THE CONCEPT OF PACKAGING LOGISTICS

Paper Number: (002-0283)

Mazen Saghir

Department of Design Sciences, Packaging Logistics

Lund University

Box 118, SE-221 00 Lund, Sweden

Tel: +46 46 222 40 42, Fax: +46 46 222 46 15

e-mail: Mazen.Saghir@Plog.lth.se

Submitted to the Second World Conference on POM and 15th Annual POM Conference, Cancun, Mexico, April 30 - May 3, 2004.

1 ABSTRACT

Packaging has a significant impact on the efficiency and effectiveness of retail supply chains, where improvements can be achieved through the adaptation and development of the concept of packaging logistics. In order to enable these improvements, models are needed that facilitate evaluations along the supply chain and show the activities involved in the packaging logistics process. The knowledge and awareness of the importance and potential of the packaging logistics activities along the supply chain is low. Case studies involving companies from the Swedish and the Dutch retail industry were conducted to identify packaging logistics parameters along the retail supply chain. The concept of packaging logistics is explained, and the paper discusses how a systematic evaluation model from a packaging logistics perspective should look like. Finally, a conceptual analysis model for packaging logistics is presented.

2 INTRODUCTION

Although packaging is recognised as having a significant impact on the efficiency of logistical systems (Twede, 1992; Ebeling, 1990; Lockamy, 1995) and activities such as manufacturing, distribution, storage and handling throughout the supply chain, many packaging dependent costs in the logistical system are frequently overlooked by packaging designers (Twede, 1992). Packaging specifications directly influence the time required for completing packaging operations which ultimately affects product lead time and due date performance (delivery) to the customer (Lockamy, 1995). Examples of the relationship between packaging and logistical activities are shown in Table I.

Table I. Packaging Cost Trade-Offs with Other Logistics Activities (Lambert et al., 1998).

Logistics activity	Trade-offs
Transportation	
Increased package information	Decreases shipment delays; increased package information decreases tracking of lost shipments
Increased package protection	Decreases damage and theft in transit, but increases package weight and transport costs.
Increased standardisation	Decreases handling costs, vehicle waiting time for loading and unloading; increased standardisation; increases modal choices for shipper and decreases need for specialised transport equipment
Inventory	
Increased product protection	Decreased theft, damage, insurance; increases product availability (sales); increases product value and carrying costs.
Warehousing	
Increased package information	Decreases order filling time, labour cost.
Increased product protection	Increases cube utilisation (stacking), but decreases cube utilisation by increasing the size of the product dimensions.
Increased standardisation	Decreases material handling equipment costs.
Communications	
Increased package information	Decreases other communications about the product such as telephone calls to track down lost shipments.

Packaging also affects supply chain effectiveness because it represents an interface between the supply chain and its main customer: the end user and enables the chain's primary task i.e. serving end consumers, to be accomplished. This is especially evident in the FMCG (Fast Moving Consumer Goods) supply chain.

Packaging Logistics is a fairly new concept that has during the last years developed and gained increased attention by both industry and scientific community (Johnsson 1998;Twede 1992;Dominic *et al.* 2000;Öjmertz 1998;Twede & Parsons 1997;Henriksson 1998; Saghir 2002). The concept of packaging logistics focuses on the synergies achieved by integrating the systems of packaging and logistics with the potential of increased supply chain efficiency and effectiveness, through the improvement of both packaging and logistics related activities. One way to achieve this is to concentrate on packaging development that benefits packaging related activities in the logistical system, often called logistical packaging. This one-sided way of approaching the packaging logistical issues is dominating in literature and the logistics discipline. There have been few efforts to present an adequate definition of packaging logistics, and these have been fragmented and vague in available literature.

Literature reviews and demands from the Swedish retail supply chain imply the lack of specific evaluation methods concerning packaging concepts from a logistical and supply chain point of view. (Dowlatshahi 1999; Saghir and Jönson, 2001). Historically packaging has mainly been evaluated considering its basic functions, e.g. from chemical, mechanical and biological points of view (Twede & Parsons, 1997; Johansson, 1998; Saghir & Jönson, 2001). The existing methods are also concentrated on quantitative and limited measures. Packaging is a multi-disciplinary issue that also requires qualitative analysis and methods. A balanced consideration of both

quantitative and qualitative aspects is therefore required in the development process of future packaging solutions. A framework for evaluating packaging concepts, with emphasis on a wider systems view, where interrelated aspects e.g. logistics, marketing and environmental aspects are addressed is therefore needed.

There is a need for methods and tools that allow packaging evaluations along the supply chain in order to avoid sub-optimisations. Existing methods are limited by the boundaries of the single company and therefore only used for certain stages in the supply chain. Multifunctional and systematic methods are required in order to emphasise the understanding of the role of packaging along the supply chain and enable the actors of the retail supply chain to agree upon a proper, efficient and effective packaging solution and enhance communication and information sharing (Saghir and Jönson, 2001).

A better understanding of the complexity of packaging logistics and providing new packaging concepts and solutions that facilitate smoother handling throughout the whole supply chain are demanded. In order to develop such concepts, we need to implement proper tools, methods and techniques at an early stage in the process of product development that secure the consideration of packaging logistical issues along the whole supply chain.

The purpose of this paper is to explore the concept of packaging logistics, identify present packaging logistical conditions in the retail supply chain and show how a packaging logistical perspective can be adopted and implemented. The paper discusses how to assess existing packaging systems, in order to identify and show their influence on primarily the logistical system in the retail supply chain.

3 PACKAGING LOGISTICS

Packaging is a coordinated *system* of preparing goods for safe, secure, efficient and effective handling, transport, distribution, storage, retailing, consumption and recovery, reuse or disposal combined with maximizing consumer value, sales and hence profit (Saghir, 2002). Above it's fundamental function of protecting, containing and preserving the product, the functions of packaging are manifold and complex and the definition here can be related to three main categories i.e. logistics, marketing and environment. Jönson (2000) presents an overview of important packaging functions in Table 2.

Table 2. Overview of different packaging functions (Jönson, 2000).

Logistical function	Facilitate distribution Protect both product and the environment Provide information about conditions and locations
Marketing function	Graphic design, format Legislative demands and marketing Customer requirements/consumer convenience for end use as well as distribution
Environmental function/aspect	Recovery/Recycling Dematerialisation One- way vs. reusable package Toxicity

Packaging may be classified as primary, secondary or tertiary, reflecting the levels of packaging (Jönson, 2000). These definitions should be used together with the consideration of packaging as a *system*, with hierarchical levels. See Figure 1. This approach highlights the natural interaction between the different levels of packaging and facilitates an understanding of their interdependence.

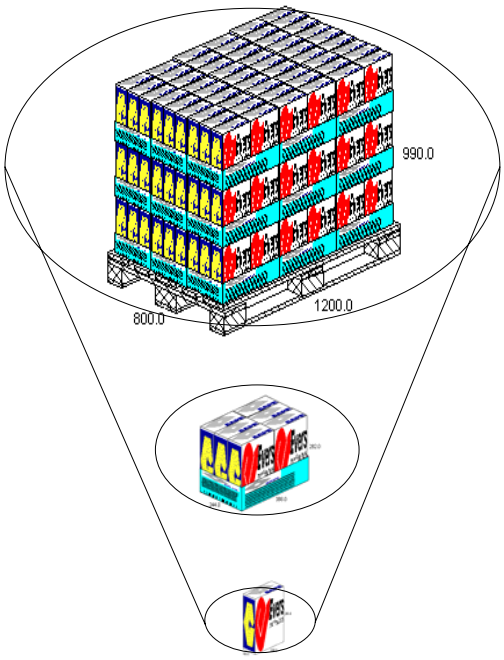


Figure 1. The levels of the packaging system.

It can therefore be argued, in a systems fashion, that the performance of the packaging system is affected by the performance of each level and the interactions between these levels. Many definitions and terms are used by practitioners when discussing packaging. Table 3 summarises some of the communally used packaging terms and definitions.

Table 3. Definitions of different packaging types – modified from Jönson (2000).

Packaging Type	**Definition**
Primary packaging, consumer packaging or sales packaging	Packaging which is in contact with the product. The packaging that the consumer usually takes home
Secondary packaging	Secondary packaging is designed to contain several primary packages
Tertiary packaging	Used when a number of primary or secondary packages are assembled on a pallet or roll container.
Group packaging	Packaging which is conceived to facilitate protection, display, handling and/or transport of a number of primary packages
Transport packaging, industrial packaging, or distribution packaging	Packaging which is conceived to facilitate handling, transport and storage of a number of primary packages in order to provide efficient production and distribution as well as prevent physical handling and transport damage
Display packaging	Same as group packaging, quite often with an emphasis on display features
Retail packaging	Same as group packaging with a special emphasis on the design to fit in retail
Used packaging	Packaging/packaging material remaining after the removal of the product it contained

Often several terms are used to describe the same type of packaging, but seen from different aspects. This complicates understanding the scope of the packaging system and does not facilitate communication among different functions and disciplines.

Dominic *et al.* (2000) define Packaging Logistics as "An approach which aims at developing packages and packaging systems in order to support the logistical process and to meet customer/user demands." This definition reflects a traditional point of view that considers packaging as a *part* of the logistical system, and addresses only a one-sided relation where packaging adapts to the logistical system.

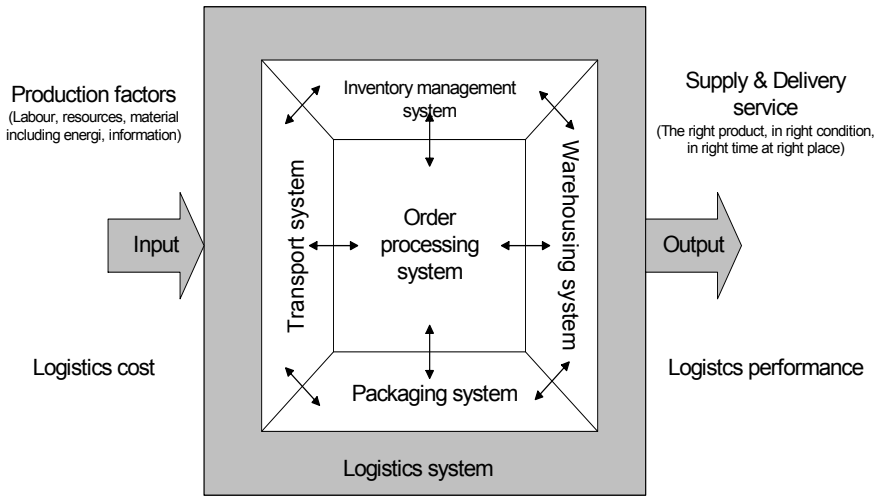
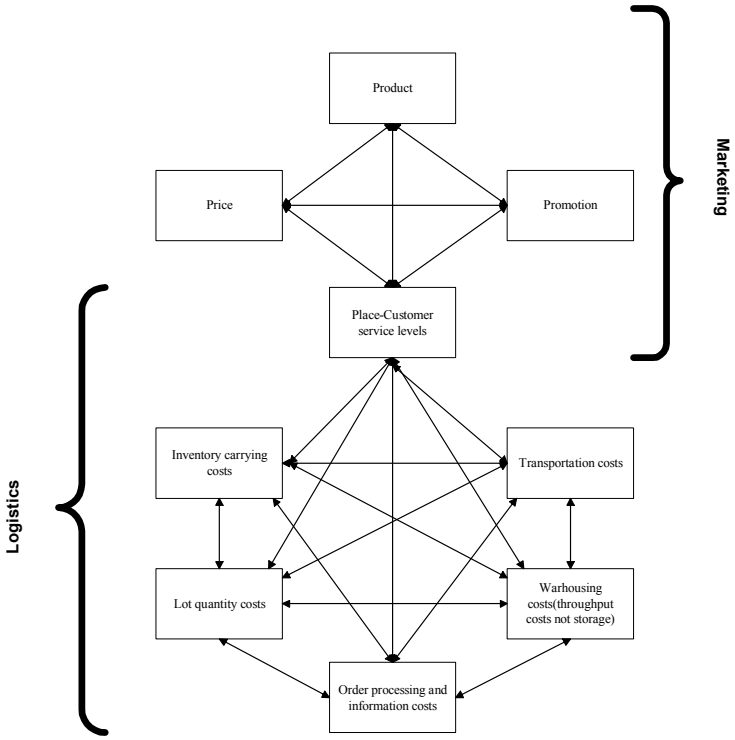


Figure 2. The logistical system and its components, freely translated (Pfohl 1990).

As Figure 2 shows, the packaging system is considered as one of other logistical sub-systems as the transport system, inventory management system, order-processing system and warehousing system. Packaging is also considered as "an important warehousing and materials management concern" (Lambert *et al.* 1998). Ballou (Ballou 1998) considers packaging as a supportive activity to Business Logistics, where he call it "protective packaging". This gives some examples

of efforts to recognise the role of packaging on various levels, but fails to stretch its influence beyond traditional limited thinking.



Marketing objective: Allocate resources to the marketing mix in such a manner as to maximize the long -run profitability of the firm.
Logistics objective: Minimize total costs, given the customer service objective.
Where total cost equal: Transportation costs + Warehousing costs + order processing and information costs + lot quantity costs + inventory carrying costs.

Source: Adapted from Douglas M.Lambert. The Development of an Inventory Costing Methodology: A Study of the Costs Associated with Holding Inventory (Chicago: National Council of Physical Distribution Management, 1976), p.7.

Figure 3. Cost Trade-Offs Required in a Logistics System (Lambert et Al., 1998).

Consider Figure 3, a widely accepted illustration of the interaction between logistics and marketing, where packaging is treated as a warehousing and material handling matter. The interface between logistics and marketing is here where logistics addresses the place aspect in the marketing mix and hence enables customer service. If packaging is to be considered as merely a subsystem of logistics, as shown in the common literature available, than it should be a part that indirectly mainly facilitates customer service. But packaging is closely related to the product

itself and contributes to all of the 4P-s in the marketing mix. Packaging is a vital tool in the marketing mix, too often ignored by companies, but twice as much is annually spent on this as on above-the-line advertising and promotions (Rod, 1990). By its marketing capabilities and properties, packaging plays a decisive role in facilitating meeting consumers' needs and expectations. Packaging is not simply a marketing or distribution adjunct but pervades the total system view (Wills 1975). The traditional point of view, described above, does simply not cover the multi-functional nature of packaging, neither does it recognise its close relation to the product and influence on most logistical activities. The term logistical packaging has been used by academics (Paine 1990;Twede 1992;Twede & Parsons 1997) but refers to a limited point of view, where it addresses packages that are customised for mainly logistical functions. Therefore the concept of Packaging Logistics, beside of focusing on the interface between the systems of Packaging and Logistics, recognises the interdisciplinary nature of packaging and consider also, among other disciplines, its interfaces with marketing. See Figure 4 for an illustration.

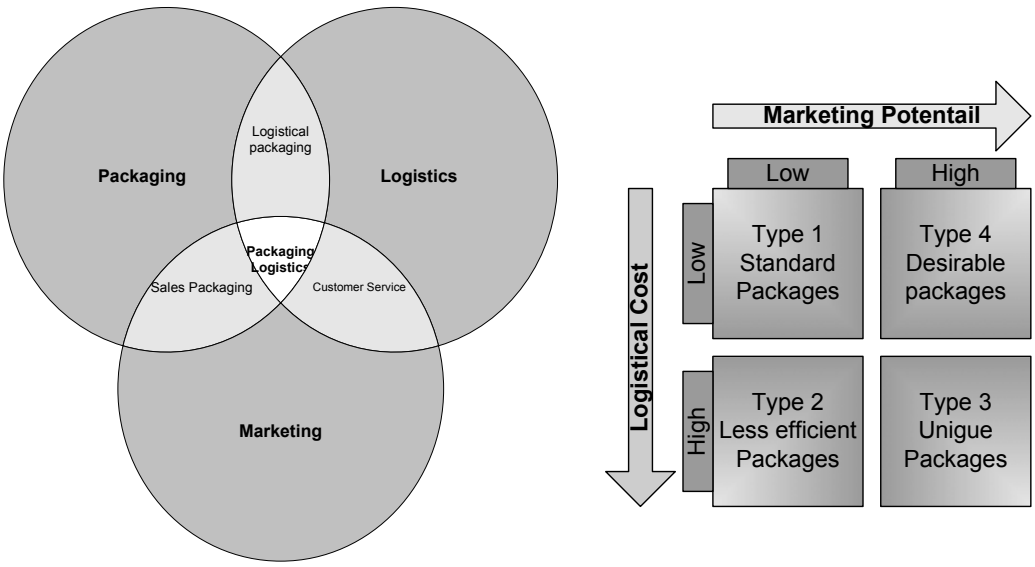


Figure 4. The interaction between packaging, logistics and marketing.

Besides enabling the logistical function, the challenge lies in fulfilling the marketing and

environmental function of the packaging system throughout the supply chain. When it comes to packaging, trade-offs among logistical, marketing and environmental issues are present, although complex to comprehend and explain (Prendergast, 1996). The packaging system has to fulfil demands from a number of dependent areas and customers, which makes it hard to isolate relationships and functions in a cause and effect manner. In order to gain insight in the influence of the packaging system in the supply chain, it is necessary to explore and analyse the packaging related activities on an operational level. The interactions between packaging, logistics and marketing are especially important due to the trade-offs that often must be made when choosing a packaging concept (Prendergast & Pitt 1996; Saghir 2002). When considering logistical and marketing issues, the balance between product differentiation and standardisation is vital. The trade-offs between a differentiated and a standardised packaging influences the choice of a proper packaging type for the desired product, especially for FMCG-products. See Figure 4, for an illustration.

Logistics *plan, implement and control*, while Packaging *contains*, *protects*, secure, *promotes, sells, informs and is a source of profit.* Packaging logistics focuses on the packaging system, addresses the interfaces between the two systems of packaging and logistics and aims at increased efficiency and effectiveness in the combined system, optimally from point of origin to point of consumption and further to reuse/recovery or disposal. Saghir (2002) suggests the following definition of Packaging Logistics: "**The process of planning, implementing and controlling the *coordinated Packaging system* of preparing goods for safe, secure, efficient and effective handling, transport, distribution, storage, retailing, consumption and recovery, reuse or disposal and related information combined with maximizing consumer value, sales and hence profit**."

Packaging Logistics should be considered as an integrated approach, where both systems of packaging and logistics interact, complement and adapt to each other. The total potential of improvement should be larger if an integrated approach was adopted. Three distinguished strategies to improvement when adopting the concept of packaging logistics has been identified, to help distinguishing possible potentials and show eligible opportunities (see Figure 5) i.e.:

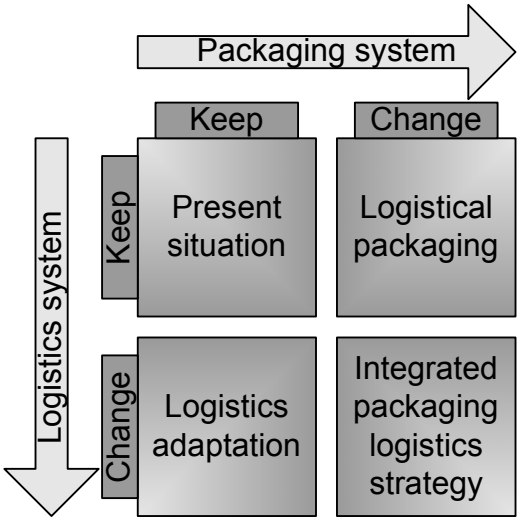


Figure 5. Packaging Logistics Strategies.

- Improving and developing the packaging system by adaptation to the logistical system (existing or future one), See logistical packaging.
- Improving and developing the logistical system by adaptation to the packaging system (existing or future one), See logistics adaptation.
- Improving and developing packaging logistics by changing both of the packaging and logistics systems, See integrated packaging logistics strategy.

The dominating strategy found today is the logistical packaging (Johnsson, 1998). *"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 packing materials. And the packaging postponement/speculation decision affects the cost of the entire logistical system. Furthermore, the characteristics of the logistics system determine the requirements and costs for packaging. An integrated logistics approach to packaging can yield significant logistics value." (Twede & Parsons, 1997).

Figure 6 summarises and describes the fundamental packaging logistical antecedents, procedures and expected consequences.

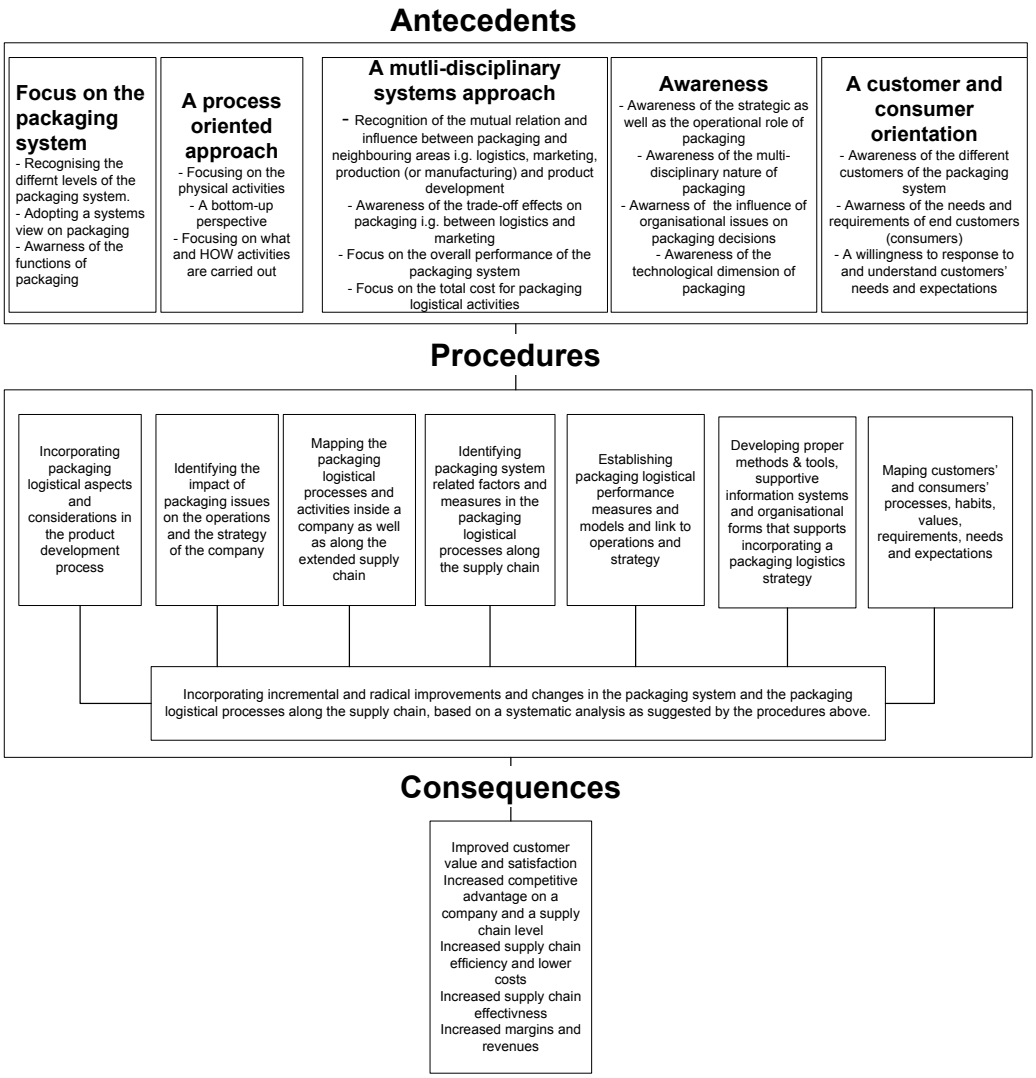


Figure 6. Packaging logistics antecedents, procedures and expected consequences.

4 CASE STUDIES FROM THE RETAIL SUPPLY CHAIN

Retail is a major consumer of different types of packaging. In Sweden alone, retail handles approximately 1000 million retail packs each year. According to a Swedish study (DULOG, 1997), the potential savings for packaging handling in the Swedish grocery retail supply chain [only from the retail distribution centre (DC) to the retail outlet] is about five million EURO (40 MSEK) for every reduced second in the packaging handling process (for consumer- and retail packaging). This alone is a good enough reason to investigate and discuss packaging logistics, efficiency, and related activities in the retail supply chain.

In this paper four case studies were used to identify, describe and in depth understand the packaging logistics activities in retail supply chains. Packaging logistical activities are best described as those involved in the functions of the packaging system in the supply chain. The activities include *fulfilling safe, secure, efficient and effective handling, transport, distribution, storage, retailing, consumption and recovery, reuse or disposal and related information combined with maximizing consumer value, sales and hence profit.* The case studies were used to explore the interactions between packaging and logistics activities in retail supply chains. The focus was on understanding how the activities were carried out and how they could affect the efficiency and effectiveness of retail supply chains. The use of a case study, according to Yin (1994), is relevant to answer HOW-questions. The main objective of using a case study here is to enhance a deep understanding of phenomena by providing a rich description based on a holistic view (Merriam, 1988). As the research here uses the systems approach, in order to stress the importance of the dependent relations in the grocery retail supply chain, it is common to work with case studies(Arbnor & Bjerke, 1997). "*Case studies can lead to new and creative insights,*

development of new theory, and have high validity with practitioners - the ultimate user of research. It is important that case research is conducted and published because it is not only good at investigating how and why questions, but also it is particularly suitable for developing new theory and ideas and can also be used for theory testing and refinement" (Voss et al., 2002).

Three case studies were used involving two Swedish retail supply chains and one case study involving a Dutch retail supply chain. Two of the retail chains were leaders in their business field while the third was a relatively small retail chain. The companies in the case studies were chosen based on their availability and interest and because they represented typical retail supply chains, although with different retail concepts. Further, the access to processes along the grocery retail supply chain from producers to retail outlet was a significant factor for choosing the companies involved. Comparing these retail chains enriches the understanding of the conditions of the packaging logistics activities in retail supply chains. The Dutch case study was conducted separately by a colleague investigator, and triangulation was used to enhance validity and obtain positive synergies in comparison and analysis. The case studies focused on ambient fast moving consumer goods (FMCG), since these products constitute the majority of the total material flow studied. See Figure 7 for an illustration of the system boundaries of the case studies.

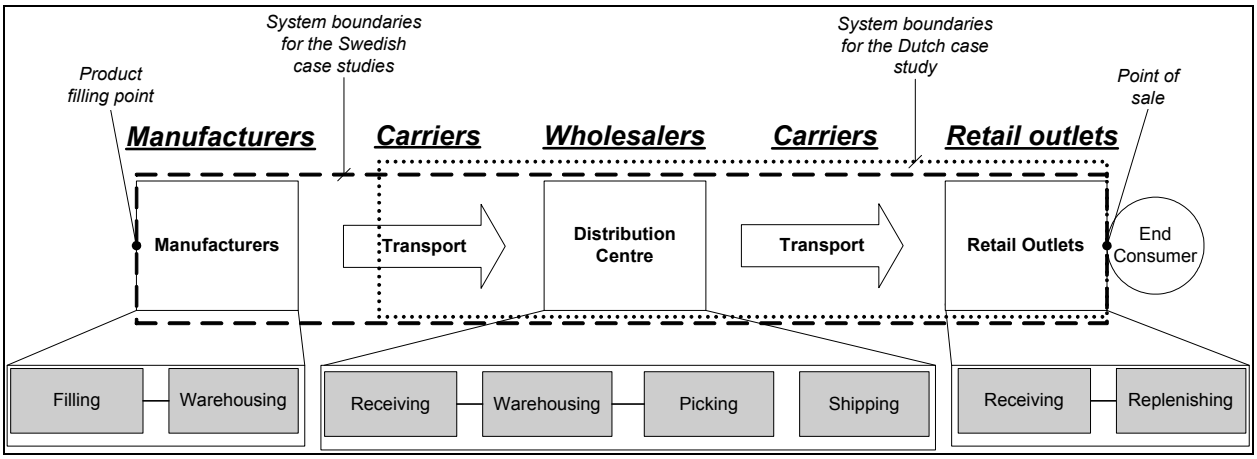


Figure 7. The context and demarcations of the case studies.

In the Swedish case studies, five companies were involved, representing two food manufacturers, a transport company and two retail chains. Three grocery products were the subject of thorough investigation and mapping through their extended supply chain, from the packing point in the producing company to the point of sale at the store. The products were used to demonstrate typical packaging logistics problems and identify critical areas through the retail supply chain. These product-specific studies gave an opportunity to follow a logical process and understand how the participating companies treated packaging and logistics related issues. Table 4 shows the types of packaging involved in these three case studies.

In the Dutch case study there was a focus on mapping the flow of the FMCG in general throughout the retail supply chain, from distribution centres to end consumers, including the reverse flow of products and packages. The purpose of studying FMCG in general, was to generate a holistic view on the total flow and to also include non-product-dependent activities. This was done to create an in-depth understanding of how packaging logistical activities were treated within the retail chain.

Table 4.Investigated packaging types in the Swedish retail supply chain.

Manufacturer (M)	Carrier (M-DC)	Distribution Centre (DC)	Carrier (DC-RO)	Retail Outlet (RO)
Primary packaging 1. Bottle 2. Plastic bag 3. Aseptic carton package **Secondary packaging** 1. Corrugated tray and stabilisation tape. 2. Corrugated box **Tertiary packaging** 1. EUR-pallet and stretch film	**Tertiary packaging** 1. EUR-pallet and stretch film	**Secondary packaging** 1. Corrugated tray and stabilisation tape 2. Corrugated box **Tertiary packaging** 1. EUR-pallet and stretch film 2. Roll cage	**Tertiary packaging** 1. EUR-pallet and stretch film 2. Roll cage	**Primary packaging** 1. Bottle 2. Plastic bag 3. Aseptic carton package **Secondary packaging** 1. Corrugated tray and stabilisation tape 2. Corrugated box **Tertiary packaging** 1. Roll cage 2. EUR-pallet and stretch film

By focusing on the physical flow in the retail supply chain, it was possible to address the packaging logistics activities in the cases, since packaging is strongly connected to the product itself. Mapping the physical flow and analysing the activities along the retail supply chain enhanced comprehending the conditions of the packaging logistics activities and their potential impact on the overall efficiency of the retail supply chain. The tool of process mapping also facilitated an analysis of the relations among the observed activities and made it possible to compare the similarities and differences in the processes of the supply chains involved. Archives, observation and unstructured interviews were used to gather information. Furthermore, semi-structured interviews were conducted with key employees responsible for packaging and logistics development. The interviews were recorded and analysed later by the authors.

Lockamy (1995) stresses the strategic impact of packaging, and stipulate the examination of all packaging related processes, in order to provide a competitive advantage for the firm. This

requires identifying all processes which are associated with packaging. Therefore, the packaging logistics processes in the retail supply chain were mapped and explored, with focus on the physical flow of products and packaging material. See Hellström & Saghir (2003) for further details on the process maps. The packaging logistical related operational factors were also mapped and listed using a systems approach, where emphasis was focused on showing the role of the various packaging levels and also their inter-dependent relations i.e. primary in secondary as well as secondary in tertiary. These packaging factors related to the packaging logistical processes along the retail supply chain are presented in next chapter.

Packaging logistical factors in the grocery retail supply chain

The case studies were used to investigate the available and used methods and tools in the grocery retail supply chain. A summary of the parameters and information considered in the evaluation process of packaging solutions in the grocery retail supply chain is presented in Table 5. Notice that the packaging producer is included.

Relevant factors from the different stages in the grocery retail supply chain are summarised and discussed below. These factors are mapped and presented separately for every stage of the grocery retail supply chain in this study i.e. manufacturer, distribution centre, retail outlet and carriers. The summary is made for each packaging level (i.e. primary, secondary and tertiary) and also for the packaging level interfaces (primary/secondary and secondary/tertiary).

Table 5. Packaging related information and evaluations in the grocery retail supply chain.

Packaging producer	Manufacturer	Carrier	Retail
• Strength tests and vibrations in laboratory • cost analysis: material cost, production costs of the packaging and filling, cost of distribution equipment and storage costs.	• Pallet pattern • Volume and are efficiency • Secondary packaging size • Strength analysis • Practical transportation tests • Stacking tests • Storage tests • Primary packaging consumer tests: visualisation, usability, attitude, size, weight and complaints	• Truck load efficiency • Distribution cost • Environmental impact	• Official goods declaration • Recommendations and packaging related information from DULOG[1]. • Internally reported complaints and insufficient packaging performance (handling, protection, ergonomics, storage).

Manufacturer

Manufacturing conditions are relatively rigid and revolve around high product volume and tied capital investments in packaging machinery, process equipment etc. The high degree of automation makes it difficult to radically change or adjust current activities. The first step of the packaging logistics journey throughout the retail supply chain begins at the packaging and filling machine. It is here that the product meets the primary packaging. From this moment on the product and the primary packaging are considered as a unified and inseparable single unit. They will not be separated until they reach the point of consumption.

The manufacturer's key operational issues are packing line efficiency and flexibility; these are governed by the type of product, primary packaging and filling and sealing technology. Label application is also dependent on the type and design of the packaging; important issues include

[1] The Development and Logistics group of the Wholesale and Retail Trade in Sweden

label application time, label placement, amount of information carried by the label and label type. The labels also have to comply with readability and traceability requirements. The information on the labels depends on the level of packaging. Primary packaging information is directed towards consumer while secondary and tertiary packaging information are used inside the retail supply chain. The pallet label serves as a location or destination label and is used to identify and verify products along the supply chain. See Table 6 for a summary of important packaging system factors at manufacturer.

Table 6. Packaging related factors at the manufacturer

Primary packaging (P)	**Secondary Packaging (S)**	**Tertiary Packaging (T)**	**Compatibility Primary/Secondary (P/S)**	**Compatibility Secondary/Tertiary**
Packing line efficiency and filling speed	Packing line efficiency (n*P/S, S/h)	Stability	Stability (shape and height relation P/S)	Protection
Flexibility (set up time)	Stability	Stackability (n of T)	Protection	Efficiency (n*S/T), Filling rate, volume and area
Closing/sealing technology (time)	Protection	Handling efficiency	Weight	Handling efficiency (n S/T*h)
Label application (time)	Image	Weight	Image and promotion (placement of P/S)	Stability (type of stabilisation and stacking style)
	Handling efficiency	Label application	Efficiency (n*P/ S) Filling rate, Volume and area	Stackability (n of T)
	Inter-stackability		Handling efficiency (n P/S*h)	Storage (n of T, days in certain conditions, type of S (corrugated board))

Distribution centre

Secondary and tertiary packaging are handled at the DC. The packaging logistics processes at the DC are receiving, warehousing, order picking, handling of used packaging materials and shipping. Most activities performed in these processes are packaging dependent. Labour generally represents the greatest cost in a DC as there is an extensive amount of manual handling. The activities in the receiving process are unloading, application of labels, and controlling the received products. Unloading is often carried out by the truck driver using a

pallet stacker, or automatically using automated unloading equipment. Once the shipment has been unloaded the pallets are labelled and verified. The labelling activity is also used as a means of verifying the number of pallets received.

In the warehousing process the allocation of storage placement is fundamental. This was done in one of three ways – employing a warehouse management system, using the T-method, or by using a pick location badge. The T-method is based on placing incoming pallets as near the pick location as possible, preferably on the right or left side of it. The pick location badge was placed at the pick location and used as a direction marker for incoming pallets bearing the same products.

Assigning pick orders was the first step in the picking process. Order picking represents the core activity of the DC and is the most labour intensive part of the DC-activities. Packaging aspects that influences the efficiency of the order picking activities are quantity, weight, volume and stackability. The main function of the pick label applied to the secondary packaging is to verify that all products have been picked. Order picking efficiency is closely linked to e.g. human factors, award systems, order structure, warehouse layout, picking equipment, type of products picked and the shape and type of packaging.

The shipping process is often organised using numbered destination columns. In two of the cases, the arrangement and verification of the shipment was done by the truck driver. In one case these activities were done by DC employees, with extensive verification of shipped products. Checks were made at the secondary packaging level so as to guarantee the accuracy of the order picking process. The controllers also arranged the roll containers in lanes and sequence to match

delivery routes.

Table 7. Packaging related factors at the distribution centre.

Primary packaging (P)	**Secondary Packaging (S)**	**Tertiary Packaging (T)**	**Compatibility Primary/Secondary (P/S)**	**Compatibility Secondary/Tertiary (S/T)**
Identification	Order picking efficiency (S/h)	Stability	Stability (shape and height relation P/S)	Protection
Information	Storage efficiency Volume and area filling rate	Stackability (n of T)	Storage (Stackability, Filling rate Volume and area)	Efficiency (n S/ T), Filling rate, Volume and area
Protection	Protection	Material handling efficiency	Protection	Stability (type of stabilisation and stacking style)
	Handling efficiency (S/h)	Weight	Weight	Intra-Stackability
	Intra-stackability, modularity	Storage efficiency (Volume and area filling rate, Height)	Image and promotion (placement of P/S)	Storage (days on certain conditions)
	Stability		Handling (shape)	Capital tie-up (Value, n S/T)
	Ergonomics (weight, shape, material and handling facilitators)		Capital tie-up (value, n P/S)	Standardised packaging types
	Identification			

The last process at the DC is related to the handling of used packaging material. Used packaging material was handled at the retail outlet or in the DC depending on the structure and ownership of the retail chain. In two cases this was carried out at the DC. In one case the crates and bottles had to be sorted at the DC according to product. This detailed sorting was not required in the other two cases as a centralised third party carried out this process. See Table 7 for corresponding packaging factors in the distribution centre.

Retail outlet

The activities at the retail outlet include all levels of the packaging system and are dominated by handling and marketing properties. Manual handling, product information and sales promotion are important primary packaging factors. The operations in the retail outlet vary depending on

the ownership, location, size, and retailing concept of the retail outlet. In the case studies where the outlets were franchised, the shipment was verified when it was received at the retail outlet. Only random checks were made when DC and retail outlet had the same owners. The location, whether it was located in central urban areas or not, and size of the retail outlet influenced the size of storage (backroom inventory), shelf capacity and the capability to handle used packaging material.

Table 8. Packaging factors in the retail outlet.

Primary packaging (P)	**Secondary Packaging (S)**	**Tertiary Packaging (T)**	**Compatibility primary/secondary (P/S)**	**Compatibility secondary/tertiary (S/T)**
Handling efficiency (n P/h) Picking and placement on shelf	Handling efficiency (S/h), opening, placement on shelf, compactability[2], shape)	Stability	Stability (shape and height relation P/S)	Protection
Product identification and information	Shelf adaptation	Material handling efficiency	Storage(Stackability, Filling rate Volume and area)	Efficiency (n S/ T), Filling rate, Volume and area
Promote sale	Protection		Protection	Stability (type of stabilisation and stacking style)
Ergonomics (Shape, Weight)	Image and information		Ergonomics (Weight)	Capital tie-up (Value, n S/T)
Shelf adaptation	Ergonomics (weight, shape, material and handling facilitators)		Image and promotion (placement of P/S)	Modularity
Protection	Identification		Handling efficiency (n P/S, shape, shelf adaptation, opening device)	
			Capital tie-up (value, n P/S)	

The replenishment activity depended on the retailing concept; the alternatives considered were – single products on shelf, secondary packaging on shelf or whole/half pallets on the floor. Retail outlets that focused on shopper experience and perception of the outlet preferred to replenish at

[2] The package's ability to facilitate compression after placing content on shelf.

night. In two cases, the used packaging material was sent to the DC, while in the third case the retail outlet handled recyclable corrugated board on site. At the retail outlet, packaging has to fulfil shelf adaptation, sales promotion requirements, the facilitation of product identification and communication, handling efficiency and ergonomic requirements. See Table 8 for further details.

Carrier

The transportation activities interact mainly with tertiary packaging i.e. pallets and roll cages. Transport unit adaptability is considered the most important factor from an efficiency point of view. Stackability is also an important factor that directly affects transportation costs. Weight and height of tertiary packaging are two limiting factors with constraints that directly affect transportation efficiency and hence cost. Pallet adaptability has a direct effect on volume and area efficiency in the transportation vehicle. See Table 9, for further details.

Table 9. Packaging factors at the carrier.

Primary packaging (P)	**Secondary Packaging (S)**	**Tertiary Packaging (T)**	**Compatibility primary/secondary**	**Compatibility secondary/tertiary**
Protection	Stability	Stability	Stability (shape and height relation P/S)	Efficiency (n S/ T), Filling rate, Volume and area
Identification	Protection	Inter-stackability (n of layers)	Protection	Protection
	Information	Handling efficiency		Stability (type of stabilisation and stacking style)
		Weight		Intra- and inter-stackability
		Height		Information
		Transport unit adaptation		Identification

5 SUGGESTED PACKAGING LOGISTICS ANALYSIS PROCEDURE

First, one needs to stress that the fundamental function of packaging to protect the product and meet its requirements must be fulfilled, along its whole life cycle. Above that, the universal constraints of time, cost and quality are essential in the evaluation of packaging concepts, together with regulations and legal issues. Therefore, these are placed in the heart of the suggested model in Figure 8.

In order to analyse the performance of the packaging system, the influence of the different levels of packaging and their internal relationship to the systems overall performance need to be determined. **The first step** is therefore to investigate the relation between the different levels of the packaging system i.e. primary, secondary and tertiary packaging. The P/S relation listed in the packaging system matrix in Figure 8 reflects the adaptability of the primary packaging to the secondary packaging. Is P dimensioned to fit the properties of S? How well does it perform? Since this is a relative measure, symbols are preferred to indicate this, i.e. + - or neutral (0). A percentage scale system can also be used to compare with best practice cases. The S/P relation on the other hand reflects how the secondary packaging is adapted to the properties of the primary packaging. T/P describes the relation between tertiary and primary packaging and so forth. Any negative value indicates an inefficient contribution to the overall packaging system.

The more traditional relation between packaging levels is often given quantitatively in number of primary packaging per secondary packaging (packages per case), number of secondary packaging per tertiary packaging (cases per layer and layers per pallet), and thereby number of primary packaging on tertiary packaging or the volume efficiency (filling rate). These relations are useful, but other properties as stability and compatibility should be added.

2nd step is to investigate how the different levels of the packaging system fulfil basic packaging requirements, see the packaging basic requirements matrix in Figure 8. The matrix presents an overview that facilitates better overall understanding, and requires a more thorough evaluation of the underlying aspects of the requirements. Questionnaires and interviews conducted with employees from the case studies indicated, as an example, a negative relation between marketing and logistical packaging requirements. Employees working with packaging issues experienced a strong influence on the choice of packaging solution from the marketing function, which affected compliance with logistical requirements negatively. An overview of packaging level-requirements matrix could facilitate avoiding such situations.

3rd step in the analysis process is to investigate the relation between the different levels of the packaging system and the packaging logistical processes in the supply chain, see the packaging supply chain matrix in Figure 8. This can be done by relating corresponding packaging level to the different requirements identified in the defined grocery retail supply chain, as shown in case study in earlier chapter.

The grade system in the matrixes in Figure 8 are qualitative and usable in a relative comparative investigation, but can be replaced by more quantitative measures e.g. costs, time, or indexes. The availability and measurability of the packaging related factors involved determine if this is possible. Notice that compulsory requirements e.g. protection are easily determined in absolute terms.

The fourth step is to analyse the relationship between the different levels of the packaging system and their actual performance. See the packaging logistics performance matrix in Figure 8. The three first steps are usable based on pre identified requirements, available historical

data and tools and serve the purpose of early evaluation of packaging concepts. The fourth step is on the other hand aimed at linking actual performance data along the supply chain to investigated packaging system. Allowing this kind of packaging level based analysis facilitates identifying insufficiencies and pointing out on what level improvements are needed.

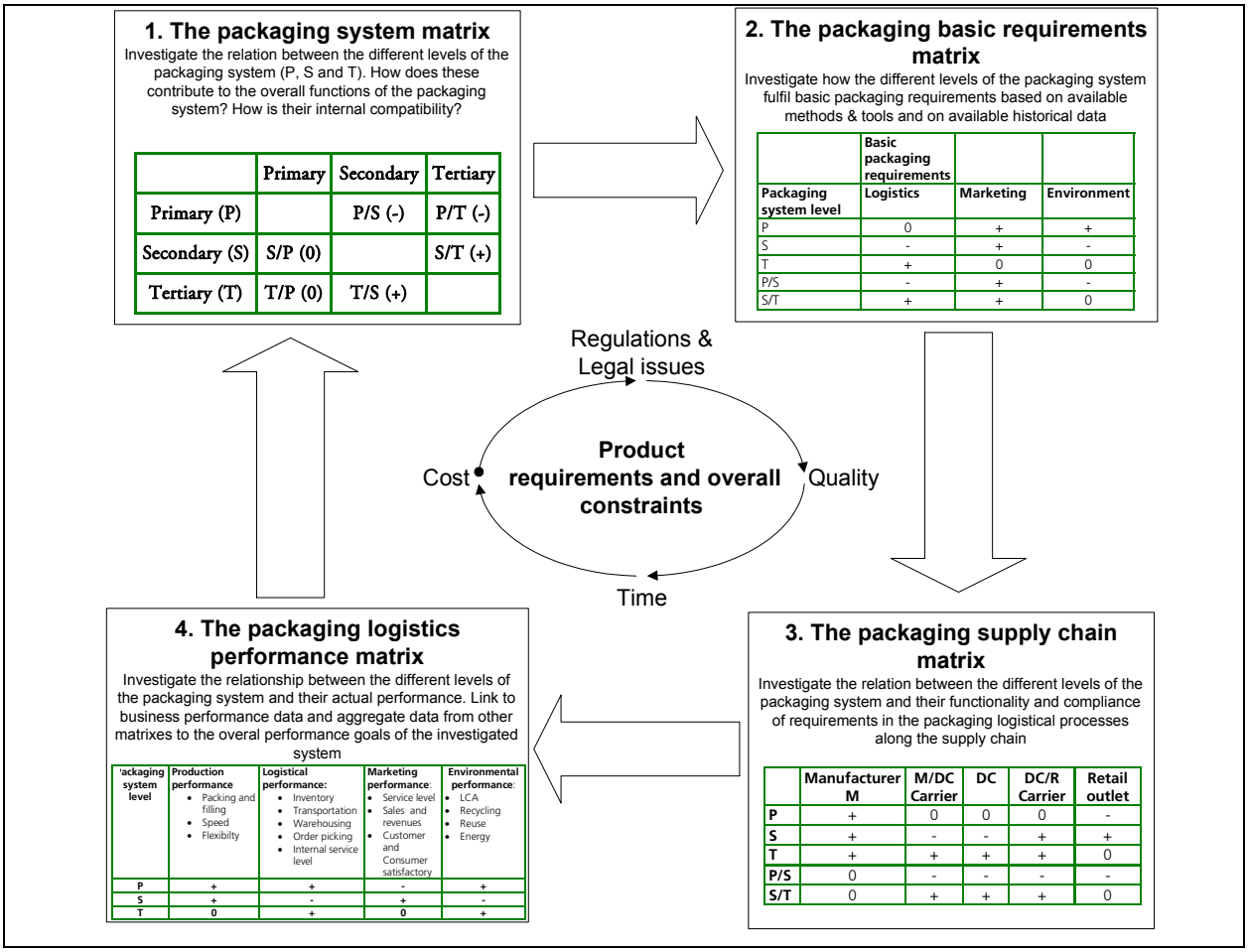


Figure 8. Suggested packaging logistics analysis procedure.

6 Discussion & Conclusions

An important issue that can cause a hindrance towards building and implementing a performance model is the measurement and availability of the performance parameters. Generally, the existing and used parameters today in industry are fragmented and limited to quantifiable ones.

We are in the beginning of an evolution that can provide us with new tools to improve efficiency and effectiveness of packaging and logistics systems. This paper presented a packaging logistics analysis model, but there is still some work to be done before the establishment of an applicable model. Packaging logistics is a new concept that needs to build up knowledge and theories that can cast light on its influence on the performance of logistics and packaging systems, knowledge and theories that are not available yet.

There is a need for identifying cost drivers related to the packaging activities in the logistical system. Industry tends to demand tools that show, in a cause-effect fashion, the relationship between packaging properties and tangible logistical service and cost parameters. Even if we consider the logistical packaging perspective, then we would still need to develop methods and model that can show the influence of packaging on the traditional logistics system. The evaluation of the packaging system also requires the existence of well-defined requirement measures or factors that would be used in a suggested packaging logistics performance model.

The companies participating in this research requested routines and procedures that support and assure the use of “optimal” packaging solutions. The companies seem to work to a large extent separately. The inter-company communication concerning packaging logistical issues is carried out mainly on an operational level and often as “fire fighting” when problems occur. The lack of co-operation along the grocery retail supply chain reduces the opportunities to grasp the situation and take advantage of the possibilities of developing a packaging logistics analysis model. Such co-operation is necessary to allow implementing and refining the suggested model. This represents a hindrance in the way for a development towards an efficiency and effectiveness improvement.

7 FURTHER RESEARCH

Here the packaging issues have been stretched from a single company, single function level to a broader multifunctional and above all a supply chain level. It is obvious that packaging issues are concerned with products life cycles, especially when treating consumer products, and a product life cycle approach is fundamental. The implications of such an extension should be of interest to explore and be subject for further research. The procedure presented focuses on internal supply chain perspective, and would be strengthened by including a consumer perspective.

Organisational issues have an impact on the packaging function in the companies and further on the overall awareness and consideration of the influence of packaging logistics on the performance of a company or a supply chain. Organisational maturity is a prerequisite for any improvement effort and this is also the case of the packaging logistics improvement in today's Swedish retail supply chain. Therefore, organisational conditions in the grocery retail supply chain needs to be investigated and explored. It should be interesting to explore the applicability of the process oriented view adopted here in the today's organisational structures.

The suggested model here represents a starting point in the process of establishing a generic packaging logistics performance model, which requires proper methods, models, tools and techniques. Efficient and effective tools and techniques that support the steps presented in the suggested procedure needs to be investigated and implemented. Available tools from disciplines such as product development, logistics, marketing and operations management should be identified, investigated, adjusted, implemented and tested. Simulation is a powerful tool that is favourable to use when complexity level is high. The use of simulation to serve the steps of the suggested procedure should be interesting to evaluate.

REFERENCES

Arbnor I. & Bjerke B. (1997) Methodology for Creating Business Knowledge, 2nd edn. Sage Publications Inc., USA.

Ballou R.H. (1998) Business Logistics Management: planning, organizing, and controlling the supply chain, 4th edn.

Dominic C., Johansson K., Lorentzon A., Olsmats C., Tiliander L., & Weström P. (2000) Förpackningslogistik, 2nd edn. PACKFORSK, Kista, Sweden.

Dowlatshahi, S. (1999). A modelling approach to logistics in concurrent engineering, European Journal of Operational Research 115, 59-76.

DULOG, Development and Logistics group of the Wholesale and Retail Trade in Sweden., 1997.

Ebeling C.W. (1990) Integrated Packaging Systems for Transportation and Distribution. Marcel Dekker, New York.

Hellström, D. and Saghir, M., Framework of Packaging Logistics Activities - In Retail Supply Chains, In proceedings of IPSERA 2003 Conference, 12-16 April 2003, Budapest.

Henriksson L. Packaging requirements in the Swedish retail trade. 1998. Lund University, Sweden, Department of Engineering Logistics. 1998.

Johnsson M. Packaging Logistics -a value added approach. 1998. Sweden, Lund University.

Jönson, G., 2000. Packaging Technology for the Logistician, 2nd Ed., Lund University.

Lambert D.M., Stock J.R., & Ellram L.M. (1998) Fundamentals of Logistics Management. McGraw-Hill, Singapore.

Lockamy, A., 1995 A Conceptual Framework For Assessing Strategic Packaging Decisions, The International Journal of Logistics Management, Vol.6, Issue 1, pp 51-60.

Merriam, S., B., 1988. Fallstudien som Forskningsmetod. Studentlitteratur, Sweden.

Öjmertz B. Materials Handling from a Value-adding Perspective. 1998. Sweden, Department of Transportation and Logistics, Chalmers University of Technology.

Paine F. (1981) Fundamentals of Packaging. Brookside Press Ltd., Leicester, UK.

Paine F. (1990) Packaging Design and Performance. Pira, Surrey, UK.

Pfohl H.-C. (1990) Logistiksysteme: Betriewbswirtschaftl. Grundlagen, 4th edn. Springer-Verlag, Berlin.

Prendergast, G. and Pitt, L., 1996 Packaging, marketing, logistics and the environment: are there trade-offs?, International Journal of Physical Distribution & Logistics Management, Vol.26, Issue 6, pp 60-72.

Rod, S., 1990, Packaging as a Retail Marketing Tool, International Journal of Physical Distribution & Logistics Management, Vol.20, Issue 8, pp 29-31.

Saghir, M. and Jönson, G., 2001. Packaging Handling Evaluation Methods in the Grocery Retail Industry, Packaging Technology and Science. 14(1): 21-29.

Saghir, M., 2002. Packaging Logistics Evaluation in the Swedish Retail Supply Chain. Lund University, Lund.

Twede D. & Parsons B. (1997) Distribution Packaging for Logistical Systems: A literatureReview. Pira, UK.

Twede D. (1992) The process of logistical packaging innovation. Journal of Business Logistics 13, 69-94.

Voss, Ch.; Tsikriktsis, N. and Frohlich, M. (2002) Case Research in operations management. International Journal of Operations & Production Management 22, 195-219.

Wills G. (1975) Packaging as a Source of Profit. International Journal of Physical Distribution & Logistics Management 20, 5-20.

Yin R.K. (1994) Case study research design and methods, 2nd edn. Sage Publications Inc, USA.