, it seems that charging fee implementation on pallet production, shipment and maintenance loops is one of the main obstacles for the market planners.

Forces on suppliers to take back pallets from previous shipments by considering charging a disposal fee for those pallets which are not taken back. Having drivers committed to pick up pallets from previous shipments. This system would charge the customers a fee for each pallet that is not provided back.

Using of high quality re-buildable pallets which are more suitable to repair and maintenance and be able to reuse more number of times, reduce the number of waste and trip costs simultaneously.

Designing a Pallet-less systems which are included the use of slip-sheets, reusable containers, recyclable top and bottom cardboard covers, rolling carts, and other material of handling systems known as one of the other method of pallet waste reduction. (From North Carolina Department of Environment and Natural Resources)
6.2.6.2. Reuse & Recycle

Pallet recycling had a tremendous growth in the past decade with a 25 percent rate of growth. The growth comes from both environmental reasons of deforestation and market reactions on timber, landfill and lumber prices. Recovery and durability issues also appear as key factors for companies to reportedly focus on this sector as the most profitable one.

In case of Third Party Logistics (3PL) provider, essentiality of pallet recycling for reuse and refurbishing is more transparent. Therefore the small family businesses and companies in this field start growing to the large independent network sharing companies.

The main concept due to the expansion of pallet recycling comes from the pallet standardization in shape, quality and size which are the key driven success factors in case of reusability. The most prevalent type of pallet in size, accessible from four sides and maximum attraction to reuse and recycle based on the widespread usage enlargement, is Euro Pallet 1 (800 x 1200).

As mentioned in University of North Carolina research paper (1998), traditionally, the barriers to entry in pallet recycling have been relatively low and thus new pallet recycling companies have been able to develop quickly and fill a market niche. Landfill diversion programs for pallets, especially when directed toward reuse and refurbishing, may be an excellent way to boosted overall pallet recovery up.

In case of pallets sale, recycled or rebuilt, enjoy a price of €3 to €6 versus the new typical one which cost between €7 and €10. Finally, it should be supposed, supplying high quality reusable pallets will make a nice level of profit margin for Third Party Logistics (3PL) companies.

6.2.6.3. Disposal

Approximately 58 percent of the MSW landfills recycling pallets simply give away ground or chipped material. Of those that sell ground or chipped pallets, the average sale prices was €10 per ton. Reuse will continue to be the higher value market for pallets, but fuel and mulch markets will play an important role in disposal diversion for the foreseeable future. For more information on markets for processed wood materials, see the Wood Residues report.

6.2.6.4. Process Waste

Focuses on process the waste with the goal of reduce, reuse and recycle of the out of order pallets, relatively need more research and investigation on market, price, alternative options and results.

Wooden pallets recovered by pallet recycling companies that cannot be directly reused or repaired are usually processed for other uses such as mulching, composting and boiler fuel. The hierarchy of succession in this area needs a huge amount of time, money and human aptitude to find adequate alternative.
In practice, pallet waste process income usually is less than purchasing cost of the merchandises and raw materials. In fact, waste reduction or prevention and total quality management system are greatly related and waste process or waste exchange industries focus on the quality of the product to reduce, reuse or recycle the wastes. (The University of Tennessee, Center for Industrial Services, 1997)

6.2.7. Storage

Storing pallets in a warehouse can help a huge deal in the efficient inventory space utilization. The factors like easiness of handling, accessibility and safety make storage an important issue in pallet utilization. Here in this project, a brief description over different storage types is presented. As (Lumsden, 2006) pointed out, there are 5 common storage methods. Rack storage which is defined as the most prevalent storage method. In this method, goods are packed on pallets and pallets are stacked up next to each other. The accessibility is quite easy in this method. The other method is Depth storage which pallets are laid subsequently on the floor. Free stacking is when pallets are put on top of each other. The other methods are Shelf box stacking and Special design.
7. Final Phase & Conclusion

As the last achievement of this thesis work, final conclusion is represented based on what have been attained and accomplished through the research. Literature review was the basis for framework and discussed panels in theoretical phase. Practical observations, experts’ ideas and opinions were the basis of the objective fulfillment in the empirical represented phase of report. The last section at this stage will be some implemental comments on the covered areas of research in form of answers to the earlier-stated research questions and problematic concerns. There will be also, few recommendations regarding further developments which are concerned as follow.

7.1. Conclusion

In a general view and by the goal of having sustainable world; cost effective, waste reductive, environmentally protective and natural recourse preservative pallet production across the supply chain are the ultimate acquisitions of this research.

Utilizing the Logistics chain systems with directive pallet pooling management to achieve operational efficiency on production, cost effectiveness on distribution and quantified benefits on sustainable environment has consequential steps which are; pallet less transportation, durable pallet production, pallet maintenance, pallet waste recycling process and pallet pool company creation.

In a specific view, pallet is one of the basic elements for unitized material handling and distribution through the whole supply chain therefore; pallet types and their applications have a direct relationship. It means that pallets are build based on the nature of the business they are about to be used in. The pallet trends and the possible structural changes are strongly depended on the global market trends which are in the hands of pallet providers. Following the substitute material trends which has been raised in recent years due to sustainability concerns has lead pallet users into a new streak but still for many applications, wooden pallets are the main concentration because of the main factors like cost and availability.

On the other hand, market demand for wooden and plastic pallets will be increased strongly and therefore, the role of Third Party Logistics (3PL) providers and pallet pool creators will be more distinguished in near future. Unidirectional based pallets like euro 1 pallets will be more useful. In fact multi-functionality of pallets in logistics loops will be the subject of future market challenge.

However, when it comes to strict trade and environmental regulations, wooden pallets may not be considered as the best options in the coming future but as a replacement for, composite pallets can be reliable substitutes. Composite pallets have considerable benefits such as light weight, easier recycling procedure and cleanliness at some points. In case of plastic pallets, recyclability and hygiene are the main advantages along with the fire safety issue furthermore; drawbacks with plastic pallets can exceed the advantages of using them.
It seems that, continues improvement on automotive smart supply chain management enforced pallet based industries to move faster through the use of plastic pallets instead of wooden ones which are built at the same sizes, weights and dimensions. Tracking and tracing the shipments faced the Third Party Logistics (3PL) providers and pallet pool creators with the importance of using RFID tagged pallets which are electronically under control.

Cost, weight and deformation are such disadvantages. Corrugated paper pallets are the best options from the recycling cost’s and procedure’s perspectives. The main focus should be on identifying the possible combination of different pallet types and sizes into the same pallet pool in order to enhancement of productivity, incensement of efficiency and reduction of operational costs.

To make a long-term realistic and tangible prediction about future trends on pallet market, remaining in transition between wooden pallet and plastic one as priority is still an open ended approach. But as the best guess laid on our pallet market share data gathering and pallet user based business investigating, in a shortage prediction till 2020, tendency to use alternative materials like plastic instead of hard wood will be increased.

Our finding about the introduction questions are;

1. *What are the current trends in using pallets?*

   At this stage of time, in harmony with the industrial and market demand and requirements, wooden pallets are leading the most consumed pallet types. As a matter of fact the most important reason for such a trend is cost. After reviewing many scientific and commercial researches it has been appeared that cost is the selection basis for any pallet classification. The other factors are being placed after cost. Factors like sustainability, design and structure, raw materials and ergonomics. This claim has been approved during the empirical phase while performing the interviews and practical observations. However, plastic pallets come to picture when cleanliness and special order characteristics are required. Corrugated paper pallets have very particular applications which are totally negligible compared to the other pallet types and classes. Metal pallets have the same situations as paper pallets. They are generally assigned upon request and for special orders. Strength and durability are the main factors in selection of wooden pallets. The main drawbacks associated with wooden pallets are the moist, pests and bark occurrence from the hygiene point of view and collapsibility from the risk perspective.

2. *What will be the trends of pallets usage in latter periods with respect to design issues, economical issues like direct and indirect costs and also sustainability issues?*

   The future trends can be defined based upon some crucial factors. For so many pallet users crucial factors are determined by the previous and current considerations in terms of cost, raw material, applicability, design, and sustainability. By considering these influential factors, wooden and composite-based pallets are the most likely trends to be achieved towards.
However, the main factor can still be identified as cost and expenses associated with pallet usage and disposal which are generally referred to as direct and indirect costs.

Standardization is one the essential issues to be dealt with in order to clarify the most likely trends in the future. For instance in EU the likely trend will be turned around on the different kinds of wooden and composite pallet classification within EPAL sanctions. In the U.S. the North American wooden pallet classifications for categorized industries and applications are of interests.

What has been achieved during this research was that there is still a long way towards the united standardization worldwide since economical factors like direct and indirect costs which have been explained earlier in this thesis, are the main obstacles. Form the design and structure perspective, most of the palletized systems are being developed to be compatible with the existing pallet standards due to cost reduction and saving policies around such developments. For sustainability, as long as there are certain reuse and recycling regulations, the wooden pallets are most probably the best trends for the coming future however,

3. Will be any reasons of considering some substitutes for pallets in the future?

According to what have been done in this thesis, since economical developments are desired and as a consequence production and subsequently handling will be increased therefore pallets will be in demand more than ever. The results derived from this research reveal that there is not a specific substitute for the pallet yet which can ease the handling processes as much as the pallet does.

7.2. Recommendations for Further Development

When it comes to the pallet usage in distribution systems, so many possible aspects of recommendations can be made. As a matter of fact, according to what have been discussed in the theoretical and analysis parts, possible outcomes in the pallet research are totally laid on the unitized tendencies in the market and the related demands and requirements for them. It is strongly recommended to consider the pallet basic raw materials and affiliated costs as the basis for the future development and researches. It has been appeared in this thesis work that cost and raw materials are the basic obstacles for certain trends identification.

Dealing with cost and raw materials can create other issues to defy with. Creating a model for efficient and effective pallet pool systems and managing them is the other interesting area of concentration. What has been found during the interviews and literature studies, demonstrates that the design, structure and ergonomics factors are following the market requirements which at this scale is negligible in comparison with factors such as cost and raw materials. As a final word, the identification of other direct and indirect costs associated with pallet usage than what have been presented in the analysis and the theoretical parts are recommended. The sustainable achievement towards the substitute raw materials and the best possible option from recycling, reusing, waste reduction and on the whole sustainability is also recommended for the future studies and researches in this area.
References:


Appendix 1. Interview Questionnaire

Company Information

Company name: ______________________ Phone: ______________________
Expert’s Name: _______________ Areas of Operation: ________
Expert’s Position (Title): ______________ Address: ________________
E-mail Address: ______________ Fax: ________________

N.B: Please answer the following questions in accordance with the real
time observations.

Panels of Interest:

Pallet Classification Panel

1. What are the most common pallet types that you mostly deal with in your areas
   of operation?

2. What do you consider as the main drivers in the use of pallet in your areas of
   operation?

3. What does encourage you towards usage of pallets in your distribution
   channels?

4. What are the main problems that you encounter while using pallets?

5. What are your points of views on the future structure on different pallet types?

6. What is the range of pallet sizes used?
Pallet Treatment Panel

7. How do you treat your pallets (reuse, refurbish, repair …etc. please state if there are any other ways)?

Pallet Impact Panel

8. What kind of end-user’s trends do you see in terms of pallet consumption?
9. What are the impacts of usage of pallets on your operational costs?
10. What are the impacts of pallets on your inbound & outbound material handling performance?

Sustainability Panel

11. How do you deal with environmental concern regarding pallet reuse?
12. What trends do you see regarding pallet materials in the coming future?
13. How do you deal with the waste of your pallets?

Risk & Safety Panel

14. What are your safety policies regarding pallet usage?
15. What are the risk & safety issues that you are facing while using pallet?
16. What are the most user friendly pallet design & types? (please specify the materials used)

Trends Panel

17. What are your opinions regarding other types of pallet such as composite, plastic, metal, paper based pallets rather than wooden pallet?
18. What changing trends do you realize that are likely to occur to the structure of pallet?
19. What trends do you see in terms of different materials used in pallets?
20. What trends do you see in terms of pallet design?
21. What are the main problems in loading pallets & what are your recommendations to improve in case of pallet?

22. What are your comments on the current pallets’ designs with respect to unit load & handling?

23. How many palletized shipments does your company make each year?

24. What volumes of each pallet size are shipped each month/year?

25. What are the main cost drivers in your areas of operation regarding pallet usage?

26. What is the typical cost per purchased pallet and what type?

27. How much do you spend on repairing pallets each month/year?

28. What charges do your carriers make for pallets (where appropriate)?

29. Do you incur any Product Damages due to poor pallet quality?

30. Do you incur any Production Downtime due to poor pallet quality?

31. Do your carriers bear any of your pallet costs (e.g. do they provide pallets for you and cover the cost in their charges)?

32. What is the typical repair cost per pallet?
Appendix 2. Tables & Figures

The following figure describes the visualized pattern of the Delphi procedures:

![Organization of the Delphi Processes](Figure24_Cuhls.png)

Figure 24 Organization of the Delphi Processes. (Cuhls, n.d. 2003)

The table below shows different kinds of EURO Pallets sanctioned by European Pallet Association (EPAL):

<table>
<thead>
<tr>
<th>EURO pallet type</th>
<th>Dimensions, mm (W × L)</th>
<th>ISO pallet alternative</th>
</tr>
</thead>
<tbody>
<tr>
<td>EUR, EUR 1</td>
<td>800 × 1200</td>
<td>ISO 1, same size as EUR</td>
</tr>
<tr>
<td>EUR 2</td>
<td>1200 × 1000</td>
<td>ISO 2</td>
</tr>
<tr>
<td>EUR 3</td>
<td>1000 × 1200</td>
<td></td>
</tr>
<tr>
<td>EUR 6</td>
<td>800 × 600</td>
<td>ISO 0, half the size of EUR</td>
</tr>
<tr>
<td></td>
<td>600 × 400</td>
<td>quarter the size of EUR</td>
</tr>
<tr>
<td></td>
<td>400 × 300</td>
<td>one-eighth the size of EUR</td>
</tr>
</tbody>
</table>

Table 2 EURO pallet sizes (EPAL)
The table below shows different kinds of North American Pallets sanctioned by National Wooden Pallets & Containers Association (NWPCA):

<table>
<thead>
<tr>
<th>Dimensions, mm (W × L)</th>
<th>Dimensions, in (W × L)</th>
<th>Production Rank</th>
<th>Industries Using</th>
</tr>
</thead>
<tbody>
<tr>
<td>1219 × 1016</td>
<td>48 × 40</td>
<td>1</td>
<td>Grocery, many others</td>
</tr>
<tr>
<td>1067 × 1067</td>
<td>42 × 42</td>
<td>2</td>
<td>Telecommunications, Paint</td>
</tr>
<tr>
<td>1219 × 1219</td>
<td>48 × 48</td>
<td>3</td>
<td>Drums</td>
</tr>
<tr>
<td>1016 × 1219</td>
<td>40 × 48</td>
<td>4</td>
<td>Military, Cement</td>
</tr>
<tr>
<td>1219 × 1067</td>
<td>48 × 42</td>
<td>5</td>
<td>Chemical, Beverage</td>
</tr>
<tr>
<td>1016 × 1016</td>
<td>40 × 40</td>
<td>6</td>
<td>Dairy</td>
</tr>
<tr>
<td>1219 × 1143</td>
<td>48 × 45</td>
<td>7</td>
<td>Automotive</td>
</tr>
<tr>
<td>1118 × 1118</td>
<td>44 × 44</td>
<td>8</td>
<td>Drums, Chemical</td>
</tr>
<tr>
<td>914 × 914</td>
<td>36 × 36</td>
<td>9</td>
<td>Beverage</td>
</tr>
<tr>
<td>1219 × 914</td>
<td>48 × 36</td>
<td>10</td>
<td>Beverage, Shingles, Packaged Paper</td>
</tr>
<tr>
<td>889 × 1156</td>
<td>35 × 45.5</td>
<td>Unknown</td>
<td>Military 1/2 ISO container, fits 36” standard doors</td>
</tr>
<tr>
<td>1219 × 508</td>
<td>48 × 20</td>
<td>Unknown</td>
<td>Retail</td>
</tr>
</tbody>
</table>

Table 3 North American Pallet sizes (NWPCA)
Appendix 3. Terms and Definitions

**Block:** it is often recognized while its location within the pallet as corner blocks, end blocks, edge blocks and middle blocks. It is generally considered as a square deck spacer.

**Bottom Deck:** configuration of different deck boards; lower and load bearing surface pallet.

**Captive Pallet:** a type of pallet used for specific and limited operations. This type of pallet is not entitled to be exchangeable.

**Closed Distribution System (CDS):** a type of the distribution systems which is intended to move the products between certain stations and facilities.

**Cost-Pass-Through:** a part of the cost of a pallet which is passed through to the different users of pallet.

**Cost-Per-Trip:** is the ballpark cost of pallet use for one trip.

**Deck:** the upper or lower surface of the pallet structure that consists of a single or more panels.

**Deck board:** a part of the deck which is pointed to the stringboard.

**Deflection:** is defined as the level of deformation in pallet and its elements caused by cargo pressure or any associated cause.

**Handling:** Is the action of moving, picking up and putting down of empty or loaded pallets.

**Non-Reversible Pallet:** is a type of pallet with different structural system in lower and upper deck boards.

**Notch:** is a part designated for the fork entry.

**PALLET DESIGN SYSTEM® (PDS®):** is a computer based program which is used for loading, carrying and the related economical issues of pallets.

**Pallet Dimensions:** is a term used to clarify the pallet measurements. In such a case, stringer board specification is mentioned first then the deck board specification.

**Pallet Life:** is described as duration in which the pallet is useful for.

**Repair:** is the action of fixing the pallet in order to be used again.

**Recycling:** is the process of putting used, disposed and damaged pallets into a new usage.

**Rental Pallet:** is a pallet which is possessed by another operator rather than the user.

**Returnable/Reusable Pallet:** is a type of pallet that is intended to be operated more than once.
**Reversible Pallet:** is a pallet kind which its upper and lower decks are specified.

**Shipping Pallet:** is defined as a sort of pallet which is just used for a single way from the origin to the destination.

**Skid:** is a type of pallet that has no lower deck board.

**Strapping:** is used to tie down load on pallet for a more secure handling.

**Stringer:** is used to backup the deck board elements.

**Trip:** is the measurement basis for pallet utilization in operation.