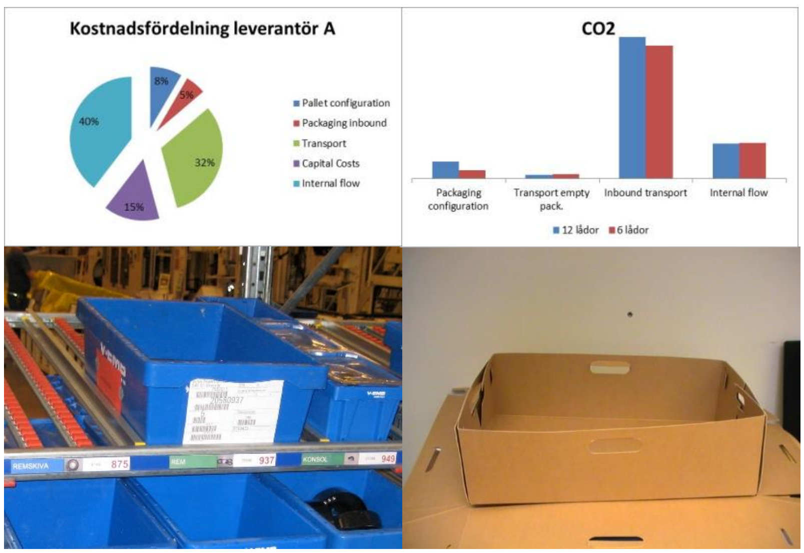
A model for packaging systems evaluation from a sustainability perspective in the automotive industry



Project within sustainable Production Technology

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FFI in short

FFI is a partnership between the Swedish government and automotive industry for joint funding of research, innovation and development concentrating on Climate & Environment and Safety. FFI has R&D activities worth approx. €100 million per year, of which half is governmental funding. The background to the investment is that development within road transportation and Swedish automotive industry has big impact for growth. FFI will contribute to the following main goals: Reducing the environmental impact of transport, reducing the number killed and injured in traffic and Strengthening international competitiveness. Currently there are five collaboration programs: **Vehicle Development, Transport Efficiency, Vehicle and Traffic Safety, Energy & Environment and Sustainable Production Technology.**

For more information: www.vinnova.se/ffi

1. Executive summary

The first purpose of the project was to develop and test an evaluation model that, from a sustainability perspective, can facilitate the choice of packaging systems for material supply from component supplier to the assembly processes in the automotive industry. The model should consider economic and environmental impacts of packaging systems in a whole supply chain, and from a life cycle perspective. Based on data collected and operationalisation of the evaluation model in an analysis tool, the second purpose was to provide insights to the participating organisations for selecting packaging systems.

The development of the evaluation model included data collection, model development, and analysis tool development. The project was carried out in a collaborative manner between all involved organisations with Lund University as the cohesive link and responsible for the model and the analysis tool development. The model created has a general setup and structure, which are applied in the analysis tool. The data in the analysis tool are specific for each plant. The general model is prepared for adaptation to other than the three involved plants in this project.

A great deal of work was related to collecting and structuring data about costs and CO_2 emissions related to transportation, materials handling, waste management, packaging material, warehouse management and administration. Data were collected from various sources and from observations. The level of detail of the data was decided in continues discussions with all organisations throughout the project.

The overall result of the project is an increased understanding of the impact of packaging on supply chain cost and CO_2 emissions in the automotive industry. The project has developed a model, which provides a logic for identifying influential cost and CO_2 factors for different packaging solutions in the materials supply. Understanding the cost and CO_2 factors help in creating guidelines for packaging selection. The analysis tool can support decisions in various areas. It can analyse:

1. Total costs and CO_2 emissions from a supply chain perspective for all components
2. Compare packaging alternatives (for instance, one-way or returnable packaging systems, or different packaging sizes)
3. Compare different supply chain structures (for instance, different production concepts, such as kitting, and with direct delivery in small boxes from the supplier or pallet delivery with repacking in smaller boxes at the plant)
4. The impact of five cost/CO_2 variables and several contextual variables on the total cost/CO_2 emissions
5. Grouped information (suppliers, type of packaging, regions, etc.) to investigate the economic and environmental impacts of making a change in packaging for the grouped item (e.g. what would be the economic and environmental impacts of changing so that one supplier only uses one type of packaging for all their components)

The results of the project contribute to better informed decisions for new or modified packaging solutions that, in turn, reduce costs and the environmental impact of materials supply for the plants involved in the project. From an academic perspective, this has contributed to new knowledge in the area of packaging logistics, particularly regarding relationships between the cost and CO_2 factors in the model, the effect of contextual factors when comparing one-way and returnable packaging, and an increased understanding of cost and CO_2 effects of different packaging selection processes.

When discussing the resulting model and the developed analysis tool with staff at the participating companies, it became clear that no matter how accurate the data and the model are, it is crucial that the model is incorporated in relevant standard processes at the companies. Otherwise, it will not be used and the companies will not benefit from it.

The project has resulted in several practical implications. The analysis tool can be, and are currently, used in the daily business as decision support for new or modified packaging solutions. There is potential to implement and roll it out in other plants, but this requires some IT resources to include it in the central IT system. Further, as the model applies a holistic supply chain perspective, which is operationalised in the analysis tool, it can also provide new input to interorganisational strategic decisions regarding, for instance, sourcing and production. In the companies involved in this project the model and the analysis tool can support ongoing and planned projects, e.g. in a planned concept development for one-way packaging. All companies have many special packaging, which are handled in a different way than standard packaging. An extension of the model can help to provide guidelines and modularise the assortment.

2. Background

In the Swedish automotive industry, the current returnable packaging systems, which have become the norm, were implemented more than 25 years ago. This project was based on the notion that these packaging systems should be challenged, as a number of conditions for packaging systems have changed during this period of time. First, the deployments of lean production and just-in-time concepts, as well as new logistics structures with increased globalised sourcing, have changed the requirements on packaging. Second, empirical data from a pre-study indicate potentials to reduce both costs and CO_2 emissions by questioning the existing packaging system. Furthermore, in both industry and research there is a lack of useful packaging evaluation models. Therefore, there is a need for packaging systems evaluation models, particularly models that consider both economic and environmental sustainability.

3. Objective

The first purpose of the project was to develop and test an evaluation model that, from a sustainability perspective, can facilitate the choice of packaging systems for material supply from component supplier to the assembly processes in the automotive industry. The model should consider economic and environmental impacts of packaging systems in a whole supply chain, and from a life cycle perspective. The project focused on and integrated the materials supply sub-processes taking place within different organisations and at different locations of a supply chain.

Based on data collected and operationalisation of the evaluation model in an analysis tool, the second purpose of the project was to provide insights to the participating organisations for selecting packaging systems. This included analysing the impact of contextual factors for selecting packaging systems among different type of packaging systems, for instance, one-way or returnable packaging systems, and for different supply chain configurations, for instance, direct delivery from component suppliers in small boxes or bulk transportation with re-packaging at the assembly site.

4. Project realization

The first step in the project was to develop an evaluation model for packaging selection. In this step, three major and interrelated activities were data collection, model development, and analysis tool development. The project was carried out in a collaborative manner between all involved organisations with Lund University as the cohesive link and responsible for the model and the analysis tool development.

The model created has a general setup and structure, which are applied in the analysis tool, while the data in the analysis tool are specific for each plant. The general model is prepared for adaptation to other than the three involved plants in this project. In this project, it has been contextualised to three particular plants. For all plants, the logistics and transportation data in the analysis tool are common as it is derived from Volvo Logistics, but the other data are plant specific. To develop the analysis tool, data were first collected from Volvo Logistics and Volvo Powertrain. The development was, however, continuously discussed with all organisations at both AB Volvo and Volvo Cars involved in the project in order to secure that the model would be adjustable to all of them and as a mean of testing the validity of the model. An example is a collaborative approach to create general descriptions of material flow types, which were needed for the model to address all alternatives at the different plants. All organisations were involved in common discussions in several meetings. Further, to secure that the logic and structure of the model remained in the analysis model, continuous comparisons were made. In principal, the model development, analysis tool development and the data collection were done in the following steps:

1. Initial data collection
2. Building a draft version of the model based on the pre-study[1] and the initial data collection
3. Discussion of the structure, content, level of details, material flows etc. in the draft version of the model in the project group
4. Developing a first prototype of the analysis tool
5. Discussing the analysis tool prototype in the project group
6. Updating the analysis tool with more detailed data
7. Discussing the first version of the analysis tool in the project group
8. Updating the analysis tool with more detailed data
9. Developing a second version of the analysis tool
10. Implementation of the second version for testing at Volvo Powertrain
11. Adjusting the analysis tool to feedback from Volvo Powertrain
12. Launching a final, complete version at Volvo Powertrain
13. Adjusting and implementation of the final version of the analysis tool at the other plants

A great deal of work was related to collecting and structuring data about costs and CO_2 emissions related to transportation, materials handling, waste management, packaging material, warehouse management and administration. Data were collected from various sources and from observations. The level of detail of the data was decided in continues discussions with all organisations throughout the project.

To disseminate results within the project consortia, and keep all organisations involved throughout the project, five to six project meetings were held annually. To promote that all involved organisations learned from each other, the meetings were held at the different organisations where we also studied the different plant operations and packaging systems.

[1] A pre-study of the economic and environmental potential of a more informed packaging selection process in the automotive industry was conducted in a case study at Volvo Cars 2010-2011.

We also held a number of workshops where we received input and requirements on the model, the analysis tool and its functionality. Participants from other parts of Volvo Cars and AB Volvo than were primarily involved were invited to the workshops. We had, for instance, participation from company global functions in sourcing, purchasing, logistics, and sustainability.

The detailed adaption of the analysis tool took place in the different plants. The academic participants spent many weeks together with staff at the different plants to develop, adjust and validate both the model and the analysis tool to the particular contexts.

To secure that the data in the model are always up-to-date, an SQL server with automatic linkages to existing data systems were setup in one of the plants to demonstrate the possibilities and necessities of such a functionality. Thus, it is easy for the users to update the data, which is crucial in order to get accurate results out of the tool.

By help of the developed tool, data were collected and processed in the analysis tool. The analysis capabilities and the analyses conducted in the project are described in the next section.

5. Results and deliverables

5.1 Project results

The overall result of the project is an increased understanding of the impact of packaging on supply chain cost and CO_2 emissions in the automotive industry. The project has developed a model, which provides logic for identifying influential cost and CO_2 factors for different packaging solutions in the materials supply. Understanding the cost and CO_2 factors help in creating guidelines for packaging selection. This is exemplified by comparing one-way to returnable packaging, which is described below.

The logic of the developed model was implemented in an analytical tool, which calculates the total cost and CO_2 emissions of a packaging solution from a supply chain perspective. Figure 1 and Figure 2 shows graphical outputs from the tool. Using this tool helps to identify and manage trade-offs in different cost and CO_2 factors related to packaging. This is useful in the daily business to calculate costs and CO_2 effects of a new packaging solution, for a new component or due to a request to change packaging or flow for a component. It is also useful in strategic decisions about packaging solutions, for instance, when to use one-way or returnable packaging or how to design the materials supply structure, for example, packaging from suppliers direct to line or with repacking, and with or without external warehouses. For the companies involved in this project, the project has resulted in that they have improved decision support for taking informed packaging decisions, both operationally and strategically.

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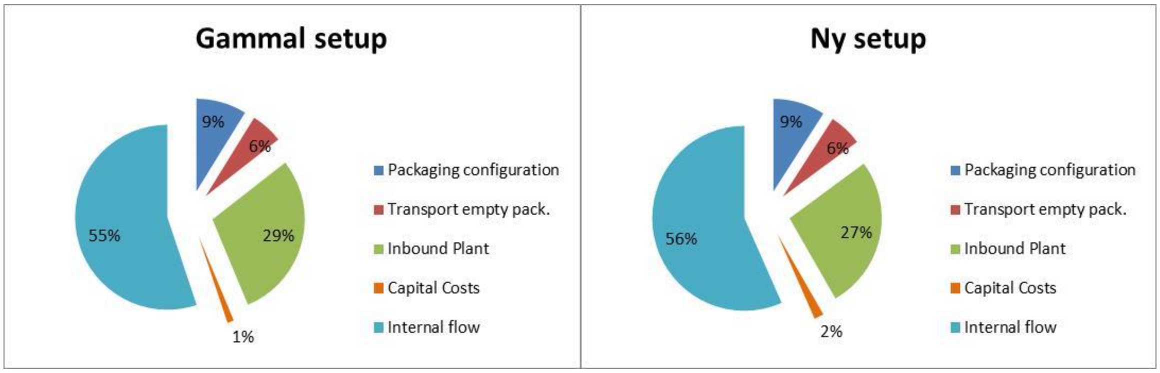

Figure 1. Comparison of share of costs per component per cost factor between the current packaging solution and a new one

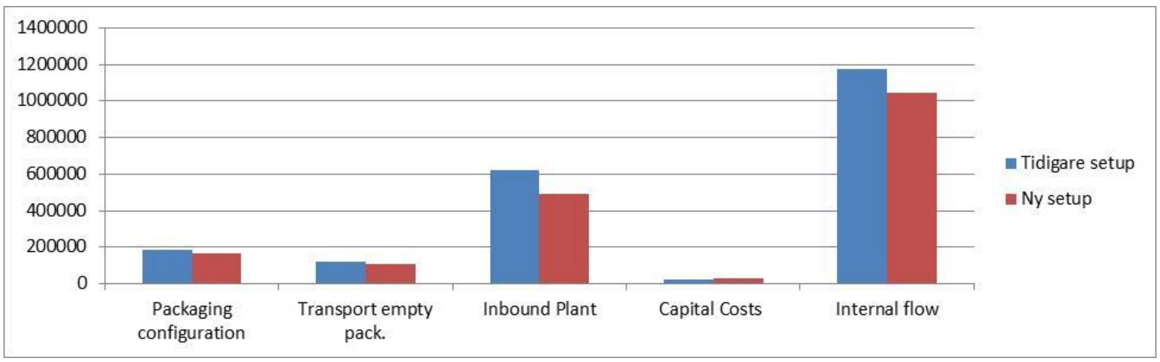

Figure 2. Comparison of costs per component per cost factor between the current packaging solution and a new one

The analysis tool can support decisions in various areas. It can analyse:

1. Total costs and CO_2 emissions from a supply chain perspective for all components
2. Compare packaging alternatives (for instance, one-way or returnable packaging systems, or different packaging sizes)
3. Compare different supply chain structures (for instance, different production concepts, such as kitting, and with direct delivery in small boxes from the supplier or pallet delivery with repacking in smaller boxes at the plant)
4. The impact of five cost/CO_2 variables and several contextual variables on the total cost/CO_2 emissions
5. Grouped information (suppliers, type of packaging, regions, etc.) to investigate the economic and environmental impacts of making a change in packaging for the grouped item (e.g. what would be the economic and environmental impacts of changing so that one supplier only uses one type of packaging for all their components)

There are several examples of benefits due to the application of the analytical tool in the daily business. In one case, the analytical tool revealed an opportunity to fill up pallets for one component with additional boxes, with a net saving of 1.3 million SEK per year. Another example is to modify quantities of components in packaging to reduce deficiencies, which reduced the costs by 0.3 million SEK per year in one plant.

One of the plants has started to use the analysis tool in the daily business and in strategic discussions. In the longer term, the application and utilisation of the tool can have a greater impact on the participating companies' packaging selection processes. It is also likely to affect the companies' material supply set-ups as it can compare packaging systems with different material supply set-ups.

By using these opportunities, we have analysed and identified how much five cost/CO_2 variables and contextual variables (cubic utilisation, flow type, transport distance, and packaging size) contribute to the cost and CO_2 differences between different packaging options in various supply chain setups, which is illustrated in Figure 1 for one of the plants in the project. These insights can form the basis for guidelines for selecting packaging systems at the different plants, and what types of analyses that are usable for different types of components.

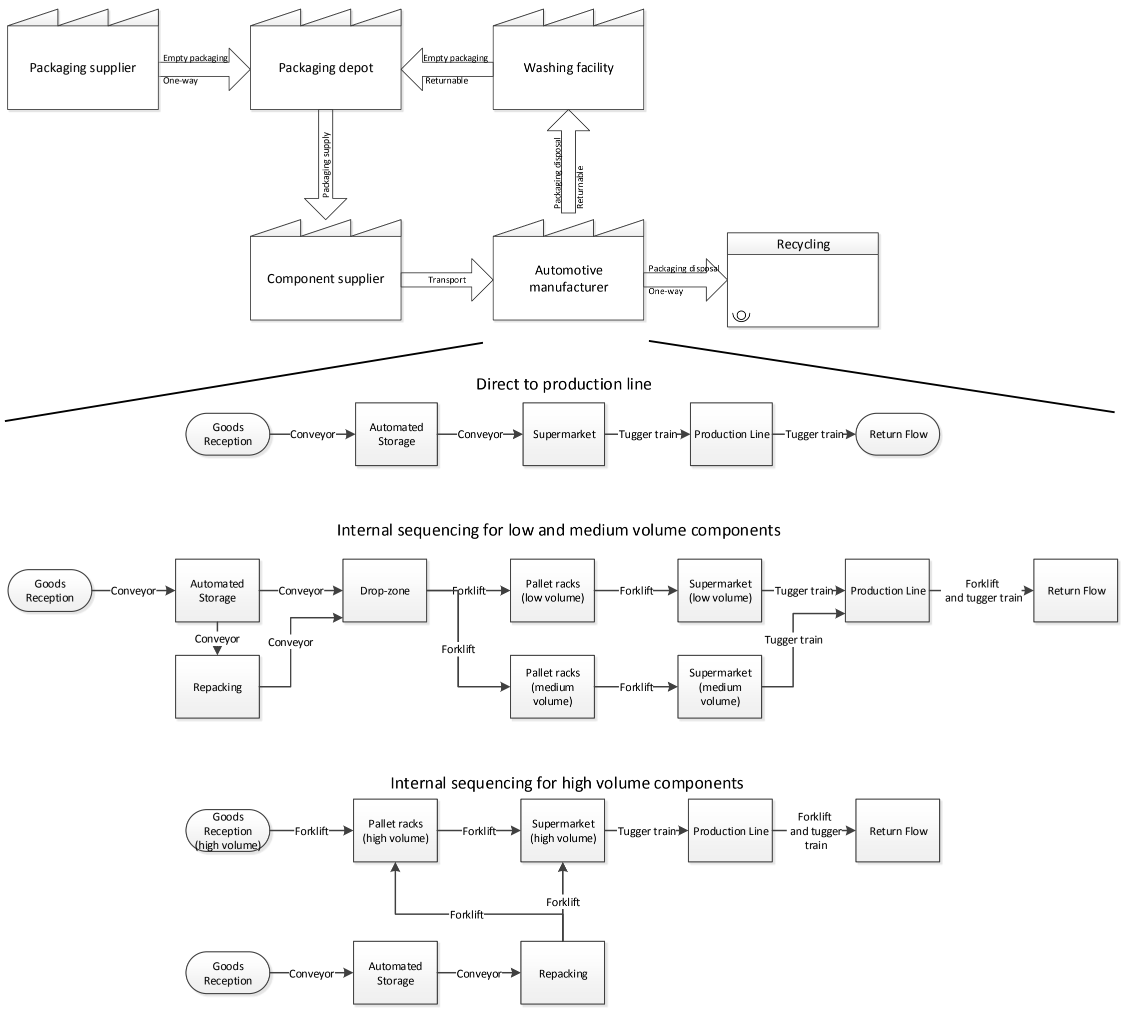

Figure 3. Overview of the supply chain and the materials flow types for the components in one of the plants covered in the analytical model

In addition to providing more informed packaging decisions, the analysis tool can provide data to sustainability reports as it calculates CO_2 emissions for the whole supply chain and per component, which was lacking before. It can also provide data to landed cost calculations. In addition to the five analyses above, the tool provides insights that have affected the packaging strategy and it have had organisational effects. Thus, the validation and demo step of the project has highlighted the need for collaboration between departments and the analyses carried out with the analysis tool has facilitated such collaboration. It became clear that the choice of packaging often varies depending on whether the finance department, the packaging department, the production department, the environmental department or management makes the decision, depending on what is considered the most important, for example, packaging size, costs, CO_2 emissions or cash flow. Thus, the researchers in the project group presented different types of analyses to facilitate discussions regarding how to deal with these issues.

In summary, the project has resulted in:

- A theoretical model filled with detailed data from three plants for evaluating packaging systems from a sustainability perspective
- Detailed case study descriptions applied in the analytical tool
- Comparative case study descriptions between cases at different companies highlighting differences of economic and environmental impacts of packaging system
- *Cost and CO_2 factors* (packaging material, transportation, internal flow, packaging supply and disposal, capital) and *contextual factors* (cubic utilisation, transport distance, packaging size, flow type) that determines when a one-way packaging system or a returnable packaging system is preferable from a sustainability perspective

5.2 Delivery to FFI-goals

The results of the project contribute to better informed decisions for new or modified packaging solutions that, in turn, reduce costs and the environmental impact of materials supply for the plants involved in the project. From an academic perspective, this has contributed to new knowledge in the area of packaging logistics, particularly regarding relationships between the cost and CO_2 factors in the model, the effect of contextual factors when comparing one-way and returnable packaging, and an increased understanding of cost and CO_2 effects of different packaging selection processes. More details of these deliverables are described above. To be able to extend the implications of the project, the logic of the developed model and the analysis tool are arranged so that full roll outs in other plants are possible. To do this, additional IT resources are needed. In addition to these deliverables, the project has the following practical implications:

- The holistic supply chain perspective applied in the model, and operationalised in the analysis tool, has supported intraorganisational supply chain discussions about sourcing, production and business development. The tool can provide new input to such decisions on a strategic level.

- The model and the analysis tool have started to support ongoing and planned projects for the companies involved in the project. One of the organisations in the project plans to develop a one-way packaging concept. The analysis tool can provide information for this concept development.
- Increased knowledge on how companies in the Swedish automotive industry can choose a packaging system to meet the requirements of the lean production philosophy and global sourcing from an economic and environmental perspective.
- Indirect productivity improvement as better informed packaging decisions positively affect transport volumes, floor space needed, and equipment and man-hours needed in the materials supply system.
- Competence enhancement among the participating companies regarding the impact of packaging decisions on sustainability throughout the supply chain. In the workshops representatives from many areas have been involved, such as purchasing, sourcing, production, logistics, packaging, business development and sustainability.
- The project has facilitated knowledge sharing between organisations. There were continuously activities including representatives from all the involved organisations, both the academic partners and the companies. Thus, knowledge were shared within the automotive industry and between industry and academia.
- The way of thinking, i.e. the model structure, and packaging selection strategy is highly relevant for other manufacturing industries as well, but as the material flows and supply chain structures differ between industries and companies, industry-specific adjustments might be required. Our publications, presentations and individual meetings with companies can facilitate such development.

6. Dissemination and publications

6.1 Knowledge and results dissemination

Companies and academia worked closely together in the project in terms of case selection, data collection, validation of the model and participation in workshops. Thus, project results were continuously disseminated among the participating companies. The analysis tool was co-developed between academia and industry, where a major activity was regular meetings involving academia and project group participants from the companies as well as their colleagues. For various steps in this development process the academic representative spent several days in the organisation. To disseminate the results within the companies a number of workshops were held during the project. The workshops took place with participants from other company functions than those primarily involved in the project groups at the companies. Throughout the project, results and developments have been reported to the Manufacturing R&D cluster within logistics.

From an educational perspective, the model is used as an effective pedagogical tool at Lund University, particularly in courses held by the Packaging Logistics research group. The tool is part of the Packaging Logistics courses at Lund University and at Stellenbosch University, South Africa, where Packaging Logistics research group teaches. A two hour lecture is dedicated to the tool. Job is on-going for integrating the knowledge within a course at the Supply Chain master programme at Chalmers.

External dissemination has been done in four areas:

- Scientific dissemination of new knowledge about packaging logistics at academic conferences, journal articles, and a licentiate thesis to be defended in August.
- Dissemination of results at industry-oriented conferences and seminars, and within the participating companies. The way of thinking, i.e. the model structure, and packaging selection strategy is highly relevant for other manufacturing industries as well, but as the material flows and supply chain structures differ between industries and companies, industry-specific adjustments might be required. Our publications, presentations and individual meetings with companies can facilitate such development.
- Knowledge transfer within education of Master's students in engineering.
- Competence enhancement among the participating companies regarding the impact of packaging decisions on sustainability throughout the supply chain.

These results have been presented at the following events:

Presentations at scientific conferences and seminars

- EUROMA conference, Palermo, June 2014
- European Research Seminar, Düsseldorf, April 2014
- EUROMA Summer School in Operations Management, Cranfield, June, 2013
- NOFOMA conference, Gothenburg, June 2013

Presentations at industry-related conferences and seminars

- The model and the analysis tool was presented and discussed in individual meetings with several companies, such as ABB, Scania and NEVS, 2013-2015
- Seminar, SWIF, May 2015 (planned)
- Logistikkluster FFI, Gothenburg, March 2015
- The 20 years anniversary of Packaging Logistics seminar with about 100 company representatives, November 2014
- FFI dissemination, Katrineholm, May 2014
- FFI dissemination, Katrineholm, May 2013
- Transporteffektivitetsdagarna, Lindholmen Conference Centre, Gothenburg, August 2012
- Livsmedelsförpackningar 2012, Lund, May 2012
- Logistik & Transport, Svenska Mässan, Gothenburg, May 2012

Workshops

- Volvo Cars, December 2014
- AB Volvo, November 2014
- Volvo Cars, June 2014
- AB Volvo and Volvo Cars, September 2013
- AB Volvo and Volvo Cars, May 2013
- AB Volvo and Volvo Cars, March 2012

6.2 Publications

Pålsson, H., Wallström, H. and Johansson, M. (2015), “Contextual impact on cost and environmental performance of packaging”, *under review in International Journal of Operations and Production Management*.

Pålsson, H., Wallström, H. and Johansson, M. (2014), “Returnable vs. one-way packaging – variables affecting supply chain cost and CO_2 emissions”, *proceedings of EUROMA*, Palermo.

Wallström, H., Cardinali, A. and Nilsson, F. (2015), “Cash-flow effects of packaging decisions – Insights from automotive supply chains”, *to be presented at NOFOMA, Molde 2015*

Wallström, H. and Pålsson, H. (2013), “Effects and trade-offs in the supply chain of a semi-integrated packaging selection approach” NOFOMA, Copenhagen.

Wallström, H. and Pålsson, H. (2014), “Effects and trade-offs in the supply chain of a semi-integrated packaging selection approach – a case study in the automotive industry”, *European Research Seminar*, Düsseldorf.

Wallström, H. (2015), “Modelling supply chain cost and environmental impact of packaging”, Licentiate thesis, Lund University (forthcoming in August 2015).

7. Conclusions and future research

A packaging model and an analysis tool was developed in the project. These compile detailed data from various sources in a new way. The output of the analysis tool makes it possible to carry out economic and environmental analyses that were previously unattainable. It is possible to analyse the economic and environmental effects of using different, but defined, material supply structures for a component.

The project confirmed that the stated problem was real and that there are large potentials in being able to take better informed packaging decisions. The results revealed that the decision support now given, in some cases as rule of thumbs, can be highly improved.

When discussing the resulting model and the developed analysis tool with staff at the participating companies, it became clear that no matter how accurate the data and the model are, it is crucial that the model is incorporated in relevant standard processes at the companies. Otherwise, it will not be used and the companies will not benefit from it.

The project revealed that an automatic updating of information is required, so that the model uses accurate and up-to-date data. This is important in order to produce high quality decision support, as well as gaining trustworthiness of the model, which affects the use of the model. A complete functional prototype of such an automated updating system was developed and implemented at one of the participating production plants.

The output from the analysis tool combined with knowledge and data from other areas presents new research and development opportunities. First, initial analyses indicate that the landed costs and the environmental impact of a component varies significantly between different material supply structures, including type of packaging used, and during the life-time of a component, due to altering circumstances (volume, supplier, etc.). Future research could combine the analysis tool output with production data to identify determining factors for when to change component supply parameters.

The basic analyses performed by help of the developed tool show the most cost and environmentally efficient materials supply structures of individual components, but they do not consider the complexity related to the linkages between different components. For instance, two components from the same supplier might benefit from using the same materials supply structure and packaging solution. To address these kinds of complexities, future research and development should address the complexity of obtaining a cost and environmentally efficient material supply for the variety of components from various suppliers. The complexity involves that the components are supplied from various suppliers with different geographical locations, the component characteristics vary in terms of size, sensitivity, volume etc., and that the supply is performed in various types of packaging.

The project has resulted in several practical implications. The analysis tool can be, and are currently, used in the daily business as decision support for new or modified packaging solutions. There is potential to implement and roll out the tool in other plants, but this requires some IT resources to include it in the central information system. Further, as the model applies a holistic supply chain perspective, which is operationalised in the analysis tool, it can also provide new input to interorganisational strategic decisions regarding, for instance, sourcing and production. In the companies involved in this project the model and the analysis tool can support ongoing and planned projects. One of the organisations in the project plans to develop a standardised one-way packaging concept. The analysis tool can provide information for the development of this concept. All companies have many special packaging, which are handled in a different way than standard packaging. An extension of the model can help to provide guidelines and modularise the assortment.

The developed model is based on empirical data from the automotive industry, but companies in other manufacturing industries have similar challenges regarding packaging selection. Companies in other manufacturing industries could get inspiration from the results obtained in this project. They could apply the logic in the model development to create context-specific analytical tools.

8. Participating parties and contact person

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