



LUND UNIVERSITY

Toward sustainable goods flows: A framework from a packaging perspective

Nilsson, Fredrik; Olsson, Annika; Wikström, Fredrik

Published in:
[Host publication title missing]

2011

[Link to publication](#)

Citation for published version (APA):
Nilsson, F., Olsson, A., & Wikström, F. (2011). Toward sustainable goods flows: A framework from a packaging perspective. In [Host publication title missing] (pp. 925-942). NOFOMA.

Total number of authors:
3

General rights

Unless other specific re-use rights are stated the following general rights apply:
Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Read more about Creative commons licenses: <https://creativecommons.org/licenses/>

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

TOWARD SUSTAINABLE GOODS FLOWS

A FRAMEWORK FROM A PACKAGING PERSPECTIVE

Fredrik Nilsson*

Annika Olsson**

Fredrik Wikström***

*), **) Division of Packaging Logistics, Department of Design Sciences, Lund University, Lund, Sweden, E-mail: *fredrik.nilsson@plog.lth.se, Tel: +46 46 222 91 55, **annika.olsson@plog.lth.se,

***) Department of Energy, Environmental and Building Technology, Karlstad University, SE-651 88 Karlstad, Sweden

ABSTRACT

Purpose of this paper

The purpose of this paper is to explore the role and potential of packaging in order to obtain more sustainable goods flows.

Design/methodology/approach

An explorative research approach based on case survey methodology in which description, exploration and analysis of 34 reported cases are made. The empirical focus is goods flows in fast moving consumer goods (FMCG) supply chains.

Findings

The insights presented highlights and provides guidance on the pros and cons packaging provides for sustainable goods flows in the FMCG industry.

Research limitations/implications (if applicable)

Based on knowledge and insights about the flows of goods and tomorrows requirements on sustainable societies, this paper reports on insights for making the goods flows in the FMCG industry sustainable based on a packaging perspective. The research has focused on FMCG goods flows, starting with the inbound flow of packaging at the product filler and ending at the retail outlet.

Practical implications (if applicable)

The insights can guide organisations to consider and reflect on how and when packaging enables or hinder sustainability aspects of goods flows. Extra effort should be on designing packaging system solutions that mitigate the negative effects of non-consumed products.

What is original/value of paper

While several studies have reported on the sustainability impact of logistics, transportation or supply chain structures, the perspective of packaging is rarely treated, neither in theory nor in practise. With a packaging perspective, the assessment of goods flows in supply chains is integrative, since packaging is naturally built on the intersection of logistics, marketing, sales, ergonomics and environmental considerations.

Keywords: Supply chain management, Logistics, Environment, Packaging Systems, Retail

1. INTRODUCTION

Packaging is today often seen by society as something bad for the environment. Furthermore, it is treated in many companies as a necessity and thereby most often taking into account very late in the development of new products (Olander-Roese and Nilsson, 2009; Olsson and Larsson 2009). However, the importance of packaging ought to be viewed differently. While packaging has been on the agenda for some time, in terms of marketing and efficient distribution and handling, its importance in bringing a more value adding approach to the product is growing (Doyle, 1996; Olander-Roese and Nilsson, 2009; Olsson and Larsson, 2009) as well as its impact on a sustainable society (Garcia-Arca and Prado, 2008; Svanes et al. 2010). Packaging affects the performance of every logistical activity throughout the supply chain (Bowersox and Closs, 1996), either direct (e.g. handling) or indirect (e.g. as information carrier, product protection etc). In food supply chains the package plays a major role in for example preventing waste (in Western Europe less than 3% of food spoils before it reaches the consumer, in developing countries the spoilage is close to 50% in the distribution of food (ECR-report 2009)). In the report Supply Chain Decarbonization (World Economic Forum and Accenture, 2009) possible commercial opportunities are assessed in order to lower the CO₂ emissions in supply chains. The five areas of most potential to lower CO₂ and with highest implementation potential are: 1) Cleaner vehicle technologies - 175 megaton CO₂ decreasing potential; 2) Lower speed in the supply chain - 171 megaton; 3) New packaging initiatives - 132 megaton; 4) Optimized networks - 124 megaton, and 5) Energy efficient buildings - 93 megaton. Hence, packaging inherits a great potential to lower the CO₂ emissions in supply chains. Consequently, packaging is an interesting carrier of sustainable development potentials, especially in the food retail industry, which represents the majority of product and packaging volumes in today's society. Furthermore, based on the fact that *"it is not products, but packed products that are handled in supply chains"* (Olander-Roese & Nilsson, 2009 p.2) the role of packaging as the intermediate between products and goods flows manifests even more its potentials for sustainable development.

The potentials packaging offers in providing efficient and effective goods flows (e.g. minimizing waste and spoilage of goods, improved handle-ability etc.), in transport, retail and consumption, needs to be further researched and communicated. In the food as well as the pharmaceutical industry for example, packaging impact the product in many ways; technically (physical protection, quality assurance, hygiene, preservation, etc.), ergonomically (openability, emptyability, recloseability) information (best-before date, content, instructions, symbols, appearance, etc.). All these factors, and many more, need to be considered at the development of packages since they all affect the amount of products reaching the consumer directly or indirectly. According to the Swedish retail organization (Svensk Dagligvaruhandel) 100 000 tons of food is spoiled every year in Sweden. Assuming improved packaging can impact 5% of the food spoilage it would mean that 5000 tons of food can be consumed rather than being thrown away. As one LCA (life cycle analysis) example on meat from pork, the production of the meat at the farm represent 89% of the total climate influence, while the package represent only 3 %. In this case an increase in packaging material e.g., that reduces the potential waste of meat, might result in less total climate influence (Nilsson 2011, Wikström et. al 2010). The role of packaging in reducing product waste with positive environmental impact as a result and on a global scale also the conditions for suppliers both financially and socially, especially in less developed areas, is interesting.

Setting out from knowledge in the present supply chains and tomorrows requirements on sustainable societies, this paper provides a framework for sustainable goods flows in the Fast Moving Consumer Goods (FMCG) industry based on a packaging perspective. Hence, the purpose of this paper is to explore the role and potential of packaging in order to obtain more sustainable goods flows. The empirical focus is the goods flows within the FMCG industry with a special focus on food supply chains. Special emphasis will be set on the packaging system as an enabler or a hinder for making goods flows more sustainable.

The paper is organized in the following way; packaging and packaging systems are presented in the next section as well as the basis for sustainable development providing the paper with the perspective and foundation for the analysis and results. This is followed by a presentation of our case survey method, in which we have used a number of packaging logistics cases to inductively find enablers and hinders from a packaging perspective on sustainable goods flows. The results and synthesis from the case survey is then presented in our framework and discussed in relation to other frameworks/models/methods found in literature that put forward packaging and sustainability issues. The paper then ends with a concluding discussion in which our prime insights are presented followed by issues for further research.

2. PACKAGING LOGISTICS SYSTEMS

Packaging influences and affects every logistics activity (Bowersox & Closs 1996; Saghir 2004) and thus affects both efficiency and effectiveness in supply chains. Furthermore packaging as such, need to be regarded as a system representing different levels of packaging (Hellström 2007); i.e. primary, secondary and tertiary, interrelating with the product, the logistics activities and the users along the supply chain (as illustrated in Figure 1). These levels are interrelated and affect each other, which means that the various levels and the interactions cannot be regarded as stand-alone levels of packaging (Saghir 2004). In dealing with packaging issues there are direct impacts involved arising from packaging material costs, packaging material characteristics, printing costs, and reuse and disposal costs etc. Lockamy III (1995) lists six main functions of packaging, in his assessment of strategic packaging decisions; 1) containment, 2) protection, 3) apportionment, 4) unitization, 5) convenience, and 6) communication. Packaging functions can also be set into a wider perspective including the indirect impacts the packaging has on different aspects such as logistics (handle, transport, store, distribute, inform), marketing (sell, differentiate, promote, provide value, inform), environmental issues (reduce, reuse, recover, dispose, inform), production/manufacturing (produce, make, assemble, fill), and IT systems (perform, inform) (Nilsson and Pålsson 2006).

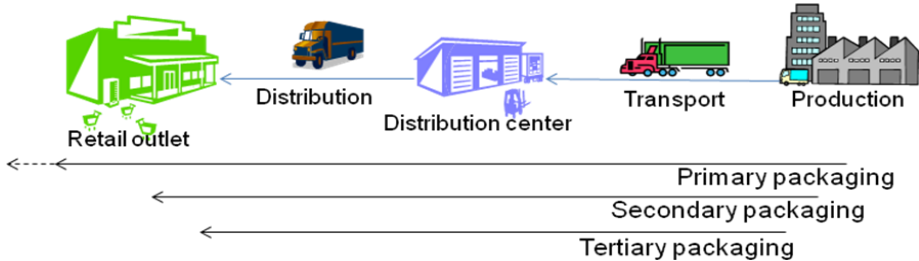


Figure 1. Generic model of the main supply chain activities in the flow of FMCGs from production into the retail outlet in our research. The interrelated levels of packaging and their different contribution in the goods flow are also illustrated.

Figure 1 provides an illustrative overview of the goods flows and packaging interactions focused in our research. The starting point is in production where the product is apportioned

and filled into a primary packaging which is unitized together into a secondary and most often a tertiary level of packaging. Transport activities are then performed to a distribution center in which the goods is deunitized and repacked on a secondary and/or tertiary level for consolidation with other products in order to be distributed to the retail outlets. Hence, in transport it is often a few types of goods (SKUs) while in distribution a great number of different products are packed together.

The supply chain in Figure 1 together with the six packaging functions provided by Lockamy III (1995) will be used as starting point for our case survey coding and analysis (further described in the method chapter). In Table 1 the functions are put together and a short explanation of them is provided. It is our intention to start from the package i.e. a bottom up perspective, and from there explore the potential role packaging has on affecting sustainable goods flows. The subsequent section will be set in the context of sustainability and FMCG.

Table 1. Packaging functions (Lochamy III, 1995) forming the packaging perspective and the factors for the case survey analysis in this paper.

Packaging function	Description
Containment and Protection	Containing and protecting the content i.e. restraining the content from interaction with the outside and vice versa.
Apportionment and Unitization	Apportion of products into handle-able units for all stages in the supply chain ending with the consumer. Optimizing the number of discrete packages and loads which require handling.
Convenience and Communication	Provides ergonomics, ease of opening and handling and disposal as well as information, branding and other value adding features.

3. SUSTAINABLE GOODS FLOWS AND PACKAGING

The concept of sustainable development became popular after the Brundtland Commission report of 1987. The perspective on sustainable development requires economic, social and environmental considerations as sustainability are required to give economic profitability, social responsibility and environmental conservation (Elkington 1998). Sustainable development in the context of logistics and supply chains have been elaborated by a number of authors (Carter and Rogers, 2008; Seuring and Müller 2008) and concepts such as sustainable supply chain management (Carter and Rogers, 2008; Svensson, 2007), corporate social responsibility (Keating *et al.*, 2008; Dyllick and Hockerts, 2002), green purchasing (Björklund, 2005; Min and Galle, 1997), reverse logistics (Srivastava, 2007; Zikmund and Stanton, 1971), and environmental logistics (Wu and Dunn, 1995) have been presented in research for some time. Packaging as being part of sustainable development has also been addressed in previous literature (Prendergast and Pitt, 1996; Gray and Guthrie, 1990; Mollenkopf *et al.*, 2005; Garcia-Arca and Prado, 2008) but most often in relation to its impact on specific aspects such as returnable systems or environmental friendly packaging material. A number of recent publications regarding sustainable development have especially addressed food supply chains (Vasileiou and Morris, 2006; Weber and Matthews, 2008). A great amount of research has focused on issues related to sustainable design and life cycle thinking. However, packaging, and especially packaging logistics, has not been explored to a greater

extent. The examples that do exist have dealt with the environmental impact of the packaging itself, including material minimization, renewable materials, recyclability, etc. For example, Bovea et al. (2006) used LCA to evaluate the effects of packaging minimization and Detzel et al. (2006) studied the role of PET packaging with special focus on the recyclability. However, according to Svanes et al. (2010, p.162) *“The studies do not quantitatively assess the packaging’s effect on the packaged product. Assessment of packaging is more complex than assessment of other product groups because it has a ‘double’ environmental impact that is evaluated through system enlargement, where the packaging system and the product system are seen in combination”*.

Based on the integrative nature of the three pillars of sustainable development (people, profit and planet) it means that any effort or assessment of sustainability must apply to the whole supply chain, rather than only on parts of it (Vasileiou and Morris 2006). In the words of Haake and Seuring (2009, p.284) *“in the long run there can be no such thing as ‘80% sustainable’”*. This increased need for coordination and integration among supply chain members in order to tackle sustainability issues has been empirically found and reported on e.g. fresh potatoes in the UK (Vasileiou and Morris 2006), wine in New Zealand (Flint and 2009), and in general by Gustafsson et al. (2006).

In the study by Weber and Matthews (2008) on the relative climate impacts of food choices in the US, it was found that the average household’s climate impact related to food was around 8.1 ton CO₂e/year. Out of this the actual delivery i.e. food-miles counted for 0.4 ton and total freight (including transport of raw material and other resources for production etc.) accounted for 0.9 ton. Hence, the transport part of food production and consumption only accounts for a smaller part, 11% of total emissions while the production accounts for 83% and wholesaling and retailing 5%. This means, from an environmental perspective, that the package’s role to reduce product waste can be more important than the package itself. Packaging has also a low contribution in relation to production (Hanssen, 1998) normally in the range of a few percents, depending on what products is packed. For example, a reduction of bread waste with 2 percent units can motivate an increase of about 50% of bread packaging material, still with a total reduction of global warming impact (Williams and Wikström 2011). However, examples do exist where the packaging represents up to 20% of the emissions (Andersson et al. 1998), depending on the CO₂e relation of product and package but also depending on package design.

Consequently, in order to make prioritized changes with the greatest impact on the sustainability of goods flows, a holistic and integrative approach is needed. Out of a packaging perspective this means that one of the most important roles of packaging to minimize product waste, i.e. to protect and contain the packed product, need to be reconsidered in an integrated manner with the packed product. This since every produced product loss due to out of date, damage, bad handling, contamination, etc. down the supply chain has a great environmental impact, without any corresponding advantage. And out of a sustainability perspective the case is that the actual impact of food production and transportation is much greater than just emissions (Weber and Matthews 2008) (i.e. land fill, usage of forests, human working rights etc.), especially in a global perspective where the western exploitation of developing countries are present in many cases and food availability is unevenly spread and handled. An example of global trade is the sourcing of table grapes from South Africa. As highlighted by Ras and Vermeulen (2008, p.333), *“The South African producer bears the market risks of the produce until it is sold to the consumer in the European shop and then only is the money transferred to the producer.”* Most producers (66% in the study, *ibid.*) are not paid for the table grapes that are damaged or non-sold in Europe. Hence, all damage that happens to table grapes downstream the supply chain are out

of the producers control at the same time as they only get paid for what is sold in retail outlets. Hence, packaging might have a great impact in reducing waste or damage to the product with the direct impact of better financial result for the producer. Food waste also makes the situation worse for poor people as increased demand for food increase food prices.

The design of the packaging system i.e. apportionment and unitization, is another important factor for sustainable goods flow since it have direct impacts on fill-rates (Olsson and Larsson 2010). As one example of this, the global retailer, IKEA of Sweden, introduced a new load carrier in 2001, the loading ledge, as a complement to the standard pallets being used before (Hellström and Nilsson, 2011). The main differences between using loading ledges and a traditional pallet are that loading ledges allow for varying size and design. One group of high-volume products at IKEA that the loading ledge has been used is made up of “600-millimetre products” (e.g. wardrobes, cabinets). The long pallet was traditionally used as the load carrier for these products. However, this left empty spaces between the unit loads in transport units, resulting in poor utilisation of the transport volume and risking product damage due to movement in transport units. With loading ledges strapped to products forming the unit load, the empty spaces between the unit loads are eliminated. Using loading ledges on all these products (three million cubic meters annually), and assuming a 20% average increase of cube utilisation, this would result in 600 thousand cubic metres’ less transport volume per year. This is equivalent to ten thousand 12-metre trailers. Hence, the impact on CO₂ reduction is profound with this packaging perspective realised.

4. METHOD

The research approach is explorative and the main method used is the case survey method (Larsson 1993, Yin and Heald 1975). Based on the initial factors set in this paper (see Table 1) the research set out to investigate the packaging system as an enabler or as hinder for the making of more sustainable goods flows. In order to get a wide scope and a comprehensive picture of FMCG the case survey method was chosen for this investigation. Larson (1993, p.1516) describes the case survey method and highlight that “*it can overcome the problem of generalizing from a single case study and at the same time provide more in-depth analysis of complex organizational phenomena than questionnaire surveys.*” The cases where chosen from our previous research and master courses cases. In total 34 cases were selected. Five cases come from PhD dissertations, two from licentiate theses, five master thesis works and 24 masters course’s case reports. In all cases chosen a packaging logistics perspective has been used and the goods flows have been empirically investigated as well as adequately reported. All cases have been supervised and/or examined by the authors or senior researchers and colleagues at the same division i.e. the selection is based on previous knowledge and impact on the studies securing the relevance of the cases. The focus and purpose of the chosen cases have been slightly different and there are some but few that especially focus on sustainability issues. Each case focuses a unique product (e.g. table grapes, cheese, ice cream) and there are not two cases investigating the same product¹. Every case contains information about the product and the supply chain studied, the packaging levels and the interactions among the packed products and the supply chain activities. In most cases (28) the scope is from the product being put into a primary package to the retail outlet. In each case packaging

¹ This could be of interest for future studies but for the purpose of this research we wanted different FMCG products in order to widen the scope.

improvement suggestions from a packaging logistics perspective are provided on aspects that can improve supply chain performance. For example, in most cases it is found that there are packaging inefficiencies in form of unnecessary “air” being transported or that the packaging system is not optimized in other ways e.g. apportionment. The cases are all conducted between 2003 and 2010 and the vast majority (33) on goods flows in Sweden.

A coding scheme (see Table 2) was created and used for the meta-analysis and synthesis of the cases. The coding scheme is based on the packaging perspective defined in Table 1 and it is identified quantitatively based on the packaging aspect each case highlights as an issue or improvement suggestion. Each issue and improvement suggestion was thereafter qualitatively analyzed out of its contribution to sustainable goods flow i.e. potential economic, environmental and social impacts that packaging has. From the qualitative analysis key factors were identified as an enabler and/or hinder for sustainable goods flows.

Table 2. The coding scheme for the case survey analysis.

	Containment & Protection	Apportionment & Unitization	Convenience & Communication	Other
Case 1				
Case x				
Case 34				

A literature review on the topic of sustainable packaging was also carried out. In the literature review, from which former chapter is derived, sustainable development and FMCG in relation to packaging and goods flows have been studied. Based on the case survey analysis, with the key factors identified, together with the findings from literature a synthesizing process was performed ending up in the framework in this article. The choice of the FMCG industry with specific focus on food products are based on the following aspects: 1) the delivery frequencies are high, 2) several products are either chilled or frozen in the goods flow, i.e. higher demands on transport conditions, 3) transport fill-rates are most often based on volume, 4) fill-rates are generally low, especially in the distribution to retail facilities, 5) the products are sensitive (temperature, moisture, biologically, physically etc.), generally low product margins and 7) all packaging levels are involved from the package is filled until it reaches the consumers in retail outlets. Hence, goods flows of FMCG, especially food products, are challenging in many aspects and thus represent a unique type of goods that we believe other areas can learn from.

5. CASE SURVEY RESULTS

The analysis of case reports revealed a great number of packaging related examples of improvement potentials i.e. enablers, to sustainable goods flows, but also hinders that will delimit the possibilities to create more sustainable good flows. In Table 3 the numbers of examples/observations from the cases are presented under each packaging factor. A significant number of other aspects related to the supply chain and the logistics processes were also identified (presented under Others in Table 3).

Table 3. The number of observations from the cases where sustainability improvement potentials were identified.

	Containment & Protection	Apportionment & Unitization	Convenience & Communication	Others
Sum of case observations	17	60	34	38

5.1 Containment and protection

Regarding containment and protection 17 observations were made in the cases investigated. Most often related to the existing systems where the amount of packaging (on all levels) was discussed in relation to the protection needed for the products. An interesting finding from the cases was the fact that most of them did not focus on the packaging as a facilitator for the minimization of product waste or spoilage, something that recent publications (e.g. ECR 2009, Weber and Matthews 2008) have manifested. One example of food protection comes from a case dealing with apples. In this case it is found that by using the secondary packaging directly in display and by adding a protective plastic edge, both increased volume efficiency and better protection of the apples can be reached. The plastic protection is put on the display table in order to prevent apples from falling to the floor either in the replenishment process or when consumers get the apples. By placing the secondary packaging on the shelf in store instead of, as it is today, manually filling display boxes, less handling is necessary and less product damage also the consequence. Furthermore, by lowering the height (15 mm) of the secondary packaging less pressure is put on each apple as they are placed onto each other. In terms of volume efficiency, the height reduction of secondary packaging also has the effects that more packages can be put on pallets. In total this means that 8% less pallets have to be handled, transported and stored, at the same time as food losses are reduced.

5.2 Apportionment and unitization

The most often suggested improvement was related to the unitization of goods, often based on suggestions how the products could be apportioned (in total 60 observations, either on one or several levels of packaging). In many cases there are examples of fill rates improvements as direct results. For example, in the case of ice cream, where the primary packaging was of an elliptic shape, a change of the primary packaging would increase so that the fill rate of secondary packaging would increase by 50 %. The effect on tertiary packaging was also an increase of 50% since the total still remains within weight limits. The secondary effects were then estimated to reduce handling activities at both the manufacturer and the distribution central by 33%. With the estimation of 5 million primary packages each year, the number of tertiary packages would be reduced from approximately 5600 to 3700, leading to environmental, societal (handling) and economic advantages, in the entire supply chain.

Another example related to unitization comes from a case of a major beverage producer in Sweden. In this case the numbers of bottles in each secondary package are elaborated leading to improvement in volume efficiency with the consequence of lower transport, handling and storage costs and in addition lower environmental impact, since fewer pallets have to be transported. In this case the primary package is kept in its original design. With the suggested change 45 boxes instead of 40 can be filled on each pallet (a reduction of pallets by 11%). For the Swedish market this would lead to 740 pallets instead of 833 have to be handled and distributed and on a global scale it would mean a pallet reduction in the range of 4500 pallets per year. In the case of fish, one case reports on a small modification on the secondary packaging that 47 percent more products could be placed on each pallet. As a result of this 31 percent fewer pallets would have to be handled and delivered to the wholesaler each year, leading to more space in trucks or fewer pickups. Hence, decreased transportation costs, less pollution and reduced use of material in primary and secondary packaging are outcomes. However, it is also raised that there is a risk that if the transport schedule would still be the same, the transport becomes less volume efficient, i.e. a hinder for sustainable development. Finally, a case focusing on toothpaste found that the number of products per pallet could be

increased from 3960 to 4536, (i.e. 38 pallets less per year to transport in Sweden) by a small change to the primary product but a new type of secondary packaging. The solution also improves the convenience for the retail store as both the primary and secondary packaging is easier to handle and display in the retail outlets.

5.3 Convenience and communication

The convenience of the package and the apportionment of products was another aspect raised that we found with impact on sustainability. In this case the numbers of observations was 34 in the 34 cases investigated. In one example, dealing with drugs containing paracetamol for the Swedish Pharmacies, it was found that elderly people having great problem getting the pills (500mg) from the blister packages. Consequently, by rethinking the apportionment of products in packaging as well as the packaging functions one way of taking consideration to disabled people in society, either by age or other causes is made. Hence, the people/societal part of sustainable development become a direct issue for packaging to either hinder or enable that development.

Concerning packaging communication, examples were found that by implementing new information technologies together with routines to handle the information in the flow of goods, lower environmental impact could be gained. One example is the picking process, where non-appropriate or convenient marking of packaging means that wrong products are picked, and then are sent away in order to be sent back again or thrown away, due to wrong deliveries. In a case on the implementation of an automatic identification system for their roll containers at the dairy company Arla it was found that by using the new identification system the number of roll container in the logistics system could be reduced by 30 percent (Hellström and Johansson, 2009). Hence, a much more efficient system with less handling and material was needed. However, it was also found that if the routines failed in updating the status of the roll containers the inefficiency of the roll container system came back. Another example comes from a case focusing on cheese supply chain where it is suggested to place a passive RFID tag on the secondary packaging. The tag could hold information about what temperatures the cheese has been exposed to all the way from the manufacturer to the store. If the temperature would exceed 10 degrees or be below 8 degrees the concerned packages could, if thought necessary, be removed as soon as the discovery was made. In this way unnecessary transportation would be avoided and improvement processes to the cold chain would be targeted to the area where the temperature was out of range.

5.4 Others

In this category it was found both direct and indirect aspects to the sustainability of goods flows, often related to the packaging material, the supply chain context or the logistics processes. The main hinders for sustainable development from a packaging perspective are related to the packaging material, the production and transport of packaging material. However, since packaging cannot be evaluated in isolation such impact must be placed in relation to what it saves in other terms during handling and consumption. Since most of the cases dealt with chilled or frozen products, the issue of temperature control along the supply chain was raised. Since the majority of cases have investigated supply chains operating in Sweden there are also other issues concerning the quality of roads, information etc. related to infrastructure. From other parts of the world this would mean totally different and other requirements on packaging in relation to transports and handling.

6. FRAMEWORK FOR SUSTAINABLE GOODS FLOWS FROM A PACKAGING PERSPECTIVE

From our case survey analysis quite many observations and examples are found where a packaging perspective on the flow of goods show great potentials in improving sustainability performance i.e. improving financial, environmental and social aspects. In Figure 4 the main insights found are presented as a framework of dimensions for sustainable goods flows from a packaging perspective. These dimensions will be elaborated in the following text and put in relation to other published work.

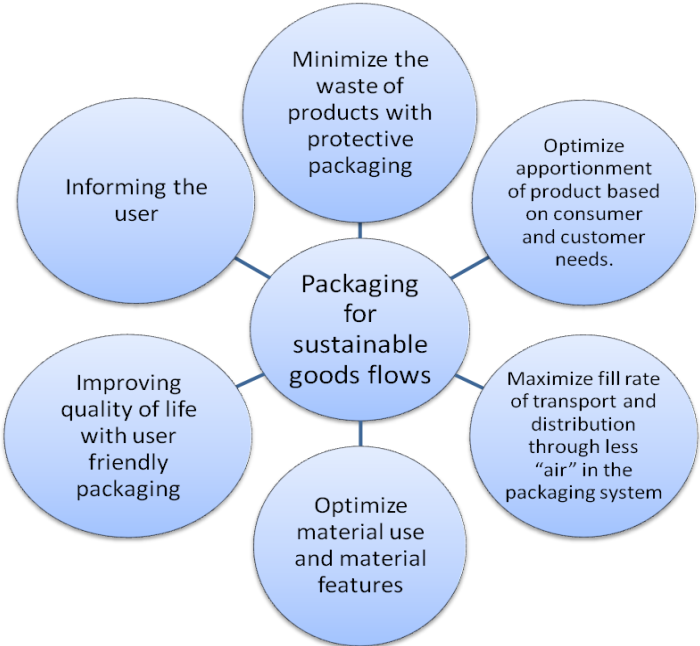


Figure 2. Framework for sustainable goods flows from a packaging perspective.

In the following subchapter we will present the different ways the suggested framework dimensions contribute, or for that matter hinders sustainable development.

6.1 Minimize the waste of products with protective packaging

Companies in general have a tendency to handle packaging in simplistic ways when it comes to environmental issues, either by focusing on packaging weight or the packaging material (Svanes et al. 2010). Value added products that become waste are one of the most wasteful consequences for any company, both financially, socially and environmentally. As declared by Williams et al. (2008, p.853) “Packaging is important to reduce food losses in the retailer and consumer steps.” In total it is a win-win-win situation out of a sustainability perspective to get more products sold as long as the increase of packaging material or other features (sensors etc.) not levels out the product value or impact. This is though rarely the case as packaging normally is between 5-15% of the product costs. In table 4 the pros and cons found for each actor is summarized.

Table 4. The sustainability impacts (pros and cons) from protective packaging identified for the actors in the flow of goods.

	Retail	Distribution	DC	Transport	Producer
Planet	+ less waste of products - more packaging material	+ less damaged products -	+ less damaged products - more packaging material	+ less damaged products	+ less waste - more packaging material
People	+ more even and higher quality of products	+ less problems with broken packages	+ less problems with broken packages	+ less problems with broken packages	+ less problems with broken packages
Profit	+ more products sold - initially higher costs	+ less damaged products - more careful handling needed	+ less damaged products - more careful handling needed	+ less damaged products - more careful handling needed	+ more products to the market - investment cost - packaging cost

6.2 Optimize apportionment of product based on consumer and customer needs

With a more heterogeneous population in terms of consumer household sizes and also more differentiated food products to choose among, differentiation of package sizes to fit different consumer needs in terms of apportionment and usage are needed. Furthermore, considerations should also be made to the handling of the packages in the goods flow. For example, as proven in one case, the change of 12 to 10 bottles (wine/liquor) per secondary package improves the working conditions for warehouse staff (easier to handle) at the same time as more products in total can be placed on pallet. Marketing campaigns, such as “now 33% more”, and the desire to get as much “facing” as possible on retail shelves, leading to larger packages with potentially more air, needs to be balanced with the strive for higher fill rates in transport and storage. The marketing aspects can in some way be argued as a hinder for more sustainable development, on the other hand with more innovative package designs, more transport efficient solutions that still attract consumers on the retail shelf might be able to find (Györei and Olsson, 2002). In table 5 the pros and cons found for each actor is summarized.

Table 5. The sustainability impacts (pros and cons) from optimizing apportionment of products needs identified for the actors in the flow of goods.

	Retail	Distribution	DC	Transport	Producer
Planet	+ less waste of products - more packaging material	+ less problems with broken packages -	+ less problems with broken packages		+ less waste - more packaging material
People	+ higher quality of products - ev. initially higher costs	+ less damaged products	+ better working conditions	+ better working conditions	+ better working conditions
Profit	+ more products sold - investments	+ less damaged products - more handling needed	- more handling needed	- more handling needed	+ more products to the market - investment costs

Consequently, the balance between increased environmental impact of packaging and decreased environmental impact from reduced product waste due to inappropriate

apportionment of packed products should be considered (Wikström and Williams 2010, Williams and Wikström 2011). However, aspects of marketing need to be incorporated as economic sustainability is predominant for any firm.

6.3 Maximize fill rate of transport and distribution through less “air” in the packaging system

The entire packaging system needs to be considered when calculating the filling grade, i.e. the product should fill as much as possible in a primary package. The secondary package should then be designed to contain primary packages to 100%, and the tertiary package should stack and fill its space with secondary packages (Olsson and Larsson, 2010). This relates to Svanes et al (2010, p.) who suggest “*The whole packaging system is considered as a combined system, including primary packaging, secondary packaging and tertiary packaging, and “Product and packaging systems are considered as interconnected in the method”* as pre-conditions for a sustainable packaging development. Furthermore, the balance between standardization and customized volumes and customized design needs to be considered for packaging adjustments (Jahre and Hatterland, 2003; Hellström and Nilsson, 2011).

Table 6. The sustainability impacts (pros and cons) from maximize fill rates identified for the actors in the flow of goods.

	Retail	Distribution	DC	Transport	Producer
Planet	+ less packaging material	+ higher resource utilization + fewer deliveries	+ less warehouse space needed	+ higher resource utilization + fewer transports	+ higher packaging fillrate
People	+ less packaging material to handle	+ less products damaged	- less people needed	- less trucks needed	
Profit	+ less packaging material to handle + less ordering - more back storage - more product handling	+ less products damaged	+ less packaging material to handle - + more products per delivery	+ higher resource utilization	+ more products to the market - less display area

6.4 Optimize material use and material features

“Double packing” meaning that one primary package was packed in an outer package e.g. tooth paste tubes in a single carton, is conceptions that was targeted in the 80’ies in Europe and the USA, and is at present an almost forgotten target for reducing packaging material use on these markets. However, even if this way of double packaging is almost eliminated in western countries it still prevails in e.g. China and Africa, high volume markets still “double packing” consumer items. The reduction of double packaging globally would be an “easy” action for more sustainable packaging and goods flow, but again it needs to be balanced with the protection aspects of the primary package.

Table 7. The sustainability impacts (pros and cons) of optimize material use and material features identified for the actors in the flow of goods.

	Retail	Distribution	DC	Transport	Producer
Planet	+ less packaging material + longer product shelf-life	+ less packaging material -	+ less energy for chilled and frozen products + less packaging material	+ less packaging material -	+ extended product life + less packaging material
People	+ less packaging material to handle	+ less packaging material to handle	+ less packaging material to handle	+ less packaging material to handle	+ less packaging material to handle
Profit	+ less packaging material to handle - more back storage - more handling	+ less products damaged	+ more efficient handling		+ innovative customer solutions - investment in new packaging solutions and equipment

Design new packaging material with less friction in order to make products to easier flow out of the packages in order to minimize product residues in empty packages. A design improvement of packages with other functions might also help this aspect. There is also a tendency, for marketing purposes, to have large primary packages in order to be more displayed on the shelf in retail stores. This ought to be reconsidered as both more packaging material is needed as well as the transportation of air is a major consequence.

6.5 Improving quality of life with user friendly packaging

Packaging attributes that affect product waste in the consumer phase were identified by Williams et al (2008), for example that the packaging is easy to open without damaging the product, and that it is easy to empty, reseal, and informative about content and open-dating. It is very important to learn more about the potential of packaging to reduce product waste at the consumer. There are indications that food waste by consumers and food institutions vary between 15-30% of the bought food in Europe and USA (Kantor and Lipton, 1997; Engström and Carlsson-Kanyama, 2004; Ventour, 2008; Qvested and Johnson, 2009).

Table 8. The sustainability impacts (pros and cons) of user friendly packaging identified for the actors in the flow of goods.

	Retail	Distribution	DC	Transport	Producer
Planet	+ more products consumed -				+ more products consumed
People	+ less packaging material to handle -	+ less damaged products + easier to handle	+ easier to handle + fewer staff being injured	+ easier to handle	+ easier to handle
Profit	+ higher consumer satisfaction - more back storage - more handling	+ less damaged products	+ more efficient processes + less damaged products	+ less damaged products	+ higher consumer satisfaction - investment costs

As mentioned above, even small reductions of product waste means significant reductions of environmental impact, especially in the food sector. Williams et al. (2008) showed that packaging solutions that resulted in product waste also resulted in dissatisfied consumers.

Hence, it is important for packaging designers to learn more of how the packaging is used by consumers in order to develop more user-friendly packaging that also save food waste.

The new trend to integrate the secondary package more through the concept of “shelf-ready” packaging for retail, will most often give more efficient solutions from a filling grade point of view, but also from a user point of view. The retail worker will reduce handling time by putting the shelf-ready solution directly into the shelf, thus reducing handling time and struggle to unpack and place primary packages in shelf one by one.

6.6 Informing the user

Packaging may be regarded as an information link between the physical flow and the IT system. The validity and reliability of parts of the logistical information in the IT systems are based on information gained from product flows, which are typically based on the actual movement and registration of packages e.g. POS data, inventory in- and out-check points etc. Consequently, in order to enable the information system to perform appropriately, packaging provides information functions which are crucial. Barcodes or RFID technology tags are examples of technologies that, put on packages, support or inform the IT system with logistical information. With this up-to-date information, logistical flows have the opportunity to perform more effectively and then with less environmental impact.

Table 9. The sustainability impacts (pros and cons) of improved information on packaging identified for the actors in the flow of goods.

	Retail	Distribution	DC	Transport	Producer
Planet	+ less damaged products	+ less return flows	+ less return handling	+ less return flows	+ increased correctness of deliveries + increased product safety and security
People	+ less handling + improved product information	+ increased correctness of deliveries	+ easier to identify correct product + decreased picking deficiencies	+ increased correctness of transports	+ increased product safety and security
Profit	+ higher consumer satisfaction Better brand recognition + more efficient processes	+ increased correctness of deliveries - investment in updated technology	+ decreased picking deficiencies + more efficient processes	+ increased correctness of transports	+ higher consumer satisfaction - investment cost in new equipment etc.

Furthermore, if packaging should be recovered or disposed, reverse logistics impacts need to be considered. When the packaging system is being set up, aspects such as packaging material separation and sorting influence the recyclability of the packaging. In the recycling process information on the package can ease the process of identifying its material type etc. Furthermore, the packaging also have role of providing the end-user with information such as information to consumers on origin, content etc. in order to make the consumer buy the right products and not bringing products home that need to be thrown away. In terms of shelf –life (best-before-date) information at its present state might hinder waste reductions since

consumers tend to rely on the best-before as a date when the product needs to be thrown away. By working on information aspects with consumers, new behaviour might lead to less waste.

7. CONCLUDING DISCUSSION

With a starting point in packaging functions with the main focus on sustainable goods flows, a framework, derived from a packaging logistics approach, is presented. The uniqueness of the framework is that it sets out on an operational level, i.e. the physical flow where packed products are handled from “farm to fork”. With this bottom up perspective, it is evident that there are a great number of changes to packaging that have impact on the three pillars of sustainable development. Most improvement suggestions in the case survey are found in relation to apportionment and unitization. The major reason for this tendency is the packaging logistics focus that all cases have had. However, by analyzing the case results and improvement suggestions together with the literature reviewed it has been possible to explore the packaging functions of product protection, convenience and communication as well. Hence, a complete picture that a packaging perspective can provide in the making of sustainable goods flows. Based on the inductive case survey carried out, we can therefore confirm several of the aspects and requirements that related work (Svanes et al. 2010; Williams et al. 2008) has put forward for sustainable packaging, also in this particular study.

While issues of marketing and branding vs. logistics efficiency and effectiveness are evident for primary packaging, the potential of increasing the logistics efficiency and effectiveness on secondary and tertiary levels of packaging is evident. Nonetheless, it is the firm belief of the authors that as a result of more environmentally concerned consumers, the branding and marketing role of primary packaging size will be less important and instead increased product protection and resource utilization manifested. Hence, graphical design of packaging, resource efficient shapes and information will be sources of brand recognition and sales advantages.

As with any research endeavor, there are some limitations that need to be considered when using our results. We have had a deliberate focus on FMCG and especially food products (most of our cases are focused on food products) which means that other industries, with different supply chain contexts, product requirements etc. may yield other dimensions as well. At the same time, it is our firm belief that the food sector is a good benchmark for other industries based on the special requirements on both products and supply chains in the food industry (temperature, low margins, frequent deliveries, consumer intense, security and safety). Hence, future research may could do similar studies or use our framework in different industries to verify and extend/focus the framework presented in this paper.

REFERENCES

- Bovea MD, Serrano J, Bruscas GM and Gallardo A. (2006) “Application of Life Cycle Assessment to improve the environmental performance of a ceramic tile packaging system”. *Packaging Technology and Science*, Vol.19, pp.83–95.
- Bowersox, D.J. and Closs D.J. (1996), “*Logistical Management - The integrated supply chain process*”, International ed., McGraw-Hill, New York, USA.
- Carter, C.R. and Rogers, D.S. (2008), “A framework for sustainable supply chain management: moving toward new theory”, *International Journal of Physical Distribution & Logistics Management*, Vol. 38, No. 5, pp. 360-387.

- Detzel A. and Krüger M. (2006), Life Cycle Assessment of PLA. A comparison of food packaging made from NatureWorks® PLA and alternative materials. Final report. IFEU GmbH, Heidelberg, July 2006.
- Doyle, M. (1996), *Packaging Strategy: Winning the Consumer*, 1st ed. Technomic Publication, Lancaster, PA.
- Dyllick, T. and Hockerts, K. (2002), “Beyond the business case for corporate sustainability”, *Business strategy and the Environment*, Vol. 11, No. 2, pp. 130-141.
- Elkington, J. (1998) ”*Cannibals with Forks: the triple bottom line of 21st Century Business*”, New Society Publications, UK.
- García-Arca, J. and Prado, J.C. (2008), “Packaging design model from a supply chain approach”, *Supply Chain Management: An International Journal*, Vol.13, No.5, pp. 375-380.
- Gray, V. and Guthrie, J. (1990), “Ethical Issues of Environmentally Friendly Packaging”, *International Journal of Physical Distribution & Logistics Management*, Vol.20, No.8, pp.31-36.
- Gustafsson, K., Jönson, G., Smith, D., and Sparks, L. (2006), *Retailing logistics & fresh food packaging*, Kogan Page Limited, London, UK.
- Haake, H. and Seuring, S. (2009), “Sustainable procurement of minor items - exploring limits to sustainability”, *Sustainable Development*, Vol.17, No.5, pp. 284-294.
- Hanssen OJ. (1998) “Environmental impacts of product systems in a life cycle perspective: a survey of five product types based on life cycle assessments studies” *Journal of Cleaner Production*, Vol. , pp.299-311.
- Hellström, D. (2007) “On interactions between packaging and logistics – exploring implications of technological developments”, PhD Dissertation, Department of Design Sciences, Division of Packaging Logistics, Lund University, Lund, 2007.
- Hellström D. and Johansson, O. (2010), ”Impact of Control Strategies on the Management of Returnable Transport Items”, *Transportation Research Part E: Logistics and Transportation Review*, Vol. 46, No. 6, pp.1128-1139.
- Hellström, H. and Nilsson, F. (2011), “Logistics-driven packaging innovation: A case study at IKEA”, working paper, Lund University.
- Jahre, M. and Hatteland, C. (2003), “Packages and physical distribution, implications for integration and standardization” *International Journal of Physical Distribution & Logistics Management*, Vol. 34, No. 2, pp. 123-139.
- Keating, B., Quazi, A.Q., Kriz, A. and Coltman, T. (2008), “In pursuit of a sustainable supply chain: insights from Westpac Banking Corporation”, *Supply Chain Management: An International Journal*, Vol.13, No.3, pp. 175-179.
- Lockamy III, A. (1995), "A conceptual Framework for assessing strategic packaging decisions", *The International Journal of Logistics Management*, Vol. 6 No. 1, pp.51-60.
- Min, H. and Galle, W.P. (1997), “Green Purchasing Strategies: Trends and Implications”, *International Journal of Purchasing & Materials Management* Vol.33, No.3, pp. 10-18.
- Mollenkopf, D., Closs, D. and Twede, D. (2005), “Assessing the viability of reusable packaging: a relative cost approach”, *Journal of Business Logistics*, Vol.26, No.1, pp. 169-198.
- Nilsson, K. 2011, “Bra förpackning – bra för miljön”, Seminar ”Färsk forskning” by SIK in Lund, Sweden, March 2011.
- Nilsson, F. and Pålsson, H. (2006), Demand-driven logistics from a packaging perspective, *Proceedings of Logistics Research Network conference (LRN)*, Birmingham 2006.

- Olander-Roese, M. and Nilsson, F. (2009), "Competitive advantage through packaging design – propositions for supply chain effectiveness and efficiency", *Proceedings of the international conference of engineering design, ICED'09*, Stanford, CA, U.S.A.
- Olsson, A. and Györei, M., (2002), "Packaging throughout the Value Chain in the Customer Perspective Marketing Mix", *Packaging Technology and Science*, Vol. 15, pp. 231-239.
- Olsson A. and Larsson A.C. (2009) "Value Creation in PSS Design Through Product and Packaging Innovation Processes", book chapter 5, pp 93-108, in *Introduction to Product/Service-System Design*", eds Sakao and Lindahl, Springer (ISBN: 978-1-84882- 909-1)
- Prendergast, G. and Pitt, L. (1996), "Packaging, marketing, logistics and the environment: are there trade-offs?", *International Journal of Physical Distribution & Logistics Management*, Vol.26, No.6, pp. 60-72.
- Ras, P.J. and Vermeulen, W.J.V. (2008), "Sustainable Production and the Performance of South African Entrepreneurs in a Global Supply Chain. The Case of South African Table Grape Producers", *Sustainable Development*, Vol. 17, pp. 325-340.
- Saghir M. (2004), *"A platform for Packaging Logistics Development - a systems approach"*. PhD Dissertation, Department of Design Sciences, Division of Packaging Logistics, Lund University, Lund.
- Seuring, S. and Müller, M. (2008), "From a literature review to a conceptual framework for sustainable supply chain management", *Journal of Cleaner Production*, Vol.16, No.15, pp.1699-1711.
- Svanes, E. Vold, M. Møller, H. Kvalvåg Pettersen, M. Larsen H. and Hanssen, O.J. (2010) "Sustainable Packaging Design: a Holistic Methodology for Packaging Design", *Packaging Technology and Science*, Vol. 23, No.2, pp.161-175.
- Svensson, G. (2007), "Aspects of sustainable supply chain management (SSCM): conceptual framework and empirical example", *Supply Chain Management: An International Journal*, Vol.12, No.4, pp. 262-266.
- Vasileiou, K. and Morris, J. (2006), "The sustainability of the supply chain for fresh potatoes in Britain", *Supply Chain Management: An International Journal*, Vol.11, No.4, pp. 317-327.
- Wikström, F. and Williams, H. (2010), "Potential environmental gains from reducing food losses through development of new packaging—a life cycle model". *Packaging Technology*.
- Williams, H., Wikström, F. and Löfgren, M. (2008) "A life cycle perspective on environmental effects of customer focused packaging development" *Journal of Cleaner Production*, Vol.16, No. 7, pp.853-859.
- Williams, H. and Wikström, F. (2011) Environmental impact of packaging and food losses in a life cycle perspective: a comparative analysis of five food items. *Journal of Cleaner Production*, Vol.19, pp. 43-48
- World Economic Forum (2009), *"Supply chain decarbonization – The role of logistics and transport in reducing supply chain carbon emissions"* .
<http://www.weforum.org/pdf/ip/SupplyChainDecarbonization.pdf> (2010-11-01).
- Zikmund, W.G. and Stanton, W.J. (1971), "Recycling solid wastes: a channels-of-distribution problem", *Journal of Marketing*, Vol.35, No.3, pp. 34-40.