

Packaging Logistics Performance

Thesis for the degree of Doctor of Philosophy

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Licentiate in Engineering

Department of Design Sciences

Division of Packaging Logistics

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Packaging Performance Logistics

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“The greater danger for most of us lies not in setting our aim too high and falling short; but in setting our aim too low, and achieving our mark.”

Michelangelo 1475 – 1564

Preface and acknowledgements

When I wrote my licentiate thesis Packaging Networks, I was convinced then that in the next work I could perform even better. Today when I look at the current work, after a lot of hard work put into it, I feel that is the best work that I have done so far. During this time I have become increasingly convinced that there is a need for more focused work dedicated specifically to Packaging Logistics Performance, a pioneering effort in this field. My advisory work helping packaging institutes, the retail industry, the packaging industry and pulp and paper industry with managing, measuring, and delivering performance has taught me that there are many issues unique to these industries. I have met many people, who have been asking me for case studies and tools to support them in solving their day-to-day tasks.

Over a cup of coffee with Dr. Fredrik Nilsson, I agreed to produce a work to provide a foundation based on the work done at the department of Design Science, Division of Packaging Logistics in Lund, my licentiate work and the research done at the research institute Innventia in Stockholm. However, when I started writing, it became clear to me that the

work was completely new and it has taken a tremendous leap from the previous work.

In addition, I would like to thank those persons from various industries who have provided me with case studies. I would like to thank my students and researchers at KTH and Chalmers who have given me new ideas and helped me with data collection processes. Without these persons, it would have been impossible for me to develop my insights and tools.

Now it is time to write the acknowledgements a rough and bumpy journey. Looking back in the mirror, it strikes me sharply that this journey cannot come to an end without many wonderful people who have given me the strength and courage to go on and to tie the final knot.

There are many wonderful people who have inspired and contributed with their support. First of all I wish to thank Innventia, Catarina Ottenstam, the director for Packaging Solutions and Kennert Johansson who initiated this opportunity, my colleagues: Professor Mikael Lindström, Dr. Carl Olsmats, Ann Lorentzon, Cathrine Löfgren, Dr. Dorotea Slimani, Eva Jansson, and Tatjana Karpenja at Sustainability and Foresight, and all the others who have encouraged me during this time. Also thanks to Lisa Tiliander who had acted as in the latter stages of my thesis.

When I started to work at Packforsk, now Innventia, I heard a lot about Professor Gunilla Jönson, and I have the opportunity to have her as my supervisor and my major inspirer, to look at the subject of logistics from different angles and guide me home with this work. Many thanks go to Dr Fredrik Nilsson also as supervisor for this thesis, who has given the scientific boost and shown me that complexity in logistics is not complicated.

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Stockholm, Sweden 2011

Chris Dominic

Abstract

Today's trends are the ever growing competition with increased globalization and sustainability. Together with ongoing technological developments it has made it easier to demand right quality of products and services, this has also resulted in increased demands for legislation and traceability. This development has also an impact on packaging and packaging logistics.

This dissertation deals with packaging, logistics and performance when packaging interacts with users and take a standpoint by finding answers to the research question: How can a systematic and holistic approach to packaging increase the logistics performance to create efficiency and effectiveness?

The purpose of this work is to increase knowledge regarding the packaging and its interacting role with agents in the Supply-Demand Chain in order to improve Packaging Logistics Performance. Further the thesis aims to increase knowledge in the area of Packaging Logistics Performance. Performance in packaging logistics is about doing the right thing and things right as well as position products and services relative to its competitor.

A model has been created to increase knowledge of packaging logistics performance, which covers interaction between packaging system with its users. This also model includes the tool. 'Packaging Scorecard' that measures the packaging logistics performance and shows the packaging-related deficiencies that exist in various levels of the value chain. Furthermore, the tool developed to enable efficient product development.

The developed model will provide support for the development of packaging strategies to change the existing systems or develop new systems. The strategies also take into account the agents involved in the supply-demand chain by demonstrating the requirements on the packaging and how small changes in the packaging system contributes to a significant improvement in the value chain. Theoretical tool enables a better integration between in picking up the desired packaging information interacting with the agents and the right knowledge on packaging can be handled more efficiently.

New functions and roles for companies operating in the various logistic processes were identified for example the research has identified a new type of service the Network Integrator that manages integrate the supply chain with the demand chain. This function was also identified in the packaging area and this agent named the Packaging Integrator.

To increase understanding of the Supply-Demand Chain the tool CATWOE (Customer, Agents, Transformation processes, World view, Owners and Environment) was applied. This tool further developed for to adapt with packaging logistics performance and complexity theory. The general methodology was action based research and case studies.

The developed model illustrates packaging systems and how they perform in order to create conditions for better and more efficient packaging logistics performance. The thesis explores and presents ways to improve the opportunities that co-operate for better packaging, and integration of value chains.

Research in theoretical contribution is to demonstrate knowledge of packaging systems, understanding the interactive roles and existing requirements in the Supply-Demand-Chain. Practical contributions were the valuable empirical knowledge and increased understanding of packaging requirements and its interactions with agent to create conditions for effectiveness, efficiency and differentiation.

Keywords: Supply-Demand-Chain, Packaging Logistics Performance, Agent Based Modeling,
Complexity Theory, Holistic Packaging Development, Adaptation, Interaction

Sammanfattning

Konkurrensen har ökat markant under 2000-talet med ökade globaliserings och hållbarhetstrender. Ständigt pågående teknologiska utvecklingar har medfört att kraven på rätt kvalitet på varor och tjänster har ökat. Det har även medfört ökade krav på lagstiftningar och spårbarhet. Ett sådant förhållande ställer höga krav på effektiv förpackningslogistik.

Detta arbete behandlar förpackningar, logistik och dess prestanda när förpackningar interregerar med användare. Arbetet tar ställning genom att hitta svar på forskningsfrågan: Hur kan en systematisk och holistisk ansats på förpackningar ge förbättrad förpackningslogistisk prestanda, skapa effektivitet och substantiell verkan?

Avhandlingens syfte är att förstärka kunskapen om förpackningar och dess integrerande roll med agenter i utbuds och efterfrågekedjan med syfte att förbättra förpackningslogistik prestanda.

Prestanda inom förpackningslogistik handlar om att göra rätt saker, att göra saker rätt och positionera produkter och tjänster i förhållande till konkurrentens. En modell har skapats för att öka kunskap om förpackningslogistik, samspelet mellan förpackningar i ett system och dess användare. Denna modell består bland annat av verktyget 'Packaging Scorecard'. Verktyget mäter förpackningslogistisk prestanda och visar de förpackningsrelaterade brister som finns i olika nivåer i värdekedjan. Vidare har verktyget utvecklats för att möjliggöra effektiva produktutvecklingar.

Den utvecklade modellen ska ge stöd för att ta fram förpackningsstrategier för att förändra det befintliga systemet eller utveckla nya system. Strategierna tar även hänsyn till aktörer som är verksamma i värdekedjan genom att påvisa de krav som ställs på förpackningen och hur små förändringar i förpackningssystemet bidrar till stora förbättringar i hela värdekedjan. Teoretiskt möjliggör verktyget en bättre integration mellan aktörer och rätt kunskap om förpackningar kan hanteras på ett effektivare sätt.

Under forskningsarbete har det identifierats nya funktioner och roller för företag som är verksamma i olika logistiska processer. Bland annat har forskningen identifierat en typ av tjänsteföretag som har den integrerande funktion som krävs för att administrera utbudet med efterfrågan. Denna funktion behövs även på förpackningssida och kallas förpackningsintegration.

För att öka förståelse om värdekedja har CATWOE verktyg (kunder, agenter, förvandlingsprocesser, världssyn, ägare och miljön) har används. CATWOE-verktyget har utarbetats till förpackningslogistik med tillämpning av komplexitetsteori. Aktionsforskning, och fallstudier har varit de centrala metodansatserna för avhandlingen.

Den framtagna modellen belyser förpackningssystem och hur de utför för att skapa förutsättningar för bättre och effektivare förpackningslogistisk prestanda. Avhandlingen utforskar och presenterar vägar för att förbättra möjligheter som samtidig verkar för bättre förpackningar, och integration i värdekedjor.

Forskningens teoretiska bidrag är att påvisa kunskapen om förpackningssystem, förståelse om de interaktiva roller och existerande krav i värdekedjan. Praktiskt ger forskningen värdefull empirisk kunskap. Ökade förståelse om förpackningens krav och dess interaktioner med användarna skapar förutsättningar för effektiva och hållbara system som förbättrar aktörers konkurrenskraft.

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Appended papers

Paper 1. Packaging Scorecard – a Packaging Performance Evaluation Method,
Olsmats, C., Dominic, C. - Published in Packaging Technology and Science,
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Paper 2. Supply and Demand Chain Integration - a case study conducted in
the packaging industry Dominic, C. - Packaging Technology and Science
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Paper 3. Integrating Packaging Suppliers into the Supply/Demand Chain

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InterScience (www.interscience.wiley.com). DOI:10.1002/pts.684

Paper 4. Supply/Demand Chain Management

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Technology, 3e, JWUS_EPT_07-0020, 2009

Paper 5. “Holistic packaging development - integrating packaging, process and
supply chain with a complex adaptive system approach”

Dominic, C. and Nilsson. F. - Supply Chain Management: an International Journal. (Submitted to Supply Chain Management: An International Journal, 2011)

Paper 6. Packaging Logistics Performance and How to Evaluate the Packaging Performance by Applying the Tool Packaperforma

Dominic, C. Scientific Research Publishing 2010, USA, ISBN: 978-1-935068-36-5 and Proceedings of the 17th IAPRI World Conference on Packaging, Tianjin, China 2010.

Doctorial dissertations and Licentiate thesis at the Department of design science, division of Packaging Logistics, Lund University, Lund, Sweden

Part I – Identifying and agreeing what matters

Is it not strange that desire should so many years outlive performance?

William Shakespeare

1 INTRODUCTION

1.1 Background

The chapter is an introduction to the concept of Packaging Logistics Performance, and it provides a brief background to the Packaging Logistics Supply-Demand Chain and agents involved in logistics processes. To give the reader an overview of the research described in this thesis, questions, objectives, scope and demarcations are presented in the latter part of this chapter.

In the last decades, the business world has been characterised by phenomena such as globalisation, sustainable growth (Fodha et al. 2009), increased degrees of competitiveness, fast evolution of new technology, rapidly changing customer demands, as well as an increased emphasis on risk management (Butner, 2010) and legislation. In this environment, Porter (2001) points out that it is vital to define clear strategies for companies that need to develop, in order to give them competitive advantages. This statement has an influence in the Supply Chain and

Supply Chain Management, defined by the Council of Supply Chain Management Professionals (CSCMP):

"Supply Chain Management encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third-party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across companies. Supply Chain Management is an integrating function with primary responsibility for linking major business functions and business processes within and across companies into a cohesive and high-performing business model. It includes all of the logistics management activities noted above, as well as manufacturing operations, and it drives coordination of processes and activities with and across marketing, sales, product design, finance and information technology."

The Supply Chain (SC) is the physical flow consisting of a number of agents, each communicating directly with the nearest agents forwards for sales and backwards for purchases. SC is a model of multiple agents (Chen, 2010) interacting in that time to process the demand. An attempt to model the SC was made by Fox et al. (2000) who had the ability to simultaneously

observe the global and local performance of the SC. The interactions often consist of finding an agent who can offer the right product, at the right time, and at the right place. When multiple agents interact on a demand level, specific agent requirements become a trade-off, leading to information gaps between one agent's needs and the one who fulfils them. This gap widens when several agents get involved in the SC. Porter (1985) stated that one should focus on creating value-adding activities, and this was later extended by Christopher (1998), to creating a chain with external agents that interact in value-creating activities. Ericsson (2003) argued that the SC is a supply-push construction rather than a construction driven by demand-pull conditions. Walter (2008) takes it further by stating that the demand defines the SC target, while supply capabilities support, shape and also sustain the demand capabilities. According to Shaw et al. (2010), the demand chain is the mirror image of the supply chain, containing all activities that result in the demand being stimulated. The Demand Chain (DC) is a value-creating activity, managing the information flow by closing the gaps between the agents during interaction with the goal to reduce the physical flow by increasing the information flow. To understand and build insight into the Supply Demand Chain (SDC), it is defined as an open system studied from a holistic view of agents interacting in the SDC.

Another way of defining the SDC is by studying the movement of packaging from one point to another.

Packaging is an essential component that could increase competitiveness (Zheng et al. 2009) in the SDC, in the transition of products from one point to another. The agents involved could in reality be the converter of packaging, the product filler, and intermediate entities with functions to fill, pack, label, distribute, open and market at the point of sale. Several authors (e.g. Hellström, 2007; Saghir, 2004a; Johnsson, 1998; Twede, 1992) have recognized packaging as having a significant impact on logistics. Packaging could be a component that involves many autonomous agents in the SDC, i.e. entities with problem-solving capabilities, rationality, socialability, reactivity and pro-activity (Muller et al. 1997). Further, the packaging serves as a protector (Paine, 2002; Lockamy 111, 1995) of the product during logistics activities and while interacting with the customer. According to Saghir (2002), Packaging Logistics is a concept with an interaction between a logistical system and the packaging system, encompassing strategic frameworks to create value for the overall enterprise. Sales promotion is yet another function which is frequently addressed to attract the potential customer of the product by communicating its message (Paine, 1990). Often, there is a trade-off in

sales to meet the demand from the user and to support the logistics performance where the packaging is involved (Nilsson, Fagerlund & Körner 2010).

The literature on logistics performance capabilities has focused on “hard” measures such as service (e.g., order cycle time and fill rates), cost, and return on assets or investment (Brewer et al. 2000; Morash et al. 1996). Few authors have examined the logistics capability and its relationship with performance from an agent perspective, hardly in relation to packaging. Neely (2000), has elaborated performance as a process of quantifying the efficiency and effectiveness of action. Based on these, ideas the work describes in this thesis was initiated with an interest in Packaging Logistics Performance from the viewpoint of technological performance, (e.g. Meroni, 2000), business performance and user interaction performance (Germain et al. 2006). There is an empirical weakness between the integration of the supply chain and logistics performance. Pålsson (2009) defines logistics performance as *“the logistics value of using real-time tracking data, or on dependent mechanisms, i.e. mechanisms determining the logistics value”*. Conceptually, Packaging Logistics Performance may be viewed as a subset of the larger notion of performance with several agents who interact with the packaging involved in the SDC. Gleason et al. (1986) chose to

distinguish between effectiveness and efficiency. They defined effectiveness as “the extent to which an objective has been achieved” or simply explained it as doing the right thing, while efficiency was defined as “the degree to which resources have been used economically” or doing the thing right. Langley et al. (1992) and Fugate et al. (2010) extended the definition of performance by adding logistics differentiation as a key element of logistics performance because the customers can differentiate the value received from the output of logistics activities. Differentiation is critical to give support to Packaging Logistics and also for Packaging Logistics Performance. Therefore, the definition of Packaging Logistics Performance includes efficiency, effectiveness and differentiation of the agents involved in the SDC interacting with the packaging.

Packaging and the product are integrated with requirements such as to contain, protect, handle, deliver or present goods (Paine, 2002). During the interaction of packaging and logistics, the performance value is created for the user at several levels i.e. strategic, tactical and operational. The interaction of packaging and logistics activities has been recognized as a core competence leading to superior performance and creating customer value (Bowersox & Closs, 1996; Milgate, 2001). The development is

established in the packaging area where many packaging agents play major roles as well as aligning with supply and demand in order to satisfy the user-agent. The Packaging Logistics Performance supports the Packaging Logistics theory by adding measures to increase efficiency, effectiveness and differentiate through having a holistic view. Packaging and its system interact with many logistical activities, and are expected to perform with all agents with the mission to avoid sub-optimization.

SDC is based on an efficiency emphasizing the physical functioning in delivering goods, responsiveness in asserting the market-mediating function for conveying information, and complex agents that simultaneously pursue multiple goals (Steers, 1975). Several authors have studied the role of packaging by defining its properties. In general, fourteen packaging performance indicators have been identified (Dominic et al. 2000; Robertson, 1990; Livingstone et al. 1994; Henriksson, 1998; Johnsson, 1998; Paine, 1981) that contribute to desirable performance while interacting with the SDC. Here, Lambert et al. (1998) state that the packaging performs two basic functions; marketing and logistics. However, the research area has developed further to integrate environment (Johansson et al. 1997; Prendergast et al. 1996) as the third leg in the concept of packaging logistics. The definition of performance

measurement system characteristics differs widely in the literature. The criteria presented in Dominic et al. (2000) are performance measurement criteria adapted to integrate companies' goals with Packaging Logistics strategies. Hence, the three measures are logistical, environmental and marketing performance. According to Rund (2010), the diversity in market strategy for packaging therefore stresses the importance of reduction to a more manageable level. Olsmats (2002) describes the packaging as a servant in silently selling the product. Löfgren (2005) further studied the primary packaging and how it silently sells the product. Rafele (2006) assigned logistics performance indicators to three broad areas: tangible components, ways of fulfilment and informative actions. The subject of logistics has also developed and within the subject the concept of Packaging Logistics Performance is emerging in Packaging Logistics, the criteria include aspects of marketing that are related to sales, information and ease to handling by the user. One of the structural elements of Packaging Logistics Performance is user- interaction that emerges being as more suitable for Packaging Logistics Performance and it is added as the third leg of the concept of Packaging Logistics Performance.

In Table 1, the performance criteria are sorted to present the Packaging Logistics Performance from, technological, business and user-packaging interaction perspectives.

Packaging Logistics Performance		
Technological perspectives	Business perspectives	User-interaction perspectives
<p><i>Machine-ability</i> refers to converting packaging material to packaging and flexible to the requirements of packaging machinery (Iye et al. 2004) for effective use of packaging materials through the production line.</p>	<p><i>Right amount and size</i> concerns the package adapting to the appropriate size concerning customer requirements and If all sales packages were plain and of a standard size consumers would become frustrated without the numerous clues provided by the graphics and distinctive shapes of sales of the package</p>	<p><i>Reverse handling</i> is interlinked to a returnable and reusable container that is designed to carry and protect the product that is returned from the producers and product fillers. Both disposable and returnable packaging are considered. A statement by Twede interviewed by Witt, (2000) explains that the efficient development of Just-in-time has reduced the suppliers, and attempts to reduce the geographical distance between supplier and user has favoured the returnable packaging.</p>
<p><i>Product protection</i> refers to the package's ability to protect the product (Duizer et al. 2003) from dynamic impacts such as vibration, shock, compression, temperature (Singh et al. 2010), fall and drops, from the producer to the consumer.</p>	<p><i>Packaging cost</i> is of great importance during the packaging operation after the assembly operation, that is to package the common item for finished-goods inventory (Graman, 2010).</p>	<p><i>Easy to discard</i> concerns the requirements for removal of unnecessary packaging materials. Packaging can add convenience in the distribution, handling, stacking, opening, reclosing, display, use, and reuse.</p>
<p><i>Tracking information</i> refers to the packaging's capacity to provide information to precede with logistics activities (Agapakis et al. 2002) in the distribution network.</p>	<p><i>Selling capability</i> refers to the package's ability to market and sell the product.</p>	<p><i>Security</i> concerns mainly the ability to protect the product from being stolen or security of the shipment through e.g. increased tamper resistance or tamper-evident</p>

<p>The package may be used to communicate how to use, recycle, or dispose of the package and content. Communication is a vital link between the entire logistics process and the suppliers and customers (Lambert et al. 1998). There are often legal requirements on information for some products, e.g. pharmaceuticals, food, and hazardous products.</p>		<p>features, functions to reduce pilfering, seals and security printing to authenticate the content and antitheft devices such as electronic article surveillance tags. User safety concerns the packaging's ability to create safety while using the product, for example, concerning child-safety.</p>
<p><i>Space & weight efficient</i> refers to the package's ability to exploit the available balance and maximum load capacity (Twede et al. 2000).</p>	<p><i>Minimal amount of waste</i> refers to the package's generated waste to reduce environmental load and to reduce the costs of waste disposal process logistics flow.</p>	<p><i>Handle-ability</i> concerns the package's ability to facilitate easy manual handling. The package provides convenience for handling and storing the product.</p>
<p><i>Stack-ability</i> concerns effective pallet stack unitization in intermodal shipping. (Reinhall et al. 1998).</p>	<p><i>Product information</i> includes brand and information about the product such as table of contents and nutritional content to guide the consumer to choose the right product as well as the recognition of the products through distinctive labels enabling the point of sale to function on a self-service basis.</p>	
<p><i>Reduced use of resources</i> relates to the package's ability to reduce waste and emissions, thus reducing environmental pollution.</p>		
<p><i>Minimal use of hazardous substances</i> concerns that the package contains the smallest possible quantity of dangerous substances to reduce the burden on the environment and prevent users from injuries.</p>		

Table 1.1 Criteria for Packaging Logistics Performance

These criteria for Packaging Logistics Performance contribute in many ways in various logistics activities. Very rarely, all performance criteria interact at the same time, which causes irregularities when designing packaging able to perform as expected all the way from the producing agent to the point-of-sale agent. The expected packaging performance in logistics includes operations to ensure that all the requirements are consistently met in an effective and efficient manner. However, an acceptable balance in performance is vital, so that one set of performance dimensions will not affect another in a negative way (Temur et al. 2007). The required expectation on performance is normally defined by agents working together in the SDC, to fit a required product or service. To evaluate the performance of a packaging, one should measure the degree of fulfillment of the promises or duties of packaging system from many agents who are involved in logistics processes.

The Packaging Logistics Performance criteria and understanding how performance is vital for creating value for the agents in the SDC are the main issues that will be further elaborated and discussed in this doctoral thesis.

Scientific work surrounding the subject of packaging is increasing in areas such as packaging materials, packaging machinery, mechanical properties

of packaging, performance in transportation, logistics and design (e.g. Kumar et al. 2008). Continuous changes in demand and increased complexity (Milgate, 2001; Nilsson 2007) of the supply chain require greater precision in performance and efficiency in using resources as well as proper decision-making on a strategic level. Several packaging performance concepts in the past could be related to successful decisions made on a strategic level, for example the Coca Cola bottle (Lundby, 1986) that is also printed on Coca Cola cans; the bottle originally designed in 1915 to perform during sales communications with the consumer as well as being easy to grip during consumption. The second example is the toilet duck package with the S-shaped neck to allow concentrated cleaner dosages, and ease of dispensing the cleaner under the rim. The third example is the company IKEA of Sweden with its flat packaging concept (Drew et al. 1995), contributing to reduced shipping costs, minimized transport damage and increased store inventory.

Another trend in this area is that the packaging companies such as the converters are working closely to develop packaging-related services with the SDC. The increase in knowledge on the packaging organizations and its interactions with the SDC could broaden the understanding of Packaging Logistics Performance from a strategic and operational level.

Logistics activities, the packaging system, and interactions between these two are interesting to explore further from a Packaging Logistics Performance perspective. To sum up this section, a number of research problems such as the interaction of packaging and logistics, packaging performance logistics, the packaging supplier and its interactions and performance criteria, emerge as common denominators of this thesis. In the next section the research questions are defined.

1.2 Research questions

In the previous section, Packaging Logistics Performance was discussed and an overview of the research area was presented. The Packaging Logistics Performance could influence the competitiveness on a strategic level, and the complexity of the SDC has an influence on an operational level. It is therefore interesting to further explore the potentials of such perceptions by providing and increasing knowledge of the subject by raising the question:

How can the performance of Packaging Logistics be improved in the context of the agents involved and their packaging requirements?

The researcher and the practitioners might agree to disagree about the improvement of the Packaging Logistics Performance. Epistemologically, the research question influence how logistics knowledge can be further developed. However, the perception of the research question is related to a paradigm that evolves over time. It was concluded in the licentiate thesis (Dominic, 2006) that the phenomenon of Packaging Logistics Performance was identified, and to assess the performance, an overview of the interfaces where packaging interacts is of great interest. This thesis takes the next step, seeks answers by focusing on the following research questions, where division into sub-questions makes it easier to find answers from the research results:

How can a systematic and holistic approach to packaging increase the logistics performance to create efficiency and effectiveness?

The knowledge of inter-agent interactions regarding the Packaging Logistics Performance is complex and rarely investigated. The question deals with efficiency and effectiveness in logistics.

How can agents in packaging interact within the SDC?

The question focuses on the packaging agent and how it interact in the SDC. Further new functions and agents are identified and presented.

Can adaptation to the SDC produce products and services that are efficiently used by the interacting agents?

Agents who are integrated into the SDC deliver value that will improve the performance in packaging logistics. The question explores the agents, how it interacts with the SDC and the interconnectivity of the agents and new roles are studied.

What are the logistics activities for the agents involved in the SDC?

The right balance in logistics activities delivers expected value for the agents in the SDC. The question explores the activities in Packaging Logistics Performance that is becoming increasingly complex for agents to interact, and it requires adaptation to interact efficiently.

How does the complex adaptive system increase efficiency, effectiveness and differentiation for the agent interactions in the SDC?

Complexity emerges when the packaging system is put into action in social context. The question explores the packaging logistics performance in action and novel model is presented to improve the efficiency, effectively and differentiation.

How can Packaging Logistics Performance systematically studied in CAS?

The novel tool Packaperforma is developed and tested in case studies. The tool supports the theories of packaging logistics performance and it enables quantity studies of Packaging Logistics Performance.

These questions are answered by triangulating studies from empirical nature and analysis from the publications. Hence the research objectives have been reached in the appended papers and a synthesis of the results as well as suggestions for further research is provided in the chapter.

1.3 Research purpose and objectives

This thesis deals with the agents from a SDC perspective with different missions and explicitly the suppliers of packaging and the role of packaging to improve logistics performance. The overall purpose of the thesis is therefore:

to increase knowledge regarding the packaging and its interacting role with agents in the SDC in order to improve Packaging Logistics Performance.

This thesis aims to increase knowledge in the area of Packaging Logistics Performance. The importance of efficient Packaging Logistics Performance for the users of the packaging is widely acknowledged. Further, this thesis aims to improve Packaging Logistics Performance by learning and understanding packaging, how it interacts in a complex nature and how it creates value for user-agents in the SDC. The main focus is therefore to contribute knowledge to academia for its developments in this

field and to further develop the methodology in Packaging Logistics and initiate its implementation by publications.

1.4 Scope and demarcations

The breadth of contemporary research into SDC makes it necessary to set limits to the research area by defining the scope of this work. The thesis covers studies on packaging from the producer to the point-of-sale. Attention is paid to the insights of the end-users, often consumers, to include these as a whole. “Performance” in this thesis is defined in a qualitative manner covering the interactions in the inter-organizational relations among the agents and perceived value. The thesis attempts to define Packaging Logistics Performance, and a tool is developed to measure Packaging Logistics Performance in the SDC.

The focus of the research is on packaging, the agents and the interactions in SDC. However, packaging influences a number of other business and managerial areas besides logistics. Environmental aspects are also of great importance (Livingstone et al. 1994) and this has been kept in mind during the research.

As the focus of this research is on Packaging Logistics Performance, most attention has been given to interfaces and the agents. However, this does not mean that the research has focused exclusively on what is the outcome of the performance of the packaging in logistics. According to Jahre et al. (2004), there are extensive interactions between packaging and logistics activities, and these logistics activities involve a number of sub-activities that more or less interact with and are influenced by packaging (Hellström, 2007). This thesis examines the performance of the packaging interacting with logistics activities, but such an approach requires a holistic view on packaging and its interactions i.e. the behavior of the Packaging Logistics Performance cannot be fully predicted. The rich knowledge that is produced contributes to increase insight.

As indicated in the objectives, this research has been conducted in a range of different industries, e.g. packaging, pulp and paper, automobile, electronics and computers, white goods, retail, mechanical, soft drinks and brewery, pharmaceutical, fresh vegetable and meats, shipping and trade, and the studies have been mainly focused on supplies and customer in business-to-business situations. The driving force for the studies based on Packaging Logistics Performance with customer insights as general indicator is presented in the appended papers.

1.5 Thesis outline

Part I

Chapter I Introduction

This section describes the packaging logistics, SDC, Packaging Logistics Performance and strategy. It also touches on current logistics development and explains some of its possible outcomes. This chapter defines the research problem, and the purpose of the work.

Part II

Chapter II Taking CATWOE further with Packaging Logistics Performance

This chapter expands the CATWOE-tool (Customer, Actor, Transformation, World view, Owner, Environment) on Packaging Logistics to a complex adaptive system from a holistic approach. This chapter is based on a literature review and proceeds from Sagir's (2004) thesis where he applied CATWOE to Packaging Logistics in a systems

approach. This thesis goes further from a systems approach and considers packaging from a holistic view and sees the world from complex perspectives with a mission to deliver Packaging Logistics Performance to the user as well as to learn and adapt new situations

Part III

Chapter III Results

Based on the sub-questions, the finding gives support to the contributions by applying empirical evidence processed from five papers presented in summaries in this chapter. The papers are the basis of this thesis.

Part IV

Chapter IV Research process

This part explains the research journey and finds answers to questions such as: how did I do that? How will it influence drawing conclusions? Also, this part describes the research method chosen and the reasons for this choice, and the data collection and analysis method. The empirical information in the papers has been gathered through qualitative case

studies, supplemented by literature reviews concerning the packaging industry and Supply-Demand Chain Management.

Part V

Chapter V and VI Conclusions and further research

This part includes a full analysis and focus on Packaging Logistics Performance that has been transferred from the perspective of the agents in SDC. It summarises the work and discusses questions which have arisen during the study and provides a basis for conclusions and contributions today and in future developments. The presentation of conclusions does not mean that the problems are solved, rather that the research area of Packaging Logistics Performance is opened up providing a pathway to move forward and it also presents research area to be explored to sustain knowledge in the future.

Part VI Further Reading

Chapter VII and VIII References and appended papers

In this part of the thesis the reference list and appended papers are presented. These represent integral parts of research findings. The papers are:

Paper I “Packaging Scorecard – a packaging performance evaluation method”.

Paper II “Supply and Demand Chain Integration - a case study conducted in the packaging industry”.

Paper III. “Integrating Packaging Suppliers into the Supply/Demand Chain”.

Paper IV. “Supply/Demand Chain Management”

Paper V. “Holistic packaging development - integrating packaging, process and supply chain with a complex adaptive system approach”.

Paper VI. “Packaging Logistics Performance and How to Evaluate the Packaging Performance by Applying the Tool Packaperforma.”

Part II – Learning about the agent in complex adaptive systems

The whole is more than the sum of its parts. Aristotle, *Metaphysica*

2 TAKING CATWOE FURTHER WITH PACKAGING LOGISTICS PERFORMANCE

This chapter expands the CATWOE tool (Customer, Actor, Transformation, World view, Owner, Environment) by challenging Saghir's (2004) research on Packaging Logistics and goes beyond the system theory approach to complex adaptive perspectives with a mission to deliver Packaging Logistics Performance to the user as well as to learn and adapt to new situations..

As mentioned by several researchers, a systems perspective on packaging (Saghir, 2004; Hellström, 2007) and logistics (Bowersox et al. 1996) is essential in order to understand and avoid sub-optimization in SDC. Checkland (1999) introduced the CATWOE tool, is known to deal with problems management in situations where there are many stakeholders. The tool proposes six significant elements, commencing with the customer (C), the one who is directly affected by the system activities. The actors (A)

or in this work defined as agents, carry out the main activities of the system. The transformation is the input to the system that is transformed (I) to output. The world view (W) in its context (translated from the German for Weltanschauung) is considered here as the holistic view on the system with the boundary covering the SDC. Ownership (O) of the system has a complex view where the packaging system interacts and is expected to perform with the users in a preferred manner. Finally, the environment (E) is wherever the system efficiency is applied. The tool is further elaborated in the next section and onwards by viewing the Packaging Logistics Performance, the interactions of packaging in the SDC, as complex adaptive systems and goes beyond system thinking.

2.1 Customer

The customer or user-agent is the one who receives the results of the product or services from a performing packaging in logistics. All agents involved in the SDC are user agents of the packaging. However, not all agents could be fully gained by the packaging performance and interactions, e.g. the intermediate agents in the SDC. The concept of Packaging Logistics Performance depends on the output of the

transformations, where and when the packaging and agents interact, the discussion about the unfortunate connotations of a recipient of goods or services, whom the system is intended to serve as described by Taylor et al. (1999). Thus, in practice, it is all too easy to overlook noted beneficiaries or victims that do not directly participate in the analysis, such as the environment or the ones who are indirectly affected by the transformation.

2.2 Agent

System thinking is based on a collection of agents that are dependent and therefore represent a structured whole (Lübcke, 1988) whose parts are mutually bound by strict rules, laws or principles. Ackoff (1973) describes a system as a sum of parts put together but which are invisible as a whole. Arbnor et al. (2009) explain that in reality a system is a set of agents interacting with each other and that the relationships among the agents are described as an open system, and they further stress the significance in having a holistic view of the interacting agents, where all the properties of a given system cannot be determined, explained or understood without the sum of its components rather than the parts alone. In such a context, Nilsson (2005) argues that it is up to the researcher to choose what will be

the system boundary and what will be its environment. Reductionism in science is a complex system that can be explained and understood by reduction to its fundamental parts (Sengupta, 2010). The system in the SDC emerges when the agents interact with each other to produce products or services delivered to the user-agent. When an organization is a living system of human relations, systems thinking helps to more easily navigate the legal process and to achieve business objectives in a world where the demand is ever changing. During this transformations process, sub-agents and the surrounding environment are directly or indirectly affected by it. The definition of performance is a challenge for the agents involved in the SDC because organizations have multiple and frequently conflicting goals (Hall, 1991) in a multi-interaction environment.

2.3 Transformation

There has been little discussion about the notion of agent interactions (Bergvall-Kåreborn et al. 2004). Very few problems and how the term is understood among those who cause the transformation have been discussed. Jayaratna (1994) states that the transformation of the input and the output is considered as a black box, so that attention is drawn away from the inner nature and logic of the process itself. Here, performance

comes into play in a natural way. For the transformation process, the content of the input is expected to fit the conversion mechanisms so that the results of the output are highly satisfactory. Bergvall-Kåreborn et al. (1996) argue that the transformation should not be simplified so that it tends to generate a narrow transformation output with reduced creativity. However, Stacey et al. (2000) go a step further and propose that to think of organizations as systems might limit the innovations produced during the interactions. Systems thinking assumes a formative teleology in which agents seek predetermined outcomes. Therefore it is more appropriate to talk about organizing complex adaptive systems where the agents' interactions are vital for the positive outcome regarding performance. This perspective assumes as a transformative teleology (Ibid.) in which agents move towards an unknown destination in order to sustain both continuity and transformation. This is to stimulate collective identities that emerge from disorder towards order, through a spontaneous process of self-organizing without pre-determined proposals. When working together in cross-disciplinary teams, for example, the converting agent produces the packages, the branding agent owns the product, and this agent could also work as a product filling agent to the package. The distributing agent distributes the product from one point to another, the selling agent sells

the product to the end-user-agent and finally the post logistics agent distributes the used packages to incineration or sends them for reuse. The transformations in SDC refer to the conversion of the package to a product for further transformation as well as the transition of the product from one point to the next.

The performance is the difference between the expected and the actual outcome of the transformation (Lu & Yang, 2010). In logistics, discussions regarding output are comparable to customer value generated by the logistics performance. In Packaging Logistics Performance, the focus is set on the package that contributes to increasing the customer value. It would be beneficial to find some way of understanding the transformation that will tend to provide richness of data whatever type of situation is faced, and also allow the analysis to elaborate a wider range of transformation. Here, it is in place to elaborate this consideration by studying, learning and adapting to the performance of the packaging when it interacts with the agents from a complex adaptive system perspective.

2.4 World view

A world view is described, in this work as holistic view, a perspective that gives transformation its meaning (Basden et al. 2006). The holistic view is essential in analysis to gain fresh insight looking at the packaging system interacting with SDC from different perspectives and to understand the performance of the packaging in logistics. However, this holistic view is rarely acknowledged by the agents. Some might even question the existence of such in the system. At an operational level, one agent interacts with another to perform and to produce improvements for a particular user-agent. Here, a strategic holistic perspective among the agents from a supply demand perspective rarely matters. However, there are dangers in overlooking important perspectives, either because no agent holds them or because an agent holds several perspectives but offers only one during the interactions, leading to unwanted sub-optimizations among agents. This is a difficult notion to grasp as Checkland et al. (1986) describe. They distinguished generally from the society comparing perspectives from which the situation is seen as problematic. Another is modelling the agents, from which it is believed that a proposed system and the transformation bring an effective solution to the problem or, as Checkland (1981, p.220) puts it, a kind of ‘thinking cap’. However, a problem that should be kept in

mind is the trivial outcome (Checkland et al. 1999) in having a holistic view that ‘neither helps to discuss and explain differences in perspective, nor pinpoint what makes transformation meaningful’ (Bergvall-Kåreborn et al. 2004). Not all agents have the same view as an active participant of a modeled SDC. Mingers (1980) pointed out that conflict often arises when an agent in the analysis comes with a conflicting holistic view that will color the interpretations. The holistic view is not fixed and it could change over time (Checkland, 2010). Although a CATWOE tool analysis might reveal conflict, it does little to resolve the conflict. Here, efforts must be made to increase the understanding of the agents and their interactions. To increase the understanding on these conflicting situations, the complex adaptive system way of thinking is presented, taking CATWOE tool further from Sagir’s (2004) conceptual model as well as having an approach to Packaging Logistics Performance that is, according to Saghir (2004, p 62), a complex and difficult task. Packaging and the packaging system have a number of functions that should perform among many agents for their internal processes to function as expected as well as for the external logistical process.

2.5 Owner

More recently, authors have maintained that logistics performance measures are linked to corporate strategy (Lambert et al. 2001; Zacharia et al. 2004) and have to the owner of the system. Defining the owner of the packaging system has always proved to be complicated in a complex world. Often, when the packaging is filled with the product the packaging becomes a part of the product and the owners' interest in the packaging is increased by many agents, e.g. the producer of the package, the brand owner and the agent that operationally fills the product. Often, the owner is described as being the one who strongly benefits the system (Bergvall-Kåreborn et al. 2004) with the focus on responsibility rather with a prime concern for performance and differentiating its concept. Checkland (1999) explains that the owners as those who that could prevent the transformations process. However, this explanation is arguable since there are other agents or sub-agent who might have the power to prevent the transformation process e.g. due to malfunction on the packaging machines or to failures in the agents in the secondary systems that directly impede the efficiency and effectiveness of the transformation processes.

2.6 Environment

The environment is assumed to be a wider system than the context of packaging interacting with the SDC. Reducing the complexity to the SDC level, the Packaging Logistics Performance has an impact on wider system during transformation, for agents and for owners of the supply-demand chain. Holistically the challenge is to identify constraints. Lockhart (1996) describes the environmental factor as being physical, atmospheric and human. At an operational level, there is a tendency for important constraints to be overlooked and to focus on very general constraints and to be satisfied with conventional ones like cost and time. Bergvall-Kåreborn et al. (2004) suggest it would be beneficial and improve understanding to consider the environment as a diversity of constraints, internal as well as external.

2.7 Towards a complex adaptive system

In this chapter, CATWOE tools were further elaborated by Saghir (2004) to adapt to Packaging Logistics theories. The systems approach provides a fundamental contribution to shifts in the perception that may also apply for Packaging Logistics Performance. The concept of Packaging Logistics Performance is an integration of multidisciplinary aspects of packaging that

cover various sets of packages that are inter-related in building a packaging system during its life-cycle and interacting with different levels of interfaces. A packaging system as such could be considered to be a hard system and, when adding the methodology to build the packaging system, it becomes a concept that could be viewed as a hard-packaging-systems-approach (abbreviated as HPSA, comparable to Checkland's (1993) hard system) emerges. Saghir (2004) defines Packaging Logistics as where and when the packaging system interacts with various logistics activities, and the main focus is on the interactions of the HPSA with the logistical activities where efficiency, effectiveness, value and profits are as a whole considered. This way of thinking was described by Downs (1989) who was seeking for a clear definition for packaging logistics, in order to apply a systems approach. Further, in Saghir (2004) considered an exploration of the concept of Packaging Logistics by studying soft-system-methodology (abbreviated, SSM, comparable to Checkland's (1993) soft system), Saghir (2004) argued that SSM methodology is highly applicable for the concept of Packaging Logistics. This is the starting point of this thesis, having a perception that covers multidisciplinary nature with sociology and a holistic view when focusing on the concept of Packaging Logistics Performance. However, the SSM has its weaknesses. It is crucial to model the real world

in detail so that lessons can be learned by the abstraction (Basden et al. 2006), for example the output of the transformation does not fit all the interacting agents, specifically in packaging where there are variations in demand (explained further in the licentiate thesis, Dominic, 2006). To increase learning about Packaging Logistics Performance, we must keep the CATWOE tool and complex adaptive systems in mind. In the next chapter details will be discussed further by putting them into practice to increase empirical relevance to Packaging Logistics Performance.

**Part III – Summarizing results and identifying Packaging
Logistics performance**

Simplicity does not precede complexity, but follows it.

Alan Perlis

3 RESULTS

For the reader's convenience, the appended papers are summarized in this chapter. To understand Packaging Logistics Performance, the SDC and the agents interacting with packaging are presented here. As mentioned earlier, the SDC is described as an open system that is modeled when the Packaging Logistics Performance is studied during its interactions with the interfaces. This chapter seeks answers to the questions posed in chapter one and thereafter it summarizes the results to seek the answer to the research question of this thesis.

3.1 How can a systematic and holistic approach to packaging increase the logistics performance to create efficiency and effectiveness?

Normally the agents interacting with the packaging have substantial experience of the requirements and expected performance delivered by the packaging to the agent. However, the knowledge of the inter-agent interactions regarding the Packaging Logistics Performance is rarely shared with all the agents in the SDC where the complexity is

growing. Packaging is becoming an increasingly significant component to create efficiency and effectiveness in logistics and it should be well integrated to provide the expected logistics performance for each agent in SDC, and to understand the Packaging Logistics Performance a holistic approach to SDC is required. To increase understanding and to evaluate the Packaging Logistics Performance, the tool Packaging Scorecard (PSC) was developed and applied to conduct case studies.

The perspectives chosen are those of different agents involved in activities in a particular manner. For each agent, the Packaging Logistics Performance was evaluated. The PSC was intended to support a common goal for all the agents involved in the SDC.

Based on the research regarding Packaging Logistics Performance, a theoretical framework was created. Thereafter a method for data collection and calculation of the collected data was developed. This method ranks the most important criteria for each agent interacting with other agents that serve as a basis for evaluating the Packaging Logistics Performance as a whole. The methods for gathering data for each agent were of a qualitative nature. These agents possessed considerable knowledge about the packaging system interacting in different tasks at an operational level. Scores were given for each significant criterion. Thereafter the scores were plotted on standing bar charts. The PSC tool was applied in two different types of packaging systems selected in the Fast Moving Consumer Goods (FMCG) industry. The selected package presented here is a refill product for jam. The result is presented in the bar chart, figure 2.1, where the

consolidated packaging scores are summarized. The manner in which these figures are obtained is described in Paper I. The maximum possible score was 4.0. The score level indicates a generally well-performing package.

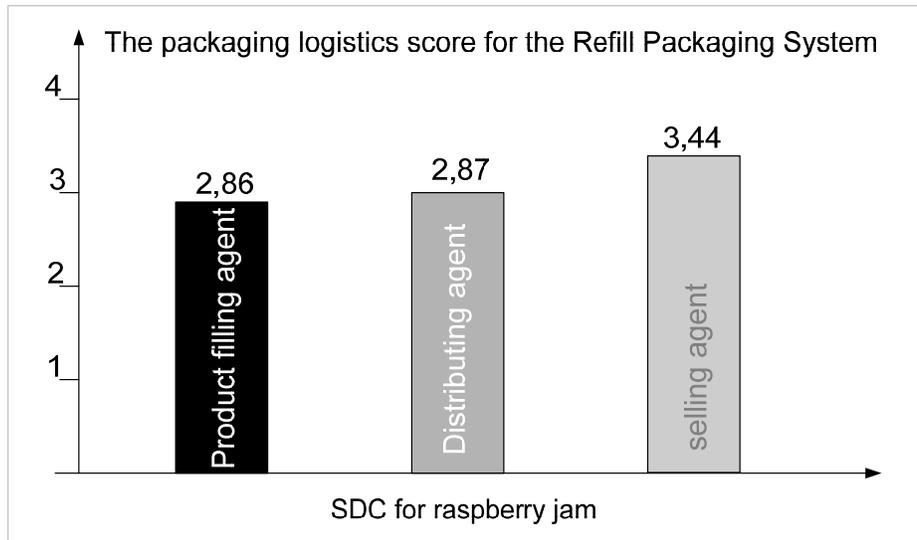


Figure 3.1 the packaging scorecard for the Refill Packaging

To interpret and evaluate the Packaging Logistics Performance, the scores must be analyzed at a lower criterion level for each agent. The Packaging Logistics Performance criteria are presented in table 1.1. At the product filler agent, the score 2,86 indicates the total logistics performance of this agent. At the distributing-agent, the score 2,87 indicates how the packaging system is performing with that agent. A comparison of the scores from product-filling-agent, distributing-agent and retail-agent indicates that this

packaging is underperforming at the first and the second agents while the packaging is over performing at the retail-agent. The results were useful for the agents involved in that SDC in their efforts to develop and produce a better packaging system. The information behind the scores was valuable to enable the agents to make detailed adjustments in the packaging system. The method consolidates the expectations of the packaging system in an interpretable form.

The Packaging Scorecard is a useful mapping tool for the agents engaged in logistics activities. The strengths and weaknesses of the packaging system are identified in a systematic way, applying a holistic approach.

3.2 How can agents in packaging interact in the SDC?

To become strong participants in a SDC, agents establish close business relations to create competitive solutions for the end-user-agent. The packaging involves several agents working actively with the mission to create efficiency and effectiveness. The aim of this study was to explore the packaging agents and how they are organized, to analyze the development of these agents, and to identify the synergies that occur in logistics when packaging agent are given greater responsibility interacting with the agents in the SDC.

The deeper interactions with the agents in the SDC have increased the potential of the packaging agent to provide packaging that creates higher value and the Packaging Logistics Performance has been improved, leading to better profitability for the agents involved in the SDC. Some studied packaging agents had developed further, with a greater knowledge of different systems to actively offer full responsibility in managing the packaging, logistics performances for all agents. The packaging agents selected for the study were sorted according to their line of business based on the packaging material. Altogether, seven agents were studied and their positions in the model are shown in figure 3.2. This figure shows that most of the studied agents are found in the inner circle of the model, which indicates that most packaging-agents are working on developing the packaging system rather than on improving the services for their interacting agents.

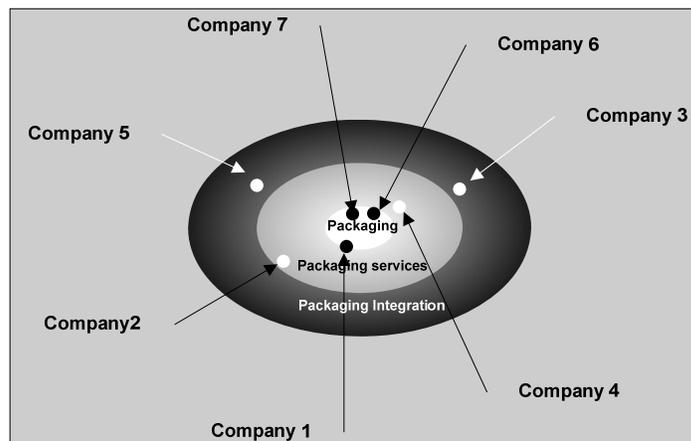


Figure 3.2 the studied agents positioned to serve its interfaces

There are great similarities between the packaging agents in the inner and outer circle. The group of packaging agents in the outer circle have expanded and moved outwards in the model by adding packaging-related services. Among the studied agents, two agents with skills to integrate SDC were found. One was a pure converting agent that, with increased expectation from the agents within SDC, has developed outwards from the inner circle and now takes full packaging responsibility for the packaging in the system. The second was a skilled logistics agent with a good knowledge of packaging who had outsourced packaging and logistics services to external parties and was himself acting as a co-coordinating agent. The results of this study show that the agent-integrating functions of packaging delivered not only the desired Packaging Logistics Performance but created profitability by reducing stock and by replacing it with accurate information leading to improved logistics performance.

3.3 Can adaptation to the SDC produce products and services that are efficiently used by the interacting agents?

Agents who are not playing an integrated role in the physical flow lead to information gaps in synchronizing the physical packaging flow with the information flow, and this reduces the performance in packaging logistics. An agent who is vertically integrated into

the SDC and adapted to its non-static structures will deliver value that will improve the performance in packaging logistics. The aim of the research was to understand the interconnectivity of the agents, to study the competitiveness of the agent, and to contribute knowledge for the weaker agents. The leading agents in this field and the network-integrating agents were studied.

The selected agents were taking part in various logistics activities in the SDC. They operated in different industries such as:

a computer integrating agent,

a consulting agent specialized within Network Integration,

a manufacturing agent for automobile engines,

a white goods logistics agent, and

a transport and shipping agent.

The studied agents mentioned how they rapidly adapted to other agents offering services that are differentiated and customized. All the agents mentioned the importance of learning and quickly adapting to offer the right type of services in order to increase the Packaging Logistics Performance.

All the agents mentioned that the driving forces were the user-agent and that these who could learn and adapt in different situations could best survive the fluctuations of the demand.

3.4 What are the logistics activities for the agents involved in the SDC?

Emergent structures in SDC are the outcome of the interaction of logistics activities resulting in individualized value for the user-agent as well as a sustainable growth for the agents involved in the SDC. The complex adaptive systems are organized to meet demand-pull activity rather than supply-push. Development in this area has improved with the implantation of new technologies and it has differentiated the competitiveness among agents. The logistics activities are driven by aggregated demand flowing in a direction opposite to the physical material flow. The demand from the user-agent is the driving force for planning, production, packing/filling, distribution, storing and sales. Post-sales activities regarding packaging are also included here. The SDC is undergoing changes; new techniques, for instance e-business that have also influenced the design of packaging. There is a growing development towards controlling the customers' inventory solutions, and the identified packing services, storage and distribution are examples of services with which some major packaging suppliers are familiar and that have served as natural links in the distribution systems.

Packaging Logistics is defined as an approach with the purpose of developing packaging and packaging systems that support the logistics process and meet user-agent's demands. In logistics, a well-functioning packaging system creates time, place, form and ownership benefits. Figure 3.3 illustrates Packaging Logistics activities and presents the Network Integrator (plotted in the middle) and its interactions with the agents. The role of the Network Integrator is to integrate the supply chain with the demand chain.

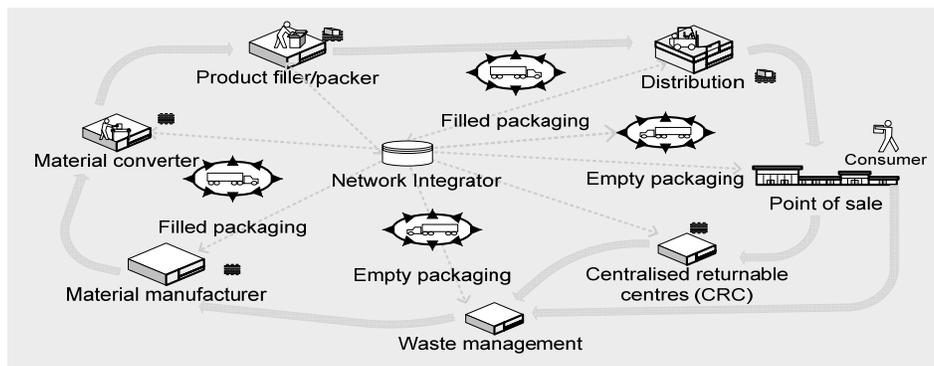


Figure 3.3 an overview of agents in a complex adaptive system

To increase the Packaging Logistics Performance, the package should be designed to interact with many agents such as storage and sales, and to reduce waste management. The role of a packaging agent in logistics is often limited to interacting with the packing agent in the SDC.

The SDCs are becoming increasingly complex for agents to interact, and it requires adaptation to interact efficiently.

3.5 How does the complex-adaptive-system increase efficiency, effectiveness and differentiation for the agent interactions in the SDC?

Complexity in a packaging logistics system emerges when technical systems are put into a social context. The complex-adaptive-system (Nilsson, 2005) not only covers the physical and information-related parts but also, the perceptions and interpretations of decision-makers working with physical and information flows. Factors such as interdependences among the agents in supply chains, and other emerging phenomena such as resource reductions in logistics operations or legislative changes ought to be considered. The specific performance of packaging in the SDC is the result of an interwoven network of aspects, often unknown in the system, but valuable for all the agents affected. For managing agents the interaction involves co-ordination with other SDC agents in order to minimise costs, create effective logistics and distribution operations which provide customer value. There great potentials

in increasing competitiveness and efficiency for the agents involved, however the complexity in SDC are increasing as the number of interactions, coordination and collaboration increases.

In the process of packaging development it is common that each agent is only requiring for specific performance in its part of the SDC (Chan et al., 2010). Small modifications could have a greater output across the SDC. However, such impacts are not always easy to detect among all agents what may lead to inefficiencies from a holistic point of view. Unless consideration is given to SDC dynamism and complexity when packaging systems are being developed, there are risks of sub-optimisation which may create unnecessary waste of time or resources, product damages and SDC costs (Fugate et al., 2006). A conceptual model, inspired by the 3-Dimensional-Concurrent-Engineering (3DCE) (Fine, 1998), providing suggestions for modifications and redesign was developed. The packaging scorecard was remodelled and extended to gather both social aspects and technical information regarding packaging performance, and to provide guidance, as well as commitment and common understanding, for further packaging development for the agents involved.

Complex adaptive systems (CAS) are the property of adaptation i.e. the agents in the system are responsive, flexible, reactive, and often proactive, regarding inputs from other agents or elements which affect them. The agents in the

distribution system are considered to include both the agent as well as its interactions with the packaging system. As a result of individuals' actions and their interpretations of the outcome of other individuals' actions, global phenomena emerge. These emergent phenomena can be new packaging concepts, changed logistics processes and/or increased agent knowledge. The complex adaptive system approach provides a perspective on the different factors and aspects which influence and affect packaging on its way through the distribution system from the different agents' perspectives, as well as on the emergent outcomes which come from interactive actions. Holistic packaging development concept covers complex and dynamic factors like social and managerial processes into traditional technical and reductionist areas. It is often found that small changes in a packaging system can lead to major changes for the entire SDC, thereby increasing SDC efficiency. Furthermore, it ensures by increasing knowledge of the packaging system and how it interacts with its agents and performs to fulfill requirements along the SDC. The section describes a case study based on these discussions.

The diagram in Figure 3.4 shows a consolidated flow of how packaging is filled and assembled at the product-filling agent's, re-packed by the distribution agent, and disassembled at the retail agent's. The related agents are presented in rectangular boxes.

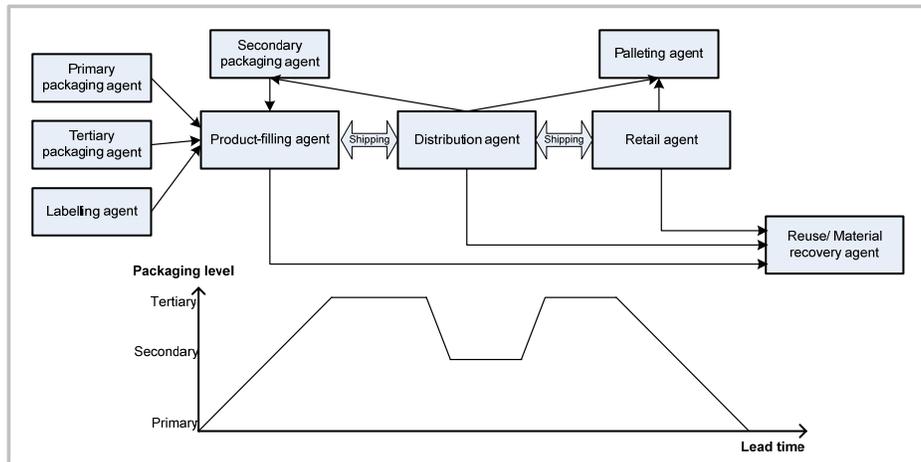


Figure 3.4. Packaging system for fresh product and its interactions with the SC agents identified in this case study.

The case study conducted is based on packaging development concept (see Table 3.1). The performance indicator value in Table 3.1 is the current performance of the packaging system.

Table 3.1. the packaging systems studied and performance indicator value.

Case Studies	Primary packaging	Secondary packaging	Packaging system	Performance indicator value
Fresh food industry				2,63

Figure 3.4 illustrates how packages containing different products were placed. The colour-coded labels were pasted onto the trays and this helped in the

process of re-sorting the trays. Each colour on the labels illustrates how the packages were placed on the pallet before and after colour labels were attached. This small adjustment led to reduced re-packing time at the distribution agent by half an hour per load carrier.

A workshop was conducted to elicit input from the agents in the SC. From this assessment, visualisation of results is the input for the agents to interact, mainly with the aim of creating increased efficiency by reflecting, discussing and creating packaging modifications, process improvements or SC set-up changes. Emergent outcomes concerning modifications and innovations are the results of this interactive process, as well as increased understanding and knowledge-sharing among the agents.

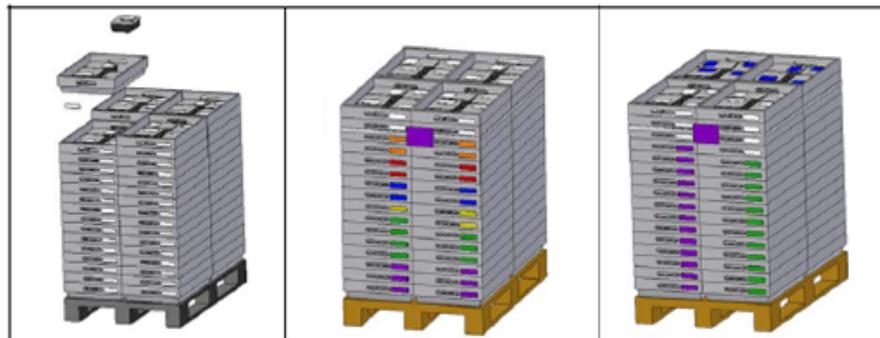


Figure 3.4. The trays labelled white (figure on left) show the unsorted fresh food packages arriving at the distribution centre. Coloured labels (middle figure) made it easier to sort and re-pack the system (figure on the right).

By implementing colour-coded labels the performance-indicating value was raised by 15 per cent. Figure 3.6 presents the details before and after the concept of holistic packaging development was used. This small change in the system contributed to a major change in the downstream SDC.

Current performance indicators		Predicted performance indicators after adjustments	
Criteria	Performance indicator value	Criteria	Performance indicator value
Information flow	2.7	Information flow	3.0
Minimum of toxic substance	3.0	Minimum of toxic substance	3.1
Handling	2.5	Handling	3.0
Machinability	2.0	Machinability	2.7
Packaging cost	2.0	Packaging cost	2.3
Selling capability	2.5	Selling capability	2.7
Reverse packaging management	3.0	Reverse packaging management	3.1

Figure 3.5. performance before and after holistic packaging development stages.

3.6 How can Packaging Logistics Performance systematically studied in CAS?

Well designed packaging systems improve the Packaging Logistics Performance. According to Hellström et al. 2007 packaging influences the supply chain effectiveness since it is an interface between the activities in the supply chain and user. However, there are still many gaps in understanding interaction of packaging in the SDC. To bridge the gaps,

improve packaging designed process and to understand the agent's demands on packaging systems in various logistics activities, the tool Packaperforma¹ was developed. The tool simplify data gathering for storing packaging performance data and to suggest improvements.

The information about the packaging interaction with the agent is collected and analyzed in order to find the performance at the interaction point. By further analysis, suggestions to improve the packaging related performance is provided.

The tool describe generative rules by analyzing and comparing the strategies applied by agents during it interaction. These rules provide agents the information which can help packaging developers to clarify the nature of interaction and choose better strategies or characteristics for the packaging and packaging system.

The tool defines a guide for the packaging developers to comprehend the information they need to optimize the

¹ www.innventia.com/packaperforma

system. The packaging fulfills its task through performing during the interaction with agents. This is also valid for the secondary agents, but considering that the characteristics of agents are specified and rather hard to change or adapt to the system, the focus is mainly on the characteristics of packaging. Thus, the tool helps to collect the information generated in the interactions, then evaluate the characteristics of packaging systems, and finally it analyze the information in order decide generative rules that guide user to suggestions for improvements.

Considering that packaging systems have several performance criteria, the contribution of each criterion to overall weighted performance should also be defined. Hence, information collected from the interaction points between packaging systems and the agents should show the importance of each criteria and the extent of fulfillment of those criteria in the interactions point. This information should be gathered and analyzed to guide the packaging developers to the best possible characteristics of packaging systems. This can be achieved by

comparing the characteristics of different packaging systems in fulfilling the performance criteria.

To calculate the importance of each criterion, the tool Packaperforma is supplemented with two different data gathering modules; one to provide data to in pair-wise weight the criteria and the other is to provide data for define the current packaging logistics performance. By applying these modules the importance and the performance of criteria are attained and the overall weighted average performance of the packaging system can be calculated.

Each packaging consists of different design characteristics such as shape, size or material. These design characteristics are usually called attributes of packaging. Each attribute has several levels; for example plastics and carton board can be the levels of material attribute. In this study, it is possible to alter different characteristics of packaging and keep the other ones constant. This alteration makes it possible to search on causal relationships between design characteristics of the packaging and their performance. In some situations, it may not always

be possible to alter packaging characteristics and keep all other variables constant. For example the agent at the point of sale has different characteristics such as location, type of equipment and size.

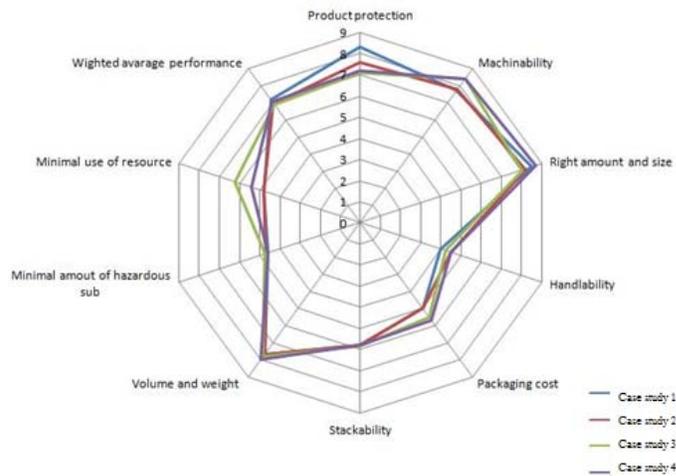


Figure 3.7 – performance of packaging system in a radar chart

The figure 3,7 presents the studied cases in a spider diagram. The performance criteria are from most important to least important criteria. The colors represent the studied cases and how the packaging system is performing, delivered to the same supply chain. The tool provides the fulfillment of the performance criteria, facilitates the information sharing

between agents and differentiate the performance of the packaging systems.

3.7 Summarizing the results

A high performing packaging system means logistics efficiency (Chan et al. 2006). However, not all components in the packaging system are equally significant for all the agents. Most commonly in a business-to-business set up, the user-agent looks for a specific performance of the packaging. The customer and also the customer's customer, who gain benefits from the performance or are affected by it. To study the Packaging Logistics Performance and to measure how the packaging is performing in logistics, the Packaging Scorecard tool was developed and applied in case studies in several industries. The results from these studies show that most of the packaging systems are designed to perform well at the point-of-sale agent. Further, this tool provided an overview of the Packaging Logistics Performance in the SDC. The studies resulted in scores that were valued by the agents. However, the tool has its limitations. According to Hellström, (2007), the Packaging Scorecard only identifies packaging weakness and does not suggest any solutions for improvements. This was

considered in paper V, explains that to increase the knowledge, the packaging system should be studied according to a more complex adaptive systematic approach. Factors such as dependencies among the agents, human factors and emerging phenomena such as resource reductions are included in this work. The packaging Scorecard was re-modeled by redeveloping the methodology, simplifying the data-collecting process and adding conceptual frames which helped to justify the results and generate solutions to improve the Packaging Logistics Performance.

Expectation of the performance of packaging in SDC is increasing considerably, as could be noted where the role of packaging has also been studied by many (see for example, Jönsson, 1997; Sörås, 1999, Jahre and Fabbe-Costes, 2006). It is often difficult for the converting agent to gain access to the information on how the packaging is performing in logistics. This could be explained to some extent by the relationship to the SDC that is on an arm-length basis. These studies were presented in paper II and III. The finding from these papers was the agent Network Integrator that plays the role in integrating agents contributing to narrow the gap in SDC. From a learning point of view, the Packaging Logistics Performance presented in these papers has a qualitative nature with the objective of studying the interactions of the packaging and agents in SDC, resulting in quantified

scores that are valuable for the agent involved in the SDC, including the end-user.

Smaller volumes of products are required because of self-service concepts, and security has also become more accountable for the distributing agent as well as the user agent who wants to know the product's place of origin, for example if something turns out to be wrong with the product. For food in particular, there is a demand for knowing where and how the raw materials were produced. This requires more accurate labeling of products and their packaging. Further, the design and choice of packages has become an essential strategy for the reduction of waste in order to reduce their environmental impact (see also, for example, Wu and Dunn, 1995; Andel, 1996; Stock, 1998; Jahre and Onsrud, 2001). In a broader context, paper II deals with the agents' demands, how they change from time to time and how to adapt to these situations. These changes put a pressure on how to design packages that are material-efficient and easy to recycle and provide efficient transportation, warehousing and handling while at the same time providing better possibilities for branding and communication. This was further elaborated in paper IV. Studies of the agents in internal and external transformations processes and insights are presented. Lessons

learned from this study were the role the agent plays in SDC and how it is organized to adapt to the SDC.

Many requirements for Packaging Logistics Performance give potential trade-offs between three basic functions; marketing, logistics and environment (see, for example, Stock and Lambert, 2001; Kassaye and Verma, 1992; Johansson et al. 1996), which implies that an increase of value in packaging with regard to one specific requirement may result in reduced benefit with regard to another. To avoid sub-optimization, packaging should be designed with regard to the different requirements (Hanssen et al. 2001). It is suggested, however, that more studies are required in order to expand the knowledge of potential trade-offs. Andersson (1992) builds on the concept of a trade-off between adaptation and adaptability. Weick (1982) claims that too much adaptation can lead to less adaptability, i.e. it becomes harder to change because more elements are adapted to each other and are thus affected by a change. In line with this, adaptations to the Packaging Logistics Performance could lead to less adaptability to usability or environmental performance or vice versa. This chapter highlights the Packaging Logistics Performance by implementing the tool that can suggest improvement. The agents, their interactions with

the SDC and how the agents interact with the SDC are suggested. By increasing and applying this knowledge, the agents can improve their efficiency and effectiveness and, through packaging, create value for the users and the SDC. Before drawing conclusions the next chapter will elaborate the research process used in the work described in this thesis.

Part IV

"The line between disorder and order lies in logistics..."

- Sun Tzu

4 RESEARCH PROCESS

This chapter discusses the choices made and the research strategy, approach and activities adopted during my research journey with the quest to provide knowledge for Packaging Logistics Performance. Before conclusions are drawn from this work, the reader needs to understand the paradigmatic evolution that has occurred during my journey, and this chapter shares the light that has been revealed during this research process. First a background description is given, followed by the approach methodologies applied in this work and the chapter concludes with a discussion.

4.1 Research journey

This research journey commenced when the conditions and the framework were set for the work described in this thesis. It is now moving towards a destination that is in the process of being explored to identify my contributions. An exciting voyage requires reliable fundamental support from a theoretical basis that has been designed during the course of this journey. In the initial stages, the areas of performance, packaging and logistics were examined and one contribution is the Packaging Scorecard

tool. In addition, business logistics, the supply-demand chain, e-logistics, vertical integration and reverse logistics were studied to increase the understanding of the agents and how these agents were organized. These empirical studies were supported by theories from the complex adaptive system to increase the understanding of the interactions and performance since CAS (Choi et al. 2001) had shown great applicability to provide an understanding of SDC and the interaction of the packaging with it. To fulfill this journey, other knowledge and tools were also required such as computer-aided software and CAS-modelling to visualize and model the dynamics of the problem, and this further helped to reduce the complexity to a more manageable level. Idealizations with models are necessary in science. They help to generate a theory ground, although one must never forget reality, after all reality is more complex than models (Hansson, 2007).

Once begun, the journey had an approach somewhere between subjective and objective, or intersubjective, with the ambition to gather knowledge in this area. During the period as a practitioner, I was involved in various business logistics activities in the area of purchasing, procurement,

production, inventory and management, shipping, outsourcing and ICT-developments in various industries such as health care, automobile, paper, pulp, and mechanical engineering. This period provided me with rich practical knowledge as well as an insight into the lack of reliable theoretical knowledge, on a strategic level and horizontally, interacting operationally with the supplier customer and the end-users. I started my research work with an immense interest in learning more and with the goals of providing the practitioner with new concepts and of helping academia by providing knowledge to further fill the gaps in the theory. It was not always obvious from the beginning that the path of the research topic was consciously set from the initial stages although it had developed towards the area of SDC, Packaging Logistics and the applications of complexity theories and complex adaptive systems. The contact networks with the industry that were created during my time as a practitioner enabled me to further evolve these contacts during the research period to try my concepts that had later developed towards the studies described in this thesis. The thoughts that later led to introducing the agent Network Integrator were an outcome of the contacts that had led to interview studies. During my research, I was practically involved in packaging and logistics activities in different processes that gave me a good insight into developing methods and also

provided me with valuable empirical insight and data to find support for the developed tool, the Packaging Scorecard.

4.2 My approach

My logistics background both in practice and in theory opens many opportunities to select a line of research in the search for improved Packaging Logistics Performance in the SDC. Although not the first choice, packaging and packaging agents were selected because packaging has various inputs that go through certain processes to add value and increase the logistics performance. If one part of the system is altered, the whole system will be affected. Very soon I realized that this system approach provided a good snap-shot on efficiency, effectiveness and the differences during agent interactions. Nevertheless, the system approach has a tendency to ignore information that could be valuable for the outcome of the overall performance, leaving out other agents with the same mission in logistics (Nilsson 2005). The advantage of selecting packaging and how it, as a whole, serves to increase performance in logistics was interesting to study from SDC perspective. The core

packaging could be regarded as a functional component providing multi-services for all the SDC. However, selecting a packaging system as the denominator could cause confusion, the difficulties in recognizing the packaging when it is filled with the product and when it move far away from the designer of the packaging, so that it then becomes a sub-system of the product, see figure 4.1. Packaging is tangible when it is at the starting point at the product filler, but it becomes an intangible logistics performer when it moves towards to the user-agent.

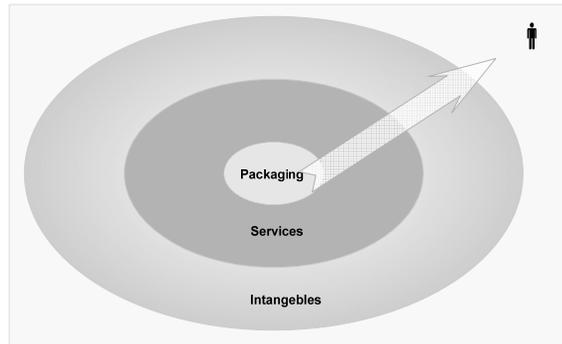


Figure 4.1 packaging as an intangible service provider

Packaging and the packaging agent in the study was also selected for practical reasons, since the research institute where I conducted my research work, in logistics provided opportunities to further develop my work by associating specifically with the packaging agents in the SDC.

Putting these components together, an approach emerged for this work. The work included the following phases: literature reviews, case studies, and interview studies.

4.3 Literature reviews

The literature review sought to find sources covering the subject and cases similar to this work. Since the topic covers various disciplines, a broad and extensive review of the literature was conducted continuously over in a spectrum of topics such as logistics, packaging, performance, Packaging Logistics Performance, performance related with management literature, packaging and performance literature combined with: marketing, logistics, environment, machine, communication, sales, strategy, engineering and design, transport, distribution, retail, reverse logistics, ergonomics, brand owners, packaging and product integration, and efficiency and effectiveness. There is a paradox in the implementation of reliable performance systems, and academic studies question whether the use of a performance system leads to specific benefits (Ahn, 2001;Ittner et al. 2003; Said et al. 2003; Sandt et al. 2001; de Waal et al. 2007; Lawson et al. 2005).

Attempts have also been made to review the trends in logistics research with tangibles on packaging. A general search among academic and management databases on the topic initially generated very few matches. However, searches for logistics performance management increased the hit rate. Most of these sources were purely conceptual, theoretical or anecdotal in nature. Measuring key performance such as cost of manufacturing, business value, product quality, or time to market and internal company performances was the most frequent subject found in the articles studied.

A broad literature review is important when dealing with a multi-disciplinary subject such as Packaging Logistics Performance that is yet to be fully explored. However, some researchers (e.g. Paine 1981; Pålsson, 2009) have studied specific component in logistics i.e. technological performance criteria. The approach taken in this study of Packaging Logistics Performance is a cross section study mainly inspired by the work of Neely et al. (2000), Saghir (2004) and Arivis et al. (2010) on performance, Packaging Logistics and logistics performance indicators.

The focus of the literature reviews has been on major journal such as Packaging Technology and Science, Journal of Business Logistics, Journal

of Supply Chain Management and Harvard Business Review. During the review, I experienced tendencies of shifts from supply-push strategies towards demand-pull strategies. Also, there is an ongoing shift in logistics research that is tending to move towards qualitative research as well as diversity in the conceptual approaches being noted during the process. Packaging literature is on the growth. The literature reviews in several disciplines revealed that there are few and rather vague descriptions on the subject of Packaging Logistics Performance related to the specific topic of SDC, packaging and the packaging agents. To holistically understand logistics performance and the driving forces for the agents in the SDC, the system approach, a predominant approach in the literature (Bowersox and Closs, 1996), was closely examined.

4.4 Case studies

The driving forces may be variable for different agents involved in a logistics process that directly have an influence on the process, and subjective aspects should also be taken into consideration in assessing Packaging Logistics Performance. The subjective value in one dimension is

not always easy to quantify. One way to detect the information and thus increase understanding is by conducting qualitative research studies. The fundamental feature of qualitative research is that the explicit intention is to study and express a phenomenon (Alvesson & Sköldbberg, 1994). The main object is to acquire information that cannot be gathered merely through observation (Silverman, 2001) or by analyzing quantified data. To gain a broad knowledge and understanding, I decided to conduct case studies.

I have, according to Yin (2003), been engaged in documentation, direct observation, physical artifacts, interviews and archival records to collect data. It was decided to conduct case studies for two reasons. The first was to test and learn more about the Packaging Scorecard tool. The results of using the tools were analyzed by triangulation and thereafter the results were checked with the case company studied. The logistics theory that was developed served as a basis for studying the packaging and the agents involved in SDC.

The second reason for selecting case studies was to investigate the Packaging Logistics Performance in the SDC. The Packaging Scorecard tool was designed to study and measure the Packaging Logistics

Performance interacting with the users-agents, and the tool also examined the packaging system performance in SDC.

Several types of industries and SDCs were chosen for the data collection process. Most of the selections were made with the ambition to conduct case studies in different packaging flows. However, to reduce the financial constraints, established contact networks as well as the member register for the packaging interest club, the private owners association for packaging, were used. The contacts with the organizations ranged from senior executives to middle managers and operational employees. The selected cases resulted in many interesting findings that has broaden the insights on how the SDC work in practices and how to develop the theoretical foundations. The diversity of the selected cases provided knowledge of this phenomenon from different angles, and this gives strength to understand how to increase the Packaging Logistics Performance, and the strategic role of the packaging and the packaging suppliers. Further the case studies gave an increased insight on how the Packaging Scorecard tool work in practice, how the Network Integrating agent work in practice and how packaging interacts in the SDC. The increased insights have

contributed to define Packaging Logistics Performance presented in this work.

4.5 Interview studies

Interview studies were carried out with agents from the packaging, the product fillers, the distributor and the point-of-sale. The selection of the agents was based on the size of the company, the line of business and its customers, company market area, domestic and foreign market, existing in databases and also the willingness to talk part in interviews. Before the interviews, background studies into the companies were carried out, observations and, where necessary, follow-up interview clarifications were sought. Further the bits and pieces of information such as company hand-outs, studies of the company strategy and policy or studies of how the company solved its day-to-day tasks helped to strengthen the answers. The main reflections from these meetings were that the agents were mostly

driven by the motivation to perform their own task as efficiently as possible. However, motivations fluctuate depending on the uniqueness of the situation, sociological factors, green thinking, power balances among the agents and total cost discussions also influenced the outcome of their functions.

The interviews with agents in packaging, SDC, Network Integration and Packaging Integration resulted in the work presented about the leaders in SDC management and the studies on Swedish packaging suppliers. The study follows the path of the packaging system in relation to the agents involved in the SDC. This was done to increase insight, and to generate theory and methods applicable to the agents. I initially conducted some pilot interviews of a conversation-like type with the purpose of making the interviewees speak as openly as possible and through their language to express their personal understanding, and experiences and to provide information to create a clearer picture of their relations to other agents in the SDC. The collected data were first observations, actively or passively taking part in an activity related to the questions of a practical nature, and thereafter interviews.

4.6 Methodological reflections

Having explained the research methods in the previous sections, attention must be given to an assignment of strengths and weaknesses of such an approach in the present context. The strengths are:

- the quality of the data obtained gives good reliability for further work in this subject.
- studies on packaging, the agent Network Integrator, the Soft System Methodology,
- the further development of the methodology to model the interacting agents,
- in order to understand how the model contribute to improve Packaging Logistics Performance.
- the reliable data quality helped to verify the results and validate to the methodology by conducting case studies.
- sub-optimization is avoided

The main weakness of this kind of approach is:

- it does not focus on one specific methodology and one could argue that there is a lack of depth studies on a single agent.

The aim was to provide knowledge in the area of Packaging Logistics Performance, which interacts with a wide range of agents as it was presented using the CATWOE tool. Altogether, twelve case studies were conducted. Features such as Network Integration, Packaging integration and the Packaging Scorecard make significant impacts on understanding and interoperating the result for the agents involved. The demand is the aggregated requirements of the users of the packaging, and this differs over time. The Packaging Logistics Performance has a qualitative nature that has a higher significance for the agents, rather than fulfilling all the requirements. The soft system methodology based on agent entities that require rational actions by the agents to meet high Packaging Logistics Performance. The rational action is stated by Johansson (2001), who mentions that the individuals belonging to a unit are likely to behave rationally interacting with other agents. However, the complexity grows when continuous inter-organizational interactions take place. The agents are in a continuous transition phase. Weick, (1995) and Stacy et al. (2000) say that it is less interesting to talk about the organization instead of rational teleology, which is a realistic view of individuals who are constantly developing and changing for the better. Any internal or external

interactions create changes in the structure and are hardly static. The communication among the agents is interwoven, that they cannot exist without each other.

According to Backstrom et al. in Otter (2006), classical scientific methods simplify reality by describing it in terms of independent components and linear processes. “Linear” means that what is fed into the input determines the output. The alternative is to see the relationship from a complex perspective. According to Nilsson (2005), the complexity framework is multi-ontological, emphasizing multi-perspectives and multi-pragmatic. However, complex systems can influence the effect on the output in both a positive and a negative direction. Interactions between the two agents result in a reoccurring pattern, which in turn leads to mutual development process. When two agents interact, the degree of complexity while interacting is high in the initial stage, and this tends to increase creativity when the agents see the opportunity, when the logistics driver of efficiency and effectiveness sets in. The teleology is formative as the agents interact to attain future goals. An aggression of this interaction in complex adaptive systems evolves towards self-organization. By finding simple rules, self-

organization it becomes a mechanism for management to control and direct towards goals (Nilsson, 2005.). The self-organized entities could be formed in the interaction between two agents. Not always this could occur and for such reasons the Network Integrator could come into play in stimulating the interactions. Self-organization allows for creativity and adaptivity to meet the demands placed on the organization from the environment (Backstrom et al. in Otter (2006)).

It might be asked whether the number of case studies conducted is sufficient to validate the tool for measuring the performance of packaging. According to Hansson (2007), objectivity may be difficult to fully achieve, and it can sometimes be quite impossible to achieve it other than to a small extent. However, we should not give up the desire to achieve it as far as possible (Ibid.). The Packaging Scorecard tool is used to obtain knowledge on packaging and its logistics performance. It has been pointed out that this has been a qualitative approach. However, efforts should be made in future studies to conduct quantitative studies to increase the amount of data and to analyze the data statistically.

Another question concerns the validity of the selected interviewees and agents using my contact network from my time as a practitioner as well the

current company contact networks. As is discussed in the previous chapter, conducting research in logistics is about meeting many individuals working to achieve existing goals and ambitions. To gather knowledge from this environment is a time-consuming and resource-demanding process. The recommendation here is to build contact networks that will be useful in future research. Working at an industrial research institute gave access to companies from the same industry, and this network is very valuable for a researcher. Furthermore, it should be pointed out that the literature review is a time-consuming procedure that limits the variety and the volume covered during the research period.

The papers presented in this thesis are shared equally by the contributors Dr. Carl Olsmats, Dr. Fredrik Nilsson and me for paper I and V. Papers II, III and IV are mono-contributions.

Part IV – Conclusions and future studies

“I never think of the future - it comes soon enough.”

Albert Einstein 1879-1955

5 CONCLUSIONS

In this chapter the conclusions from the research are summarized and contributions to industry, to methodology and to academia are discussed. The main aim of the thesis has been to generate knowledge for further developments in the area of Packaging Logistics Performance.

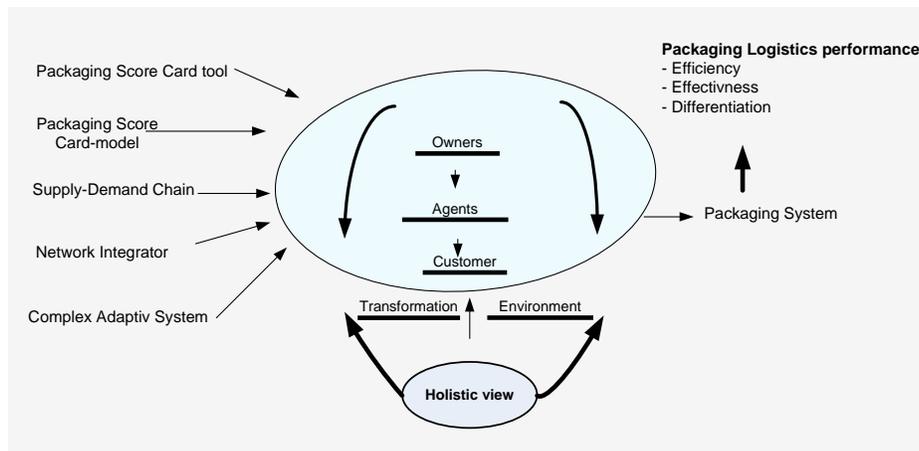


Figure 5.1 moving towards Packaging Logistics Performance

The contents of the illustration above summarize the work that has been done to identify Packaging Logistics Performance to seek knowledge and how performance of Packaging Logistics could be improved. In the middle of the figure 5.1 the agents, customers, and owner that interact with the packaging system are illustrated. To increase knowledge on performance

when the packaging interacts with the agents the PSC-model was presented. This model contains the Packaging Scorecard tool that in detail measures the performance of the packaging using the performance criteria, it also suggest an approach to modify the packaging system and how to improve the conceptual results for the agents involved in the SDC. Further, the driver of the supply-push and demand pull has been elaborated. The agent Network Integrator that integrates the supply and demand has been presented. The CATWOE-tool has been elaborated in Packaging Logistics and by applying Complex Adaptive System (CAS) the hidden phenomena when Soft System Methodology (SSM) and Hard System Methodology interactions emerge. The supply goes through several transformations while influencing the internal and external environment. In a continuous flow the interactions self-organize from disorder to order. Holistically, the self-organized order could be transformed in to performance. Studying the packaging system provides logistics performance for packaging. The Packaging Logistics Performance emphasize on the efficiency, effectiveness and to positioning the packaging by differentiating the packaging system.

This work contributes to the development of Packaging Logistics research, Packaging Logistics Performance by learning and understanding the

packaging requirements in the SDC. In a wider content, the work supports innovative and sustainable SDCs by understanding how packaging interacts with agents in a complex adaptive nature and differentiates value for customers and consumers.

Furthermore, this work contributes to better understanding within the SDC, its impact on overall Packaging Logistics Performance and its agents. The findings provide both theoretical and industrial insights. The results contradict the traditionally assumed “either-or” relationship between efficiency and effectiveness (Fisher 1997). Another finding is the indication that pursuing one does not preclude the pursuit of the other, but rather that the performance dimensions perhaps reinforce each other. There is a trade-off between efficiency, effectiveness, and differentiation. The main focus has been to contribute knowledge to academia for its developments in this field, to further develop the methodology in Packaging Logistics Performance and initiate implementation by publication. In the next section the contribution of this work is presented in detail.

5.1 Contributions to industry

The work has focused on Packaging Logistics Performance, covering efficiency or “doing the right thing”, effectiveness or “doing things right”, and differentiation or uniqueness to consolidate core competence as been the constituting element. Understanding multi-agent interactions with the packaging system increases knowledge on packaging performances that valuable for the packaging industry that are the sub-agents to the SDC. Increased knowledge in this are contributes to improved competitiveness for the packaging industry. The work has contributed the Packaging Scorecard model that is valuable to gain understanding on how the packaging performs for a specific SDC that increase knowledge about the dynamics of the supply-push and demand pull mechanisms as well to adapt to new situations. This specifically contributes to product development processes and designing the packaging system adapted to the agents’ demands. This thesis has an inter-disciplinary approach to explore the agent in the SDC. The development of SDCs proceeds and, with globalization trends, several new agents apply the results to work closely with the SDC. The work rests on reliable empirical base that is valuable for further studies based on this work for the packaging industry. An ongoing discussion considers the power struggle and who will benefit by having a

holistic view. To bridge the gaps between the holistic view and agent interactions, the agent Network Integrator was introduced.

Furthermore, in-depth studies are needed to increase the knowledge in this area to elaborate the Network Integrator agent, by studying from a complex adaptive systems approach.

5.2 Methodological contribution

In order to explore the Packaging Logistics Performance, a qualitative approach and the diversity of conceptual approaches has been presented. A tool to investigate and re-design the packaging system is introduced and applied to study the performance of packaging in logistics. A Hard System Methodology to build a packaging system is considered, and criteria for assessing Packaging Logistics Performance were contributed. This means that the methodology could adapt and implement the tools that have been presented in this work. Most significant methodological contribution is that the work facilitates to investigate from an interorganizational perspective and performance on a holistic level.

The work has processed an extensive amount of literature that could help other researchers to use it as a base for any future literature searches related to Packaging Logistics Performance and a literature list is presented in part VI. In the latest literature searches, more and more publications were found in the area of logistics performance, although very little was done in the subject of Packaging Logistics Performance.

Further, the strength is the quality of the data obtained that gives good reliability to further work on this subject. I have studied the packaging, the Network Integrator agent, the Soft System Methodology, and further developed the methodology to model the interacting agents, in order to understand how they contribute to improving Packaging Logistics Performance.

5.3 Contributions to academia

This work contributes knowledge that will increase the understanding of Packaging Logistics Performance as well as to further sustain the subject. The agent interactions by using a tool developed to show how packaging

performs to provide efficiency, effectiveness and differentiation contributes to increase insights both holistically and operationally. The agents and the packaging are modelled and studied from complex approach opening new research areas. Learning and understanding the Packaging Logistics Performance as inter-related sub-systems to deliver performance on a holistic view has produced valuable lessons and topic need to be explored further. The development has led to finding patterns new in order to increase knowledge in the subject of logistics.

The model Packaging Scorecard contributes to further research work. To obtain information about Packaging Logistics Performance in the SDC from a strategic, tactical or operational level could be difficult, hence the Packaging Score card tool was developed and it helps to highlight hidden complex phenomena for further analysis. Further the tool suggests improvements and how to follow-up. This opens a novel research area for Packaging Logistics research. A concept is generated by combining logistics, packaging and the agents involved to a product outcome that is a measure of Packaging Logistics Performance. The work serves as a basis for studying packaging and the agents involved in the SDC. The broadness of the literature review is valuable when dealing with a multi-disciplinary subject such as Packaging Logistics Performance that is yet to be fully

explored. The gaps in Packaging Logistics research where the main focus has been on systems thinking is highlighted by bridging the theory with applying CAS. This contribution enables holistic approach and increased Packaging Logistics Performance interorganizationally. The findings are that not all agents in a SDC have a holistic view, but by studying the Packaging Logistics Performance efficiency e.g. the source reduction, increases profitability and cooperation among the agents working in the supply-demand chain. Increases effectiveness of agents can be achieved by reducing internal and external environmental loads.

The system thinking on the SDC stresses the importance of understanding the demand chain to organize the supply. The theoretical reasoning about Packaging Logistics Performance is another contribution that encourages elaborating this research area even further and as a whole the contribution strengthens the logistics theories.

Furthermore, studies in which more than one constituency provides data in evaluating performance should be encouraged. Excellence in performing logistics activities and capabilities is associated with superior organizational performance (Lambert et al. 2000; Lynch et al. 2000). Despite this

evidence, doubt remains concerning the strength of the direct link between Packaging Logistics Performance and organizational performance. Further investigations are needed, therefore, to understand Packaging Logistics Performance and to reinforce the potential value of logistics within the organization. The next chapter presents suggestion for future research conducted from this origin.

6 FUTURE RESEARCH

The final station of the journey is to reflect on the work that has been done to obtain knowledge of the topic Packaging Logistics Performance. Many questions are yet to be answered and this is challenge for me and other researchers to move further in this field. As shown in the literature, the topics of packaging, logistics and performance are well established and often these subjects interact in theory. However, efforts must be made to further explore the subject of Packaging Logistics Performance.

There are numerous areas which could benefit from the framework and conceptual methodology that has emerged during the current research. There are areas in sustainability, foresight studies on supply chain management, Life Cycle Assessment and some parts of the logistics discipline that could directly benefit from such research work. Packaging Logistics Performance goes beyond the requirements for the immediate customer to holistically create efficiency and effectiveness for all

customers. Therefore, the subject could directly apply to the field of Demand Chain Management where customer insight is mainly in focus.

Efforts must be made to increase understanding of the agents and their interactions.

Further, the significance of the interaction between the packaging and the agents the operational process in logistics a tool for evaluation of the Packaging Logistics Performance was presented, in order to increase the efficiency and customer satisfaction in the future design of packaging systems. The developed tool could be quantitatively applied to product and packaging development theories. By utilizing this model, packaging designers can see the functions of the packaging system in the logistics process. This means that the gap between packaging decisions and logistics decisions can be mitigated, as it can share the downstream information with the upstream and the designers. To follow this research up, future researchers can apply some other tools, such as the Analytic Hierarchy Process (AHP), Design of Experiment (DoE) a whole approach as well look into ICT-fication strategies by applying the Packaperforma tool². This tool could be used to conduct comparative studies in multiple supply-

² www.innventia.com/packaperforma

demand chains. A study as such increases the quantity of data in the Packaperforma database that could be used to indicate the performances of the packaging, the agent and the SDC.

The thesis supports ongoing qualitative and action research in logistics and encourages elaborating the methodological approach in order to increase knowledge on Packaging Logistics Performance for complex adaptive systems.

Studies to create a deeper understanding of the Network Integrators role are planned in future research.

Another interesting subject that surfaced during the studies was the request to prevent counterfeit by plagiarism, expressed by brand owners. This has become an important issue for all companies in the global marketplace. Another issue mentioned was the increasing demand for product traceability. The questions of counterfeit and traceability were not deeply dealt with, but one possible solution is to use active and/or intelligent packaging in the SC. However, the most efficient way is to let the packaging supplier take the full responsibility for packaging in the entire DC. This subject will also be studied in the next step.

Part VI – Further Reading

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Appended Papers

Paper 1. Packaging Scorecard – a Packaging Performance Evaluation Method, Olsmats, C., Dominic, C. - Published in Packaging Technology and Science, Packag. Technol.Sci.2003; 16: 9-14 DOI:10.1002/ pts.604

Paper 2. Supply and Demand Chain Integration - a case study conducted in the packaging industry Dominic, C. - Packaging Technology and Science (Submitted to Packaging Technology and Science, 2010)

Paper 3. Integrating Packaging Suppliers into the Supply/Demand Chain

Dominic, C. - Packaging Technology and Science

Packag. Technol. Sci. 2005; 18: 151–160 Published online in Wiley InterScience (www.interscience.wiley.com). DOI:10.1002/pts.684

Paper 4. Supply/Demand Chain Management

Dominic, C. - Published in The Wiley Encyclopaedia of Packaging Technology, 3e, JWUS_EPT_07-0020, 2009

Paper 5. Holistic packaging development - integrating packaging, process and supply chain with a complex adaptive system approach

Nilsson. F. & Dominic, C. - Supply Chain Management: an International Journal. (Submitted to Supply Chain Management: an International Journal, 2011)

Paper 6. Packaging Logistics Performance and How to Evaluate the Packaging Performance by Applying the Tool Packaperforma

Dominic, C. Scientific Research Publishing 2010, USA, ISBN: 978-1-935068-36-5 and Proceedings of the 17th IAPRI World Conference on Packaging, Tianjin, China 2010.