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

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Abstract; Packaperforma is a tool developed in order to increase the efficiency, effectiveness and differentiation in the future design of packaging systems. The tool is based on the theory Packaging Logistics Performance. Packaperforma is a further development of Packaging Scorecard and it could be utilized by packaging designers and supply chain managers to see the functions of the packaging system in the logistics processes. 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. Packaperforma is used to conduct comparative studies in multiple Supply-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 Supply Demand Chains.

The paper presents a study on Packaging Logistics Performance, how to evaluate packaging performance; how to collect feedback information from different agents and efficiently solve packaging related problem. Further the paper describes a web system based tool, packaging performance indicators and packaging performance database.

Keywords: Packaging Logistics Performance, Supply Demand Chain, Packaperforma, Complex Adaptive Systems, Packaging Performance Indicator

1. Introduction

From the business point of view it is becoming extremely important for the transition of products and services from one point to another, to fully use the contributions of the packaging in order to gain competitiveness in the marketplace (Olsmats et al. 2003; Dominic 2006; Zheng et al. 2009). Very rarely the packaging is considered in the strategic decision making process and to support the logistics theory the concept of Packaging Logistics theory was introduced (Johansson et al. 1996; Dominic et al. 2000). The concept of Packaging Logistics is a value adding process in the supply chain meeting the customer demands by considering the packaging systems in various logistics processes. A well designed packaging and packaging system improve the profitability as well as reduce the cost by eliminating product damages, easier handling solutions, and better resource utilization, increased revenue by consumer fascination and satisfaction from the marketing point view.

Lately many logisticians have practice the concept of Packaging Logistics, and although Packaging Logistics is an important concept to the logistics theory, only a few tools are available in this area to study the Packaging Logistics Performances. Further, packaging has been considered solely in product development process, although recently some researchers have been conducting depth studies in this area to clarify the impact of packaging in customer or consumer satisfaction combining with logistics (Ståhlknapp, 2007; Dahlborg & Johnsson, 2006). 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 consumer. However, there are still many gaps to study in the interaction of logistics and packaging. The main gap is in marrying packaging and logistics related to development of packaging and to logistics activities such as easier handling for consumer. Further in-depth understand on packaging system performing throughout the supply chain with other agents such point-of-sale or distributor. The problem is that each agent considers its packaging without considering packaging on a inter-organizational level.

To bridge these gaps in Packaging Logistics concept this paper systematically introduce a tool and further developed the tool Packaging Scorecard that was introduced by Olsmats and Dominic (2001). The newly developed tool named Packaperforma1 indicates the performances of the packaging during its interactions with the agents and suggesting improvement alternatives for the designers of the packaging or product developers. The proposed alternatives are passed the satisfaction level of all involved agents, not only the product filler, from logistical and

packaging point of view.
Firstly in this paper, the concepts applied in the tool Packaperforma is discussed; thereafter the tool and its structures are described. Finally, the developed tool is analyzed and tested by conducting case studies.

2. What is Packaperforma?

Packaperforma is a web based tool for gather packaging related data to study the Packaging Logistics Performance on an inter-organizational level. The problem is that each agent of the chain considers its packaging leading to sub-optimization causing inefficiency in the downstream of the supply chain. The previous tool, the Packaging Scorecard (PSC), was developed by Olsmats & Dominic (2003), a systematic approach to evaluate the performance of packaging in supply chain and, one of the tools that tries to merge the logistics concepts with packaging one. It approaches packaging as a system. PSC was based on the concept of Balanced Scorecard which was a general business performance measure tool. A proper use of packaging scorecard outlined the performance of packaging. This evaluation is based on 14 criteria, which have been extended to 16 in a later study conducted by Ståhlknapp (2007), and categorization of criteria in the way that each criterion is dedicated to one or several agents (Table 1). The criteria which are utilized in the tool are Machine-ability, Product protection, Flow information, Volume and weight efficiency, Right amount and size, Handle-ability, Product information, Selling capability, Safety, Reduced use of resources, Minimal use of hazardous substance, Minimal amount of waste, Packaging costs, Stack-ability, Easy to discard, and Security (Olsmats & Dominic, 2003; Ståhlknapp, 2007). For instance, “Machine-ability” can only be defined for product filler, since the only agent who deals with the packaging materials, rapping and utilizing them in their packaging machine is product filler. However, the “Product Protection” can be defined for all agents as the primary function of packaging is protection the product and all agents deal with this criterion. The rest of the criteria can be defined in a similar manner. These criteria also apply for Packaperforma.

Table 1 - Criteria for packaging system – Adapted from (Olsmats & Dominic, 2003; Ståhlknapp, 2007)

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Product Filler</th>
<th>Distributor</th>
<th>Point of Sale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machine-ability</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Product protection</td>
<td>X X X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flow information</td>
<td>X X X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Motivation

Although the Packaging Scorecard (PSC) has many advantages, such as easy to use, easy to understand the approach, overall view of packaging system in supply chain, and definition of fourteen criteria, it has some shortcomings which are mainly related to internal reliability. The main shortcomings are imperfection in weighting the criteria, 0-4 scale for measuring the performance of current situation, imperfection of normalization method, and no guide for improvements of packaging system. The redevelopment of PSC, the tool Packaperforma mainly focuses on the performance, to simplify and used for rapid performance assessments of packaging. The tool was released in Scandinavia in 2009 after involving major food and beverage companies, members of The Private Owners’ Association Packforsk and Innventia. Packaperforma is designed to easily identify, review and prioritize actions to increase the performance of the packaging at every point within the supply chain. Evaluations with Packaperforma are therefore a possibility to improve the company’s profitability by efficiently developing the packaging and reduced time for data gathering.

The tool is web based contents with a set of functions
written in the Java language and containing dynamic database. The tool utilizes unified process to analysis and design the system, use JSP, Servlet and Hibernate to develop the system. They deploy it on a third party web server. Packaperforma consists of three parts: the administrator that can manage all the users’ accounts and check the performance of a packaging, user that can evaluate their packaging and browse the feedback from supply chain concerning certain packaging. The registered user’s customers and customer’s customer can evaluate a packaging and send the feedback to registered user.

4. Methodology

As the study, i.e. packaging logistics, is related to the interactions between packaging systems, agents, and the entities of agents such as production facilities, transportation equipments and individuals, it is rational to simulate the supply chain as a complex system including agents, packaging system and supply chain (Nilsson, 2005). Hence, the outcome of the study can define some generative rules that can analyze and apply information in this complex adaptive system. 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.

![Diagram of packaging system and supply chain](image)

**Figure 1 – Fundamental elements of the tool Packaperforma - Adapted to packaging logistics performance from Kezavaraz and Imen, 2009**

Functions of packaging system, in this study, are converted to 16 criteria (Table 1). Different packaging systems have similar goals and characteristics. Therefore, this study defines packaging systems as a sum of subcomponents i.e. packaging levels put together as a whole. The developed tool can 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. On the other hand, the tool functions the same for other agents in the system such as point of sale, intermediate and product fillers that can adapt the strategies to the characteristics of the packaging. Thus, this simulates a complex adaptive system that agents can learn from each other (Figure 1).

Adding complexity to Packaging Logistics, the outcome of the new simplified tool generates packaging related data that the packaging developers/designers need. This information is about the packaging system and its goals. By taking the complex adaptive approach into the theory of Packaging Logistics Performance, the tool defines a guide for the packaging developers to comprehend the information they need to optimize the system. Thus, each packaging system was defined as a primary component in complex adaptive 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.

In order to evaluate the design characteristics of the packaging systems, we need to know the extent of fulfillment of overall goal (overall weighted performance). Considering that packaging systems have several functions (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.

All in all, the tool should find out the importance of each goal or criteria, evaluate the fulfillment of each criterion, and make the comparison of characteristics possible for each packaging system.

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 one to provide data for define the current packaging logistics performance. By applying these methods and calculating the results, the importance and the performance of criteria are attained. This means that, the overall weighted average performance of the packaging system can be calculated. However, in order to evaluate the characteristics of packaging system against the performance of that packaging system, further analysis on the second sort of data, collected by the second questionnaire has been designed. This final analysis can facilitate comparison between packaging systems. Thus, choosing a set of packaging systems with some common characteristics are required.
Previous researches generated the initial idea of this tool. The most important contributions to this idea were the criteria defined by Olsmats and Dominic, 2003 and Stålknapp, 2007; excluding the criterion “other value adding activities”. However, the drawback, is that it can influence the accuracy of data, since each pair-wise comparison in the module represent some other relations between criteria. Finally, the “geometric mean” of three matrices was calculated, generated from pair-wise comparisons, to determine one matrix to calculate the prioritizations of criteria.

Packaging Logistics Performance evaluation is basically the same as what has been done before in Packaging Scorecard, but by breaking down the packaging system to the design characteristics, it is possible to relate these characteristics to performance ratings by respondents. A simple design of experiment can perform this task. 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 cardboard 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.

It is assumed that most of the attributes of the higher levels of packaging system, such as primary packaging and tertiary packaging, are highly influenced by the attributes of first level packaging; i.e. any change in attributes of the primary packaging effects secondary and tertiary packaging. The respondents were asked to specify which packaging level they deal with. This question helps us to know that the ratings were related to which one of the packaging levels. The result will define that how the specific packaging performs regarding each criterion and have 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.

The purpose of designing the web based tool was to use them as a supportive tool to simplify data gathering and to use the packaging performance database to suggest improvements based on the data, gathered from respondents and existing in the database. The tool was tested by conducting in four case studies in the frozen food industry. The respondents were experts who were in charge for selected packaging. The products were selected in a way to have many variations in content, size and materials. These variations in products help to generate suggestions; as if the products reflect the same characteristics, then it is not possible to compare different design characteristics.

<table>
<thead>
<tr>
<th>Table 2 - Results for from the study</th>
<th>Importance of criterion (%)</th>
<th>Performance of Pre-cooked fish meal (Färskgratäng)</th>
<th>Performance of Frozen Broccoli (Broccoli-grön saker)</th>
<th>Performance of Frozen meatballs (Köttbullar)</th>
<th>Performance of Frozen vegetables (Salladsgrön saker)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product protection</td>
<td>36.1</td>
<td>8.3</td>
<td>7.6</td>
<td>7.1</td>
<td>7.2</td>
</tr>
<tr>
<td>Machine-ability</td>
<td>19.7</td>
<td>7.7</td>
<td>7.8</td>
<td>8.4</td>
<td>8.4</td>
</tr>
<tr>
<td>Right amount and size</td>
<td>10.3</td>
<td>8.5</td>
<td>8.2</td>
<td>8</td>
<td>8.7</td>
</tr>
<tr>
<td>Handle-ability</td>
<td>7.2</td>
<td>4.5</td>
<td>4.2</td>
<td>4.2</td>
<td>4.5</td>
</tr>
<tr>
<td>Packaging cost</td>
<td>7.2</td>
<td>5.5</td>
<td>5.5</td>
<td>5.5</td>
<td>5.7</td>
</tr>
<tr>
<td>Stack-ability</td>
<td>7.2</td>
<td>5.8</td>
<td>5.8</td>
<td>5.8</td>
<td>5.8</td>
</tr>
<tr>
<td>Volume and weight</td>
<td>5.2</td>
<td>7.7</td>
<td>7.7</td>
<td>7.8</td>
<td>6.8</td>
</tr>
<tr>
<td>Minimal amount of hazardous substance</td>
<td>5.2</td>
<td>4.6</td>
<td>4.7</td>
<td>4.7</td>
<td>4.6</td>
</tr>
<tr>
<td>Minimal use of resource</td>
<td>2.1</td>
<td>4.8</td>
<td>4.8</td>
<td>6.2</td>
<td>5.4</td>
</tr>
<tr>
<td>Average performance</td>
<td>-</td>
<td>7.2</td>
<td>7</td>
<td>6.9</td>
<td>7.1</td>
</tr>
</tbody>
</table>

5. Case Study

The first conducted case study was frozen meatball in a plastic bag. The second case study was, frozen vegetables in a large plastic bag. The third case was Broccoli in a small carton board box. Finally, the forth case was pre-cooked fishmeal in a large carton board box. The secondary level of all selected cases was corrugated board box. The tertiary level of packaging differs in each agent. At the point-of-sale and at product-filler, roll-cage was used as third level, but at the distribution center third level packaging the pallet was used. The “retail supply chain”,

![Image](image_url)
studied in this problem, is illustrated by figure 2.

The results from product filler are shown in table 2 and figure 3 as a sample. The first column shows the criteria considered for the agent, and second column shows the weight (importance) of those criteria calculated from first questionnaire. The next four columns shows the products with their performance measure calculated from second questionnaire.

According to Table 2 and Figure 3, the first three criteria, which are Product protection, Machine-ability, and Right amount and size, take 66.1% of total portion of the weight. Table 2 and figure 3 show that the performance of these three criteria for all four packaging systems is above seven, which means the performance of packaging systems fulfilled these criteria, resulting in an overall average performance of about seven. The next three criteria, which are considerable, are Handle-ability, Packaging cost, and Stack-ability. The performances of these criteria are even below six. These shortcomings create room for improvements. Considering that the importance of all these three criteria are 7.2%, one unit improvement in performance of these criteria leads to 0.072 unit improvement in overall performance. For instance, if the performance of handle-ability in the product “Pre-cooked fish meal” was improved from four to seven, then the overall performance would be improved by 0.22 units. The analysis shows that change in packaging material from plastic bag to cardboard box can improve the Minimal use of resources. Also, the figure 3 shows the gap between performances of “Meatballs and “Vegetables” and “Pre-cooked fish meal” and “Broccoli”. Considering that the importance of Minimal use of resources is low, improvement in performance of this criterion would not contribute to the overall performance much. Radar chart shows that all criteria, except Minimal use of resources, have the same performance for all four packaging system.

6. Analysis

According to Saghir (2002), enhancement in Packaging Logistics can improve the efficiency and effectiveness of the supply chain. Enhancement of Packaging Logistics Performance means improvement in performance of packaging functions. On the other hand, Olsmats et al. 2003 and Ståhlknapp 2007 have broken down the packaging functions to criteria of packaging system to a detail level. Based on these researches, the tool Packaperforma was developed for measuring the fulfillment of these criteria, as well as for recommending suggestions for improvements for the shortcomings of packaging system, resulting in fulfilling the criteria. The tool can reveal the fulfillment of these goals. Further Packaperforma enable pair-wise comparisons in a scientific way. Pair-wise comparison, which was found by the respondents easier to answer, enabled the tool to find the most important criteria sharply. Studying the results from the respondents showed that the results of weighted criteria are scientifically reliable. Furthermore Packaperforma enhances the analytical power of the tool to produce generative rules, which in turn can propose ways to adapt the strategies (characteristics) of the packaging systems. Adaptation in strategies advances the collaboration between them and other agent. Furthermore, the quantitative feature of the tool facilitates the standardization of data collection process. Thus, this standardization guides to generation of a database that can be applicable for product development processes. Hence, PSC is developed to a more reliable and powerful tool which not only can find the strengths and weaknesses of packaging system but also can suggest improvements in the packaging system as well as it predict the extent of improvement in overall performance of the packaging system.

Packaperforma generates suggestions for improvements and facilitates the information sharing between agents and makes the collaborations possible. The results show that the tool can work even more efficiently when supported by more input data to the tool. Analysis and results proved that if number of product and respondents increases, the outcome of the tool will be more reliable and rich. Even, because of the nature of performance the tool can suggest an alternative packaging system. However, the tool makes the data collection and analysis process more complex than PSC. Nevertheless, complexity of the tool has a trade off with internal reliability.

7. Discussions and conclusions

During the testing phase it revealed that the complexity of system was higher than what was expected. Therefore, the more quantitative and detailed data collection process is necessary to make the tool more valid. For instance, respondents perceived the value of the words or criteria differently, such as variations in experience and perspective of respondents exist even among different point-of-sale agents, as it was observed during the validation phase. The data collection process has a critical impact on quantitative approach.

In order to measure the overall performance of a packaging system, it is always needed to consider several interrelated criteria. Changes in packaging system can influence the performance of each criterion. These changes are not always in the same direction, thus it is hard to predict the changes in overall performance. This means that positive change in one criterion can have a negative impact on the performance of other criteria. Hence, in order to quantify the changes in overall performance, a complex mathematical analysis is needed. This, in terms, leads to more quantitative data.

Also, it is recommended to collect data and analyze the importance of each criterion and then develop the data gathering module for performance by selecting only for the important criteria. Another advantage of this two stage data collection is that it makes possible to use a full pair-wise comparison. Full pair-wise comparison is ad-
vised because it leads to more internally reliable results. Moreover, by applying two stage data collection, it is possible to remove unimportant criteria from the questionnaire. Therefore, the number of questions in the performance evaluation part can be decreased. This encourages respondents to put more effort on answering the questionnaire, thus improving the quality of data. Accordingly, it is recommended to apply this strategy in future researches.

To conclude the tool Packaperforma is more efficient than PSC in many ways. Easier data collection process, weighting the criteria scientifically, suggestion for better alternatives of packaging system, information sharing among supply chain agents, and most importantly gather information for packaging developers by consideration of both logistics activity and packaging system are some advantages of Packaperforma. Also, the data about system can be stored in the dynamic database and later on can be used in another packaging system for performance evaluation.

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